Appendix 5.2 Environmental, Social and Economic Attribute Evaluation of Resource Options (Intergroup, EDI, Ecofor and CNC 2016)

RESOURCE OPTIONS EVALUATION

FINAL REPORT

PREPARED FOR

YUKON ENERGY CORPORATION

BY

INTERGROUP CONSULTANTS LTD.

IN ASSOCIATION WITH EDI, ECOFOR AND CNC

DECEMBER 2016

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December 16, 2016

Marc-André Lavigne
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Dear Mr. Lavigne:

Re: Resource Options Evaluation – Revised Final Report

Please find enclosed a PDF version of the revised final report for the Yukon Energy Corporation Resource Options Evaluation prepared by InterGroup Consultants Ltd. in association with EDI Environmental Dynamics Inc., Ecofor Consulting Ltd. and Campbell's North Consulting. The revised report contains updated economic information as provided by Yukon Energy on specific resource options, including an evaluation of one new option (i.e., the Anvil Creek small hydro site option).

This study supports Yukon Energy's current 2016 Resource Plan update by providing a comparative evaluation of more than 45 power generation and transmission resource options in Yukon and northern British Columbia against more than 40 environmental, social and economic indicators. No attempt is made to evaluate resource options in the context of forecast grid loads. The ratings for each indicator show on a common scale (low, medium and high) which indicators are particularly relevant to each resource option, without attempting to provide an overall ranking of these options.

This final revised report addresses comments received from Yukon Energy on the earlier report. We thank you for the opportunity to work on this project.

Yours truly,

INTERGROUP CONSULTANTS LTD.

Mona Pollitt-Smith
Principal and Consultant

Cam Osler
Chair/Principal

Attachment

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1.0 INTRODUCTION AND OVERVIEW

This report supports Yukon Energy Corporation's (Yukon Energy's) current 2016 Resource Plan (RP) update by providing an evaluation against environmental, social and economic attributes of potential power generation and transmission resource options as inventoried by Yukon Energy to meet long-term load forecasts (2016-2035).

InterGroup Consultants Ltd. (InterGroup) has prepared this report in association with EDI Environmental Dynamics Inc. (EDI), Ecofor Consulting Ltd. (Ecofor) and Campbell's North Consulting (CNC). The evaluation is based on publicly available information and information from inventoried resource option project reports and other reports provided by Yukon Energy. No attempt is made in this report to evaluate resource options in the context of forecast Yukon Energy loads. Resource portfolio option definition and assessment in the context of long-term load forecasts will be done subsequently by Yukon Energy as part of the current RP update.

Section 1 of this report provides an overview of the resource options examined and the evaluation approach adopted. Section 2 provides the summary evaluation of the resource options against the environmental, social and economic criteria and indicators. Section 3 provides an overall summary and conclusions.

This report summarizes more detailed analysis provided in the following appendices:

- **Appendix A: Project Summaries**, which summarizes key information from Yukon Energy's resource option reports.
- **Appendix B: Evaluation Approach - Criteria & Indicators**, which reviews overall criteria, indicators, metrics and methods used to compare and rank resource options.
- **Appendix C: Environmental Evaluation - Technical Report**, which provides details on methodology, ranking approach and evaluation of resource options against environmental criteria.
- **Appendix D: Social Evaluation - Technical Report**, which provides details on methodology, ranking approach and evaluation of resource options against social criteria.
- **Appendix E: Economic Evaluation - Technical Report**, which provides details on methodology, ranking approach and evaluation of resource options against economic criteria.

1.1 OVERVIEW OF RESOURCE OPTIONS

The more than 45 resource options evaluated in this report are summarized below by technology groups. (See Table 1 for a list of the options and a summary of locations and key attributes. See Appendix A for added details.)

- **Fossil Thermal:** Diesel and Liquefied Natural Gas (LNG) 20 MW options - each in Whitehorse with two site options.

- **Non-Fossil Thermal:** Waste-to-energy and Biogas in Whitehorse, Biomass in Haines Junction (each small scale, i.e., less than 2 MW).
- **Other Non-Hydro Renewable:** Storage Battery option at Whitehorse (2 technologies); Solar PV in Whitehorse and Haines Junction (different scale options up to 10 MW); Wind farms (seven 20 MW site options examined); and Geothermal options (2 sites, average 1.6 to 3.8 MW).
- **Hydro Generation:** 8 pumped storage site options (2 scales of development at 2 sites - overall range 15 to 40 MW), 6 small hydro site options (5.7 to 20 MW range), 4 other hydro options to enhance existing generation (diversion or storage), and 2 refurbishment options (1 to 2.3 MW).
- **Transmission Corridors:** 6 options (the Stewart-Keno City transmission option, which was recently recommended in a Yukon Environment and Socio-economic Assessment Board [YESAB] report, is the only option that addresses an existing corridor).

Photo courtesy of: InterGroup Consultants Ltd.

Table 1: Overview of Resource Options Evaluated

Resource Options	Installed Capacity (MW)	Annual Average Energy (GWh)	Assumed Economic Life (years)	Comments
Fossil Thermal				
Diesel: 20 MW - Whitehorse	20.0	up to >166	20-40	Largest scale options at 2 locations (Whitehorse landfill & Takhini substation). Economic life reflects expected backup use.
Diesel: 20 MW - Takhini	20.0	up to >166	20-40	
LNG: 20 MW - Whitehorse	20.0	up to >166	20-40	
LNG: 20 MW - Takhini	20.0	up to >166	20-40	
Non-Fossil Thermal				
Waste to Energy	1.6	10.0	25	Unspecified Whitehorse location - need sale of waste heat.
Biogas (CHP)	0.2	0.4	20	Whitehorse landfill
Biomass 0.5 MW Boiler / Steam Turbine	0.5	3.2	20	Haines Junction-sale of waste heat-beetle-kill biomass.
Other Non-Hydro Renewable				
Storage Battery: 4 MW, 40 MW.h (lead acid, 10hrs)	4.0	0.04	30	Whitehorse-Takhini substation & some use of adjacent land. (Two technology options noted).
Storage Battery: 8 MW/40 MWh (lithium ion, 5hrs)	8.0	0.04	30	
Solar PV: Whitehorse Fixed Tilt: 1 MW	1.0	1	30	Range of development scales at two potential locations with lowest LCOE of technologies examined (Whitehorse Copper Mine Quarry location, and Haines Junction location at about 1 km from dump). Evaluations focus on largest scale option at each location.
Solar PV: Whitehorse Fixed Tilt: 5 MW	5.0	5	30	
Solar PV: Whitehorse Fixed Tilt: 10 MW	10.0	10	30	
Solar PV: Haines Junction Fixed Tilt: 1 MW	1.0	1	30	
Solar PV: Haines Junction Fixed Tilt: 5 MW	5.0	5	30	
Wind: Cyprus Mine Hill, 20 MW	20.0	50	25	Seven preferred site options, each evaluated at largest scale examined (20 MW). Kluane site requires added transmission to grid (unless Aishihik-Destruction Bay Transmission Corridor is developed).
Wind: Kluane Lake, 20 MW	20.0	48	25	
Wind: Miller's Ridge, 20 MW	20.0	57	25	
Wind: Mt. Sumanik , 20 MW	20.0	42	25	
Wind: Sugarloaf Mountain, 20 MW	20.0	32	25	
Wind: Tehcho (Ferry Hill), 20 MW	20.0	33	25	
Wind: Thulsoo Mountain, 20 MW	20.0	54	25	
Geothermal: McArthur Springs (3.8 MW Av.)	3.8	25	30	Two site options. Scale of development shown in each case is average of potential range identified (need drilling to define).
Geothermal: Vista Mountain (1.6 MW Av.)	1.6	11	30	
Hydro Generation				
Pumped Storage: Moon Lake (Tutshi-Moon)	20.2	54	65	Eight preferred site options evaluated (two sites also have 2 scale options for development). Evaluations focus normally on site and largest option for that site (current initial estimates for land areas affected not typically sensitive to scale options at a site). Moon Lake option based on Midgard report, and Vangorda Pit option based on EP report (all other sites based on KP report). All sites other than Canyon-Ittlemit and Vangorda Pit require added transmission to connect to grid (unless relevant Transmission Corridor developed). Most sites are in B.C. (i.e., all except the last three listed).
Pumped Storage: Racine - Moon	15.0	50	65	
Pumped Storage: Lindeman-Fraser	15.0	50	65	
Pumped Storage: Racine - Mt. Brown	15.0	50	65	
Pumped Storage: Racine - Mt. Brown	25.0	100	65	
Pumped Storage: Atlin - Black Mountain	15.0	50	65	
Pumped Storage: Atlin - Black Mountain	25.0	100	65	
Pumped Storage: Squanga - Dalayee	25.0	100	65	
Pumped Storage: Canyon - Ittlemit	25.0	100	65	
Pumped Storage: Vangorda Pit	40.0	134	50-65	
Small Hydro: Drury Lake	8.1	32	65	Six preferred site options evaluated - each site has storage, except for Wolf River (run of river). Atlin/Pine Creek option is expansion of existing hydro site (Morrison Hershfield report) in B.C., with transmission connection needed to Yukon grid. Drury Lake and Anvil Creek are only site options not requiring added transmission to connect to grid (absent Transmission Corridor development).
Small Hydro: Tutshi - Windy Arm	7.2	57	65	
Small Hydro: Wolf River	20.0	96	65	
Small Hydro: Finlayson River	17.6	139	65	
Small Hydro: Anvil Creek	9.8	41	65	
Small Hydro: Atlin/Pine Creek	5.7	36.3 avail to Yukon	65	
Other Hydro: Gladstone Diversion	NA	37	65	Diverts waters into Aishihik existing hydro reservoir.
Other Hydro: Southern Lakes Storage	1.0	6	NA	Extends storage into fall for existing Whitehorse hydro.
Other Hydro: Mayo Lake Storage	NA	2 to 4	NA	Adds bottom storage for existing Mayo hydro.
Other Hydro: Mayo Dredging	NA	1 to 2	NA	Removes sediment built up in Mayo Lake Outlet Channel.
Aishihik Re-runnering	1.0	3	NA	Refurbishing existing hydro generation units at Aishihik and at Mayo.
Mayo A Refurbishment	2.3	10	65	
Transmission Corridors	Transfer Capacity			
Transmission: Whitehorse - Atlin (138 kV)	97	NA	45	Six options examined for transmission corridors (options are not tied to any specific loads or generation projects, but many would provide transmission connection for other generation resource options [wind or hydro generation]). The Stewart-Keno City option was recently recommended in YESAB Screening Report (replace end-of-life line and enhance overall voltage).
Transmission: Whitehorse - Skagway (230 kV)	443	NA	45	
Transmission: Whitehorse - Teslin (138 kV)	95	NA	45	
Transmission: Faro - Watson Lake (230 kV)	190	NA	45	
Transmission: Aishihik - Destruction Bay (230 kV)	484	NA	45	
Transmission: Stewart-Keno City (138 kV & substations)	NA	NA	45	

In order to simplify the evaluations, variations in technologies for a specific resource option and/or smaller scale development alternatives for a specific resource option are generally ignored in this report. Where new transmission is required to connect an option to the grid, this requirement is reflected in the assessment where feasible. In order to avoid variances related to different possible utilization levels and/or ownership options, all options are assumed to be fully utilized (with the potential exception of fossil fuel thermal generation) and to be developed by Yukon Energy. A weighted average cost of capital of 3.38% (net of inflation) reflective of Yukon Energy costs is assumed when reviewing Levelized Cost of Energy (LCOE) for different resource options over an option's economic life.

GIS mapping of resource options to assist in the evaluations was developed to the extent feasible and based on available Yukon Energy reports, which in most cases were preliminary initial assessments. Buffer areas were assumed in the land area assessments where appropriate. Best management practices (BMPs) were assumed for each resource option's construction and operation, and each option was examined assuming that feasibility planning and environmental/socio-economic impact assessment was not yet feasible (although hydro storage enhancement options, Mayo Lake Outlet Channel Dredging, Stewart-Keno City transmission, and Gladstone Diversion have each already been subject to extensive examinations as compared to most other options).

The resource options in Table 1 cover a wide range of energy and/or capacity scales, as well as varying energy attributes:

- Fossil fuel thermal generation options (Diesel and LNG) each provide firm capacity of 20 MW and a wide range of dispatchable energy generation options up to 166 GWh/yr.; economic life varies from 20 to 40 years depending on whether these options are used for backup generation (e.g., for peak, winter, emergency or drought periods), which tends to extend unit life versus regular annual full use of capacity which would imply a 20 year life. Current resource studies have not examined waste heat use options for fossil fuel thermal generation options.
- Non-fossil thermal generation options, as well as geothermal options are each relatively small:
    - Capacity ranges from 0.2 to 3.8 MW (Geothermal estimates are an average of potentials for each site).
    - Annual energy initial year generation ranges from 0.4 GWh/year (biogas) to 33.4 GWh/year (geothermal option at McArthur Springs), with economic lives from 20 to 30 years (biogas and biomass at 20 years, waste-to-energy at 25 years, geothermal at 30 years).
    - These options are assumed to run year round with high utilization; waste-to-energy and biomass option waste heat is assumed to be fully utilized to displace other heating fuels.
    - Geothermal net capability is enhanced in winter, and declines at about 2% per year over the economic life without drilling of additional maintenance wells. e.g., lifetime average annual generation approximates 75.6% of the initial year generation.

- Other renewable energy generation-related options show a wide range of installed capacity and annual energy generation:
    - Solar PV is relatively small (1.1 to 10.2 GWh/year with 1 to 10 MW), with energy focused from March to August and limited from November through February. Options have an assumed 30 year life.
    - Wind at 20 MW per site ranges from 32.3 to 57.3 GWh/year, depending on site attributes and an assumed 25 year life. One of the seven wind site options (i.e., Kluane) requires added transmission corridor development to connect with the grid.
    - Small hydro sites range from 31.7 to 138.9 GWh/year, reflecting installed capacity ranging from 5.7 to 20 MW per site; except for Wolf River (which is run-of-river), each site has storage (requires a dam), which allows energy to be focused in winter months. Options were constrained to 20 MW, and some sites, such as Wolf River and Finlayson River, could likely accommodate higher capacities and energy generation than assumed in this evaluation. All small hydro options have an assumed 65 year life. All but two of the six small hydro site options (i.e., all but Drury Lake and Anvil Creek) require added transmission corridor development to connect with the grid. The Atlin-Pine Creek small hydro site is in B.C.
    - Pumped storage hydro sites range from 50 to 134 GWh/year, reflecting installed capacity ranging from 15 to 40 MW; generation is focused in winter months. All pumped storage options have an assumed 65 year life. These options also each need adequate non-winter surplus energy for the required pumping during summer months. All but two of the eight pumped storage hydro site options (i.e., all but Vangorda Pit and Canyon-Ittlemit) require added transmission corridor development to connect with the grid. Five of the eight pumped storage hydro sites are in B.C.
    - Gladstone Diversion provides up to 36.6 GWh of winter energy and has an assumed 65 year life.
    - Other hydro projects, which range from 2 to 10 GWh/year, affect existing hydro operations, e.g., storage enhancements, channel dredging, refurbishments.
- Other resource options are not directly related to generation of energy:
    - The energy storage battery option would facilitate energy storage to support variable renewable generation, e.g., wind or solar generation. This option has an assumed 30 year economic life.
    - Transmission corridor development options would facilitate access to some of the hydro and wind generation sites, as well as potential new markets for renewable generation (e.g., Skagway cruise ships, new mine developments that otherwise would be supplied by fossil fuel generation, diesel generation communities that are not currently connected to the hydro grid). Transmission corridor options have an assumed 45 year economic life.

1.2 OVERVIEW OF EVALUATION APPROACH

The evaluation approach displays key differences among the resource options, rather than attempting an overall ranking of these options. Accordingly, separate summary evaluation matrix tables are provided for each of the three main sets of attributes (i.e., environmental, social, and economic), and each evaluation matrix table has a range of separate criteria and indicators to be addressed:

- Each evaluation matrix includes multiple criteria (five environmental criteria, five social criteria, and two economic criteria) to address different aspects of each attribute that are important.
- Multiple indicators are also included for each criteria (with only one exception), resulting in 16 environmental indicators, 17 social indicators (including one that is also a criteria) and 8 economic indicators.
- Each resource option is evaluated separately for each indicator adopted for each of the criteria.

Table 2 provides an overview of the criteria, indicators and metrics adopted for each of the three main evaluations (see Appendix B for added details).

Photos courtesy of InterGroup Consultants Ltd.

Table 2: Overview of Environmental, Social and Economic Evaluation Criteria, Indicators and Metrics

Evaluation of Resource Options - Environmental Criteria & Indicators

Aquatic Environment

Criteria	Fish & Fish Habitat (En1)			Water Quantity & Quality (En2)		
Indicators	Salmon & Habitat (En1-1)	Species at Risk & Habitat (En1-2)	Commercial, Recreational & Aboriginal Fisheries Species & Habitat (En1-3)	Consumptive Water Use (En2-1)	Relative Scale of New Impoundment / Flooding (En2-2)	Flow Changes (En2-3)
Metric	Presence or absence (Y/N) & Relative Impact (+/-)	Presence or absence (Y/N) & Relative Impact (+/-)	Presence or absence (Y/N) & Relative Impact (+/-)	Water Use Intensity (m^3/day)	Presence or absence (Y/N) & Relative Scale (L/MH)	Presence or absence (Y/N) & Relative Scale (L/MH)

Terrestrial Environment

Criteria	Terrestrial Species & Habitat (En3)				Terrestrial Footprint & Land Use (En4)			
Indicators	Species at Risk & Habitat (En3-1)	Protected & Conservation Areas (En3-2)	Wildlife Key Areas (En3-3)	Caribou Ranges (En3-4)	Footprint Terrestrial Area (En4-1)	Linear Dev for Roads / Transmission (En4-2)	Permafrost (En4-3)	Wetlands (En4-4)
Metric	Presence or absence (Y/N) & Relative Impact (+/-)	Proximity to Protected & Conservation Area (L/M/H)	Proximity to WKAs (L/M/H)	Proximity to Caribou Ranges (L/M/H)	Area of Terrestrial Footprint (km^2)	Total Length of Linear Features (km)	Presence or absence (Y/N) & Relative Scale (L/MH)	Presence or absence (Y/N) & Relative Scale (L/MH)

Air

Criteria	Air Quality (En5)		
Indicators	GHG Emissions (En5-1)		Other Air Pollutants (En5-2)
Metric	with Biogenic CO2 --intensity per kWh	without Biogenic CO2 - intensity per kW.h	intensity per kWh

Evaluation of Resource Options - Social Criteria & Indicators

Criteria	First Nation Lands (S1)	Traditional Lifestyle (S2)				Heritage Resources (S3)		Tourism, Recreation & Other Resources and Land Use (S4)						Cultural & Community Well-being (S5)		
Indicators	First Nation Settlement Lands / Interim Protected Lands (S1-1)	Footprint Land Area Impact (S2-1)	Land Area Loss Re: Traditional Lifestyle (S2-2)	Land Quality Effects on Traditional Lifestyle (S2-3)	Cabins, Camps & Structures (S2-4)	Country Foods (S2-4)	Density of Heritage Resources (S3-1)	Importance / Cultural Value of Heritage Resources (S3-2)	Recreational Values (S4-1)	Tourism Values (S4-2)	Aesthetics (S4-3)	Non-renewable Resources (S4-4)	Other Renewable Resources (S4-5)	Land Use & Renewable Resources Plans (S4-6)	Infrastructure & Services (S5-1)	Public Safety, Worker Interaction, Human & Community Health (S5-2)	Community, First Nation & Personal Development (S5-3)
Metric	Overlap and/or access with these lands (Y/Potential/N)	Total area (ha) of direct land use	Total area (ha) of Traditional Use land area loss	Indirect effects on land or access for such pursuits (+/-; L/M/H)	Number in footprint that may be affected	Effects to opportunity to harvest (+/-, L/M/H)	Density of known or potential heritage resources	Importance/ Cultural Value of resources & land area (L/M/H)	Effect on nature & scale of rec. values (+/-; L/M/H)	Effect on nature & scale of tourism values (+/-; L/M/H)	Effect on auditory or visual aesthetics (+/-; L/M/H)	Effect on non-renewable resources (+/-; L/M/H)	Effect on other renewable resources (+/-; L/M/H)	Consistent with Land Use & Renewable Resources Plans (Y/N/NA)	Effect on Infrastructure & Services (+/-; L/M/H)	Risks to Community Health & Safety const. & operation (L/M/H)	Effect on local jobs, business, training & development (L/M/H)

Evaluation of Resource Options - Economic Criteria & Indicators

Criteria	Local Economic Impacts (Ec1)			Climate Change Risk affecting Resource Financial Attributes (Ec2)				
Indicators	Yukon Opportunities During Construction (Ec1-1)	Yukon Opportunities during Operation (Ec1-2)	Community & Other Development Opportunity (Ec1-3)	Susceptible to Extreme Heat / Drought (Ec2-1)	Susceptible to Extreme Precipitation - flood / snow (Ec2-2)	Susceptible to Extreme Wind Events (Ec2-3)	Susceptible to Ice Related Processes / Events (Ec2-4)	Conditions Susceptible to Climate Change (Ec2-5)
Metric	Capital cost -civil & other local share (L/M/H)	Operating costs - Yukon labour & business opp. (L/M/H)	Community, industry development opp. (L/M/H)	Susceptibility (L/M/H)	Susceptibility (L/M/H)	Susceptibility (L/M/H)	Susceptibility (L/M/H)	Extent of permafrost in project footprint (L/M/H)

The overall objective of the evaluation approach is to identify on a common scale (low, medium, and high) which indicators are particularly relevant to each resource option. A high rating indicates that potential effects on an indicator are high for a specific resource option compared with the other resource options under review. A low rating indicates that potential effects on an indicator are low for a specific resource option compared with the other resource options under review. A medium rating indicates an evaluation that falls between the high and low ratings.

The evaluation approach involves criteria that address a diverse range of risks, benefits, and potential linkages with the resource options. The following examples demonstrate this range, and highlight the need to consider in each instance the nature of the indicator when interpreting the ratings of high, medium or low for different resource options:

- **Adverse Effects Indicators:** Many of the environmental and social criteria and indicators focus on potential risks of adverse effects on specific criteria and indicators, where a high or red rating means a high relative risk of an adverse effect, e.g., effects on fish and fish habitat, effects on terrestrial species and habitat, effects on air quality, effects on First Nation lands, effects on traditional lifestyle, effects on heritage resources, and some indicators related to cultural and community well-being. When rating adverse effects for a resource option on an indicator, red means a high rating, yellow means a medium rating, and green means a low rating.
- **Positive Effects Indicators:** Some social and economic indicators focus on potential beneficial effects on specific criteria and indicators, where a high rating means a high relative level of potential benefits, e.g., effects on criteria such as Local Economic Impacts and Community, First Nation and Personal Development. In this instance, a red colour rating as adopted for adverse effects indicators might suggest (incorrectly) that a high rating has adverse rather than positive effects, while a green colour rating to suggest "positive" outcomes could also be confusing given that green means low level effects when assessing adverse effects indicators. Accordingly, no colour rating is used for the few indicators that focus on positive effects and tables simply show the rating as high positive, medium positive or low positive.
- **Linkage/Overlap Effects Indicators:** Some environmental, social and economic criteria and indicators address overall magnitudes related to linkages or overlaps, where a high or red rating means a high level of linkage or overlap without directly addressing specific adverse or positive effects that may occur, e.g., footprint territorial area, footprints land area effect, linear development distances, flow changes, relative scale of impoundment/flooding.
- **No Linkage included as Low Rating:** For many resource options there is no linkage with various environmental indicators (or the indicator is not applicable to the resource option). A low or green rating includes these situations (thereby highlighting no basis for special attention in the future with regard to this indicator when pursuing the resource option).

At this initial stage of the resource option review, effects on any indicator are often best characterized as "potential" given the need to rely on existing information without project specific baseline or assessment studies to verify existing conditions as well as expected effects. For most resource options evaluated here, current information is at a preliminary level of assessment.

In assessing potential adverse or positive effects, the evaluation assumes adoption of well understood mitigation measures or best management practices to manage potential effects. However, to provide a common evaluation approach for all options, customized mitigation developed for a specific resource option is not considered even for the few options where more detailed studies and assessments have been carried out, e.g., Stewart-Keno City Transmission, Mayo Lake and Southern Lakes hydro storage enhancement projects. This is particularly relevant to understanding the evaluations of environmental criteria for the enhanced storage projects. Detailed explanations behind the ratings are provided in Appendix C (Table C 2-5, Table C 3-5 and Table C 4-8).[1]

Accordingly, a high or red rating related to potential adverse effects on an environmental or social indicator does not in any way signify that the resource option is infeasible. Such a rating only shows that these effects will need to be addressed and managed/mitigated in order for the project to proceed.

In summary, the ratings for the evaluation of each indicator are classified in terms of high, medium and low as follows (see also Figure 1):

- **High (red when non-positive and no colour when positive effect)** means the resource option has a high expected effects linkage to the indicator (depending on the indicator, the likely effects may be adverse, positive or simply signify linkage and/or overlap without much additional guidance);
- **Medium (yellow when non-positive and no colour when positive effect)** means the resource option has potential expected linkage to the indicator that falls between high and low ratings; and
- **Low (green when non-positive and no colour when positive effect)** means the resource option likely has minimal, if any, expected effects linkage to the indicator (again, depending on the indicator, any potential minimal effects may be adverse, positive or simply signify no linkage/overlap with the indicator, i.e., no effects pathway).

[1] See Appendix C, Page C-14 which notes that the evaluations in Table C 2-5 do not take into account the specific mitigation and adaptive management measures developed to date as a result of detailed environmental assessment studies. Notably, for Mayo Lake Enhanced Storage Yukon Energy's Yukon Environmental and Socio-economic Assessment Board submission set out measures to address potential adverse effects based on studies and ongoing work with the local First Nation.

Figure 1: Rating Criteria for Indicator Evaluations

High	Classification of high means the resource option has a high expected effects linkage to the indicator (depending on the indicator, the likely effects may be adverse, positive or simply signify linkage/overlap without much additional guidance). Red signifies a high rating for all non-positive effect indicators. • A red (high) rating related to potential adverse effects does not signify that the resource option is infeasible - such a rating only shows that these effects are high and will need to be addressed and managed/mitigated in order for the project to proceed. • No colour is used to signify a high rating related to potential positive effects. A high positive rating indicates that such effects for the resource option are high relative to the effects on the indicator from other options; associated with such a rating is a likely requirement to address specific benefit management or enhancement measures.
Medium	Classification of medium means the resource option has potential expected linkage to the indicator that falls between green (low) and red (high) ratings. Yellow signifies a medium rating for all non-positive effect indicators. • A yellow (medium) rating related to potential adverse effects indicates a likely need to proceed with caution and/or special attention to the management of certain potential adverse effects (without any determination today that a high expected effects linkage exists). • No colour is used to signify a medium rating related to potential positive effects. • In many evaluations of adverse effects, a yellow (medium) rating indicates a lack of information needed for a red (high) or green (low) rating.
Low	Classification of low means the resource option has minimal, if any, expected effects linkage to the indicator (again, depending on the indicator, any potential minimal effects may be adverse, positive, or simply signify no linkage/overlap with the indicator, i.e., no effects pathway). Green signifies a low rating for all non-positive effect indicators. • A green (low) rating related to potential adverse effects indicates that such effects are well understood and likely can be managed through best management practices or standard mitigation measures. • No colour rating is used to signify a low rating related to potential positive effects. A low positive rating indicates that such effects for the resource option are low relative to the effects on the indicator from other options, and unlikely to require special benefit management or enhancement measures. • A green (low) rating may also signify no linkage between the resource option and the indicator.

2.0 EVALUATION OF RESOURCE OPTIONS

2.1 OVERVIEW

Evaluations for each inventoried resource option are summarized separately below for the following three sets of criteria (see Table 2):

- **Environmental** criteria and indicators;
- **Social** criteria and indicators; and
- **Economic** criteria and indicators.

Evaluations are provided for each resource option and indicator, using the rating scheme outlined in Figure 1. The detailed evaluations are provided in Appendix C (Environmental), Appendix D (Social) and Appendix E (Economic).

2.2 ENVIRONMENTAL EVALUATION OF RESOURCE OPTIONS

Figure 2 provides the summary evaluation of the RP resource options for the environmental criteria and indicators, grouped by Aquatic Environment, Terrestrial Environment and Air. Within each of these three broad groupings, separate criteria are addressed:

- **Aquatic Environment:** Fish and Fish Habitat, and Water Quantity and Quality (the first criteria focuses on effects to selected indicators, the second criteria focuses on specific pathways for resource project effects to affect the aquatic environment).
- **Terrestrial Environment:** Terrestrial Species and Habitat, and Terrestrial Footprint and Land Use (the first criteria focuses on effects to selected indicators, the second criteria focuses on specific pathways for resource project effects to affect the terrestrial environment).
- **Air:** Greenhouse Gas (GHG) Emissions, and Other Air Pollutants.

All effects are rated adverse for the environmental criteria and indicators.

Summary by Criteria and Indicators

Red or yellow ratings in Figure 2 highlight resource options that have high or medium levels of adverse effects on an indicator. These ratings are summarized as follows:

- **Aquatic Environment**:
    - **Fish and Fish Habitat:** Red (high) and yellow (medium) adverse effect ratings occur only with hydro resource options that require modification to water regimes.
        - **Salmon and Habitat:** Red (high) rating for only one pumped storage option, yellow (medium) rating for only three small hydro options and one storage enhancement option.

- **Species at Risk and Habitat:** Red (high) rating for only one pumped storage option, yellow (medium) rating for only one small hydro option.
- **Commercial, Recreational and Aboriginal Fisheries Species and Habitat:** Red (high) rating for six of the eight pumped storage options, four of the six small hydro options, Gladstone Diversion and both of the storage enhancement options[2]; yellow (medium) rating for the two remaining pumped storage and two remaining small hydro options.

o **Water Quantity and Quality:** Red and yellow adverse effect ratings occur only with hydro resource options that require modification to water regimes.

- **New Impoundment/Flooding:** Red (high) rating for all eight pumped storage options and two small hydro options; yellow (medium) rating for two of the remaining five small hydro options.
- **Flow Changes:** Red (high) rating for Gladstone Diversion and both storage enhancement options[3]; yellow (medium) rating for all pumped storage and small hydro options.

- **Terrestrial Environment:**

o **Terrestrial Species and Habitat:** Red (high) and yellow (medium) ratings occur for many wind, hydro and transmission options and one geothermal option; a yellow (medium) rating also occurs with the biomass option.

- **Species at Risk and Habitat:** Red (high) rating for Gladstone Diversion and one hydro storage enhancement option; yellow (medium) rating for six of the seven wind options, seven of the eight pumped storage options, all small hydro options and one hydro storage enhancement option[4].
- **Protected and Conservation Areas:** Red (high) rating for one geothermal option, one pumped storage option, one hydro storage enhancement option[4] and one transmission option; yellow (medium) rating for one wind option, one pumped storage option, one small hydro option and one transmission option.
- **Wildlife Key Areas:** Red (high) rating for three wind options, one pumped storage option, Gladstone Diversion and one hydro storage enhancement option[4]; yellow (medium) rating for three of the four remaining wind options, all seven of the remaining pumped storage options, three small hydro options, all transmission options, one geothermal option and the biomass option.
- **Caribou Ranges:** Red (high) rating for only one transmission option; yellow (medium) rating for three wind options, one geothermal option, seven of the eight pumped storage options, three small hydro options and Gladstone Diversion.

[2] See Appendix C, Table C 2-5 which provides rationale for ratings for Southern Lakes and Mayo Lake.
[3] See Appendix C, Table C 3-5 which provides rationale for ratings for Southern Lakes and Mayo Lake.
[4] See Appendix C, Table C 4-8 which provides rationale for ratings for Southern Lakes.

- **Terrestrial Footprint and Land Use:** Red (high) and yellow (medium) ratings occur for many wind, hydro and transmission options and one geothermal option; a yellow (medium) rating also occurs for the largest solar PV option.
  - **Footprint Terrestrial Area:** Red (high) rating for all wind, pumped storage, small hydro and transmission options and for one geothermal option and Gladstone Diversion option; yellow (medium) rating for largest solar PV option.
  - **Linear Development for Roads/Transmission:** Red (high) rating for all transmission options; yellow (medium) rating for all wind options, one geothermal option, six pumped storage options, all small hydro options, and Gladstone Diversion option.
  - **Permafrost:** No red (high) rating; yellow (medium) rating for three pumped storage options, three transmission options, one small hydro option, and Gladstone Diversion option.
  - **Wetlands:** Red (high) rating for one hydro storage enhancement option; yellow (medium) rating for four pumped storage options and one small hydro option.

- **Air – Air Quality**:
  - **GHG Emissions:** Red (high) and yellow (medium) ratings limited to thermal generation options.
    - **With biogenic CO_2 emissions**: red (high) rating for all fossil and non-fossil thermal generation options.
    - **Excluding biogenic CO_2 emissions**: red (high) rating for all fossil generation options, yellow (medium) rating for waste-to-energy and biogas options.
  - **Other Air Pollutants**: No red (high) ratings; yellow (medium) ratings limited to thermal generation options and include all fossil and non-fossil thermal generation options.

Summary by Resource Options

Overall assessments are summarized below by indicator for each of the major sets of resource options:

1. **Fossil Thermal (Diesel and LNG in Whitehorse area):** Each of these resource options is rated as follows:
   a. Aquatic and Terrestrial criteria and indicators: green (low or no linkage);
   b. GHG Emissions Air Quality indicator: red (high); and
   c. Other Air Pollutants Air Quality indicator: yellow (medium).
2. **Non-Fossil Thermal (Waste-to-energy and Biogas in the Whitehorse area, and Biomass in the Haines Junction area):** Ratings for these resource options vary as follows:
   a. Aquatic and Terrestrial criteria and indicators:

- With the exception of wood biomass effects on Wildlife Key Areas, each of these resource options is rated green (low or no linkage) for all of the Aquatic and Terrestrial indicators.
- Wood biomass is rated yellow (medium) with respect to Wildlife Key Area effects to reflect potential effects of harvesting beetle-kill timber on key wildlife and related habitat, including moose winter range.

b. Air Quality criteria and indicators: These non-fossil thermal generation options are each rated as follows:

- GHG Emissions with biogenic CO_2 emissions: red (high);
- GHG Emissions without biogenic CO_2 emissions: yellow (medium) (waste-to-energy and biogas) or green (low) (biomass); and
- Other Air Pollutants: yellow (medium).

3. **Other Non-Hydro Renewable (Storage Battery in Whitehorse, Solar PV in Whitehorse and Haines Junction, Wind at seven different sites, and Geothermal at two sites):** Ratings for these resource options vary as follows:

a. Aquatic and Air Quality criteria and indicators:

- All of these resource options: green (low or no linkage).

b. Terrestrial criteria and indicators:

i. Terrestrial Species at Risk and Habitat

- Each wind site other than Tehcho: yellow (medium).
- Tehcho wind site, storage battery, solar PV (both sites), geothermal (both sites): green (low or no linkage).

ii. Protected and Conservation Areas

- McArthur Springs geothermal (reflects location within Ddhaw Ghro Habitat Protection Area): red (high).
- Kluane Lake (reflects proximity to Kluane National Park and Kluane Wildlife Sanctuary): yellow (medium).
- Each wind site other than Kluane Lake, storage battery, solar PV (both sites), geothermal at Vista Mountain: green (low or no linkage).

iii. Wildlife Key Areas

- Three wind sites (Kluane Lake, Mt. Sumanik, and Sugarloaf Mountain; see Appendix C, Table C 4-3 for specifics): red (high).
- Three wind sites (Miller's Ridge, Tehcho, and Thulsoo Mountain), McArthur Springs geothermal: yellow (medium).
- Cyprus Mine Hill wind site, storage battery, solar PV (both sites), Vista Mountain geothermal: green (low or no linkage).

iv. Caribou Range

- Three wind sites (Cyprus Mine Hill, Miller's Ridge, and Sugarloaf Mountain), McArthur Springs geothermal: yellow (medium).
- The remaining four wind sites, storage battery, solar PV (both sites), Vista Mountain geothermal: green (low or no linkage).

v. Total Terrestrial Footprint Areas

- Each wind site: red (high).
- Solar PV (10 MW at Whitehorse site): yellow (medium).
- Storage battery, solar PV (Haines Junction, 5 MW at Whitehorse), geothermal (both sites): green (low or no linkage).

vi. Linear Development Footprint

- Each wind site, McArthur Springs geothermal: yellow (medium).
- Storage battery, solar PV (both sites), Vista Mountain geothermal: green (low or no linkage).

vii. Permafrost and Wetlands indicators

- All wind sites, storage battery, solar PV (both sites), geothermal (both sites): green (low or no linkage).

4. **Hydro Generation (Pumped Storage at eight different sites, Small Hydro at six different sites, Other Hydro [Gladstone Diversion, two Storage Enhancement options, Mayo Lake Outlet Channel Dredging], and hydro refurbishment/re-runnering at Mayo A and Aishihik)** - All hydro options are rated green (low) for all Air Quality criteria and indictors. Hydro resource options rankings for Aquatic and Terrestrial indicators are summarized below (Hydro refurbishment/re-runnering and Mayo Lake Outlet Channel Dredging are each rated green [low or no linkage] for all of these indicators):

a. **Fish and Fish Habitat Indicators**

i. **Salmon and Habitat**

- Vangorda Pit pumped storage: red (high).
- Drury Lake, Wolf River and Anvil Creek small hydro, Southern Lakes Enhanced Storage: yellow (medium).
- All other hydro generation options: green (low or no linkage).

ii. **Species at Risk and Habitat**

- Squanga-Dalayee pumped storage: red (high) (due to presence of Squanga Whitefish).
- Finlayson River small hydro: yellow (medium).
- All other hydro generation options: green (low).

iii. **Commercial, Recreational and Aboriginal Fisheries Species and Habitat**

- All pumped storage options other than Moon Lake and Atlin-Black Mountain, all of the small hydro options other than Wolf River and Atlin/Pine Creek, and all of the Other Hydro options[5] other than Mayo Lake Outlet Channel Dredging: red (high).
- Moon Lake and Atlin-Black Mountain pumped storage, Wolf River and Atlin/Pine Creek small hydro: yellow (medium).
- Mayo Lake Outlet Channel Dredging: green (low or no linkage).

b. **Water Quantity and Quality indicators**

i. **Consumptive Water** - All hydro resource options have no linkage (green rating).

ii. **Relative Scale of New Impoundment/Flooding**

- All pumped storage options, Finlayson River and Anvil Creek small hydro and Gladstone Diversion: red (high).
- Drury Lake and Tutshi-Windy Arm small hydro: yellow (medium).
- All other hydro options are rated green (low or no linkage).

iii. **Flow Changes**

- Gladstone Diversion and the Storage Enhancement options (Mayo Lake and Southern Lakes): red (high).[5]
- All other pumped storage and small hydro options: yellow (medium).

c. **Terrestrial Species and Habitat indicators**

i. **Species at Risk and Habitat**

- Gladstone Diversion and Southern Lakes Enhanced Storage: red (high).[6]
- All pumped storage and small hydro site options other than Vangorda Pit, Mayo Lake Enhanced Storage: yellow (medium).
- Vangorda Pit pumped storage: green (low or no linkage).

ii. **Protected and Conservation Areas**

- Lindeman-Fraser pumped storage (Chilkoot Trail National Historic Site), Southern Lakes Enhanced Storage[6] (overlaps Lewes Marsh and Tagish Narrow Habitat Protection Areas: red (high).

[5] See Appendix C, Table C 2-5 and Table C 3-5. For Southern Lakes, changes to downstream flows are predicted to be over 20% higher in the late winter than historical flows. For Mayo Lake, changes to downstream flows are predicted on average to be over 20% higher in late winter/spring than flows without the enhancement (effects will vary for different years). Reductions of flows that occur during the summer are expected to be over 10% and perhaps slightly over 20% (depending on load conditions).
[6] See Appendix C, Table C 4-8. Project effects are primarily related to changes in water levels during different seasons or years.

- Squanga-Dalayee pumped storage and Wolf River small hydro: yellow (medium).
- All other hydro resource options: green (no linkage).

iii. **Wildlife Key Areas**

- Squanga-Dalayee pumped storage, Gladstone Diversion and Southern Lakes enhanced storage[6]: red (high).
- All other pumped storage options, all small hydro options other than Atlin/Pine Creek, and Mayo Lake enhanced storage: yellow (medium).
- Atlin/Pine Creek small hydro, Southern Lakes enhanced storage, Mayo Lake Outlet Channel Dredging, re-runnering/refurbishment options: green (low or no linkage).

iv. **Caribou Ranges**

- All pumped storage options other than Canyon-Ittlemit, three small hydro options (Tutshi-Windy Arm, Finlayson River and Anvil Creek) and Gladstone Diversion: yellow (medium).
- All other hydro options: green (low or no linkage).

d. **Terrestrial Footprint and Land Use Indicators**

i. **Footprint Terrestrial Area**

- All pumped storage and small hydro options, Gladstone Diversion: red (high).
- Other Hydro storage enhancements (Mayo and Marsh), Mayo Outlet Channel Dredging and the re-runnering/refurbishment options: green (low or no linkage).

ii. **Linear Development for Roads/Transmission**

- All small hydro options, all pumped storage options other than Moon Lake and Atlin-Black Mountain, Gladstone Diversion: yellow (medium).
- Moon Lake (Tutshi-Moon) and Atlin-Black Mountain pumped storage, the Other Hydro storage enhancements (Mayo and Marsh), Mayo Outlet Channel Dredging and the re-runnering/refurbishment options: green (low or no linkage).

iii. **Permafrost**

- Gladstone Diversion, Finlayson River small hydro, and three pumped storage options (Racine-Mt. Brown, Canyon-Ittlemit, and Vangorda Pit): yellow (medium).
- All other hydro options: green (low or no linkage).

iv. **Wetlands**

- Southern Lakes Enhanced Storage: red (high) (reflecting quality wetlands at the edges of this storage).
- Wolf River small hydro, and four pumped storage options (Moon Lake, Racine-Moon, Squanga-Dalayee, and Vangorda Pit): yellow (medium).
- All other hydro options: green (low or no linkage).

5. **Transmission Corridors (Six Transmission Corridor Options)** - These resource options are each rated green (low or no linkage) for all of the Aquatic and Air Quality criteria and indicators. The following are noted for Terrestrial ratings:

a. **Species at Risk and Habitat**: all transmission options rated green (low or no linkage).

b. **Protected and Conservation Areas**

- Aishihik-Destruction Bay (assumed use of Kluane National Park): red (high).
- Whitehorse-Atlin: yellow (medium).
- All other transmission options: green (low or no linkage).

c. **Wildlife Key Areas:** all transmission options rated yellow (medium).

d. **Caribou Ranges**

- Faro-Watson Lake: red (high).
- All other transmission options: green (low or no linkage).

e. **Footprint Terrestrial Area and Linear Development**: all transmission options rated red (high).

f. **Permafrost**

- Faro-Watson Lake, Aishihik-Destruction Bay, and Stewart-Keno City: yellow (medium).
- All other transmission options: green (low or no linkage).

g. **Wetlands**: all transmission options rated green (low or no linkage).

Photo courtesy of InterGroup Consultants Ltd.

Figure 2: Evaluation of RP Resource Options - Environmental Criteria & Indicators

High
Medium
Low

Resource Options	Aquatic Environment						Terrestrial Environment								Air	
	Fish & Fish Habitat (En1)			Water Quantity & Quality (En2)			Terrestrial Species & Habitat (En3)				Terrestrial Footprint & Land Use (En4)				Air Quality (En5)	
	Salmon & Habitat (En1-1)	Species at Risk & Habitat (En1-2)	Commercial, Recreational & Aboriginal Fisheries Species & Habitat (En1-3)	Consumptive Water Use (En2-1)	Relative Scale of New Impoundment / Flooding (En2-2)	Flow Changes (En2-3)	Species at Risk & Habitat (En3-1)	Protected & Consevation Areas (En3-2)	Wildlife Key Areas (En3-3)	Caribou Ranges (En3-4)	Footprint Terrestrial Area (En4-1)	Linear Dev for Roads / Transmission (En4-2)	Permafrost En4-3)	Wetlands (En4-4)	GHG Emissions (En5-1)[1]	Other Air Pollutants (En5-2)
															with Biogenic CO2	without Biogenic CO2
Fossil Thermal																
Diesel: 20 MW - Whitehorse					No Linkage	No Linkage		No Linkage	No Linkage	No Linkage		No Linkage				
Diesel: 20 MW - Takhini					No Linkage	No Linkage		No Linkage	No Linkage	No Linkage						
LNG: 20 MW - Whitehorse					No Linkage	No Linkage		No Linkage	No Linkage	No Linkage		No Linkage				
LNG: 20 MW - Takhini					No Linkage	No Linkage		No Linkage	No Linkage	No Linkage						
Non-Fossil Thermal																
Waste to Energy					No Linkage	No Linkage		No Linkage	No Linkage	No Linkage		No Linkage				
Biogas (CHP)					No Linkage	No Linkage		No Linkage	No Linkage	No Linkage		No Linkage				
Biomass 0.5 MW Boiler / Steam Turbine	No Linkage	No Linkage	No Linkage		No Linkage	No Linkage						No Linkage				
Other Non-Hydro Renewable																
Storage Battery: 8 MW/40 MWh (lithium ion, 5hrs)	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage		No Linkage		No Linkage		No Linkage		No Linkage		
Solar PV: Whitehorse Fixed Tilt: 10 MW	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage		No Linkage	No Linkage	No Linkage		No Linkage				
Solar PV: Haines Junction Fixed Tilt: 5 MW	No Linkage	No Linkage		No Linkage	No Linkage	No Linkage				No Linkage		No Linkage				
Wind: Cyprus Mine Hill, 20 MW	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage		No Linkage								
Wind: Kluane Lake, 20 MW	No Linkage	No Linkage		No Linkage	No Linkage	No Linkage				No Linkage						
Wind: Millers Ridge, 20 MW		No Linkage		No Linkage	No Linkage	No Linkage		No Linkage								
Wind: Mt. Sumanik , 20 MW	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage		No Linkage		No Linkage						
Wind: Sugarloaf Mountain, 20 MW	No Linkage	No Linkage		No Linkage	No Linkage	No Linkage		No Linkage								
Wind: Tehcho (Ferry Hill), 20 MW		No Linkage		No Linkage	No Linkage	No Linkage				No Linkage						
Wind: Thulsoo Mountain, 20 MW	No Linkage	No Linkage		No Linkage	No Linkage	No Linkage		No Linkage		No Linkage						
Geothermal: McArthur Springs (3.8 MW Av.)	No Linkage	No Linkage		No Linkage	No Linkage	No Linkage										
Geothermal: Vista Mountain (1.6 MW Av.)				No Linkage	No Linkage	No Linkage		No Linkage	No Linkage	No Linkage						
Hydro Generation																
Pumped Storage: Moon Lake (Tutshi-Moon)	No Linkage	No Linkage		No Linkage				No Linkage								
Pumped Storage: Racine - Moon	No Linkage	No Linkage		No Linkage				No Linkage								
Pumped Storage: Lindeman-Fraser	No Linkage	No Linkage		No Linkage												
Pumped Storage: Racine - Mt. Brown	No Linkage	No Linkage		No Linkage				No Linkage								
Pumped Storage: Atlin - Black Mountain	No Linkage	No Linkage		No Linkage				No Linkage								
Pumped Storage: Squanga - Dalayee	No Linkage			No Linkage												
Pumped Storage: Canyon - Ittlemit	No Linkage	No Linkage		No Linkage				No Linkage		No Linkage						
Pumped Storage: Vangorda Pit		No Linkage		No Linkage				No Linkage								
Small Hydro: Drury Lake		No Linkage		No Linkage				No Linkage	No Linkage							
Small Hydro: Tutshi - Windy Arm	No Linkage	No Linkage		No Linkage				No Linkage								
Small Hydro: Wolf River		No Linkage		No Linkage	No Linkage											
Small Hydro: Finlayson River	No Linkage			No Linkage				No Linkage								
Smally Hydro: Anvil Creek		No Linkage		No Linkage				No Linkage								
Small Hydro: Atlin/Pine Creek	No Linkage	No Linkage		No Linkage				No Linkage	No Linkage							
Other Hydro: Gladstone Diversion	No Linkage	No Linkage		No Linkage				No Linkage								
Other Hydro: Southern Lakes Storage		No Linkage		No Linkage							No Linkage		No Linkage			
Other Hydro: Mayo Lake Storage		No Linkage		No Linkage				No Linkage		No Linkage	No Linkage		No Linkage	No Linkage		
Other Hydro: Mayo Dredging	No Linkage	No Linkage		No Linkage	No Linkage	No Linkage		No Linkage	No Linkage	No Linkage			No Linkage	No Linkage		
Aishihik Re-runnering	No Linkage	No Linkage		No Linkage	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage					
Mayo A Refurbishment	No Linkage	No Linkage		No Linkage	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage	No Linkage					
Transmission Corridors																
Transmission: Whitehorse - Atlin (138 kV)		No Linkage		No Linkage	No Linkage	No Linkage										
Transmission: Whitehorse - Skagway (230 kV)		No Linkage		No Linkage	No Linkage	No Linkage		No Linkage								
Transmission: Whitehorse - Teslin (138 kV)				No Linkage	No Linkage	No Linkage										
Transmission: Faro - Watson Lake (230 kV)				No Linkage	No Linkage	No Linkage		No Linkage								
Transmission: Aishihik - Destruction Bay (230 kV)	No Linkage	No Linkage		No Linkage	No Linkage	No Linkage										
Transmission: Stewart-Keno City (138 kV & substations)				No Linkage	No Linkage	No Linkage				No Linkage						

1. GHG Emissions considers Global Warming Potential (GWP) for each option for both 20-year and 100-year time horizons

2.3 SOCIAL EVALUATION OF RESOURCE OPTIONS

Figure 3 provides the summary evaluation of the RP resource options for the social criteria and indicators, building on the outcomes of the environmental evaluations.

- The first three groupings of criteria and indicators focus on First Nations, traditional lifestyle and heritage resources potential effects from the resource options.
- The last two groupings of criteria and indicators focus on a broader range of potential social effects.

Except for Community, First Nation and Personal Development (for which effects are rated positive), all effects are rated adverse for the social criteria and indicators.

Summary by Criteria and Indicators

Red or yellow ratings in Figure 3 highlight resource options that have high or medium levels of adverse effects on an indicator. High and medium adverse and positive ratings are summarized as follows:

- **First Nation Lands:** Red (high) and/or yellow (medium) ratings occur for all transmission options, many of the hydro options that modify water regimes, and some of the wind options; yellow ratings occur for both geothermal options and one of the fossil thermal site options.
    - **First Nation Settlement Lands/Interim Protected Lands:** Red (high) rating for three transmission options, three pumped storage options, three small hydro options, two wind options, one of the hydro storage enhancement options, and the Gladstone Diversion option; yellow (medium) rating for remaining transmission options, two of three remaining small hydro options, two of the remaining five pumped storage options, both geothermal options, one wind option, and the Takhini fossil thermal site option.
- **Traditional Lifestyle:** Red (high) and yellow (medium) ratings occur for most of the non-thermal options for total footprint areas impacted, but are limited to only a few hydro options and one transmission option for all other indicators.
    - **Footprint Land Area Impact:**[7] Red (high) rating for all transmission options, all pumped storage options, five of six small hydro options, six of seven wind options, one geothermal option, Gladstone Diversion and both hydro storage enhancement options; yellow (medium) rating for the remaining small hydro, geothermal and wind options and both solar PV options.
    - **Land Area Loss regarding Traditional Lifestyle:** No red (high) ratings; yellow (medium) rating for only one pumped storage option and one small hydro option.

[7] See Page D-8. Footprint Land Area Impact is a quantitative metric that considers only direct land loss. The total footprint or land area affected may not be permanently lost for the purposes of traditional lifestyle activities. This indicator is used only as background information and is not directly adopted for the assessment of effects on the Land Quality Effects on Traditional Lifestyle. The rating criteria were selected simply to help assign resource project options to clearly separate groups based on the indicator.

- **Land Quality Effects on Traditional Lifestyle:** No red (high) ratings; yellow (medium) rating for only one pumped storage option, one small hydro option, Gladstone Diversion and one hydro storage enhancement option.
- **Cabins, Camps and Structures:** A red (high) rating for one hydro storage enhancement option and a yellow (medium) rating for only one transmission option.
- **Country Foods:** A red (high) rating for Gladstone Diversion; yellow (medium) rating for only one pumped storage option and one small hydro option.

- **Heritage Resources:** Red (high) ratings are limited to only two hydro options; yellow (medium) ratings occur for many of the non-thermal options.
  - **Density of Heritage Resources:** Red (high) rating for one pumped storage option and one hydro storage enhancement option; yellow (medium) rating for three pumped storage options, four small hydro options, five transmission options, and Gladstone Diversion.
  - **Importance/Cultural Value of Heritage Resources:** No red (high) ratings; yellow (medium) rating for five wind options, three pumped storage options, two small hydro option, one geothermal option, one transmission option, Gladstone Diversion, and one hydro storage enhancement option.
- **Tourism, Recreation and Other Resources and Land Use:** Red (high) and yellow (medium) ratings occur for many hydro options with water regime changes, many of the wind options, one geothermal option, and the biomass option.
  - **Recreational Values:** Red (high) rating for four pumped storage options, and five small hydro options; yellow (medium) rating for three wind options, one geothermal option, one of the four remaining pumped storage options, the one remaining small hydro option, and Gladstone Diversion.
  - **Tourism Values:** Red (high) rating for three small hydro options; yellow (medium) rating for two wind options, one geothermal option, five pumped storage options, and two of the three remaining small hydro options.
  - **Aesthetics:** Red (high) rating for one geothermal option and one small hydro option; yellow (medium) rating for biomass option, four wind options, four pumped storage options, two small hydro options, and Gladstone Diversion.
  - **Non-renewable Resources:** Red (high) rating for one small hydro option; yellow (medium) rating for one wind option, one geothermal option, five pumped storage options, two small hydro option and Gladstone Diversion.
  - **Other Renewable Resources:** No red (high) ratings; one yellow (medium) rating (for one geothermal option).
  - **Land Use and Renewable Resource Plans:** Red (high) rating for three pumped storage options and one geothermal option; yellow (medium) rating for biomass option, three wind options, four of the five remaining pumped storage options, five of the six small hydro options, and Gladstone Diversion.

- **Culture and Community Well-being:** Red (high) adverse effects ratings occur for all pumped storage and small hydro options; yellow (medium) adverse effects ratings occur for most wind options, one geothermal option, and Gladstone Diversion; high and medium positive effects ratings occur for all transmission options, all pumped storage and small hydro options, most wind options, and Gladstone Diversion; medium positive effects ratings occur for one geothermal option and thermal options other than diesel.
    - **Infrastructure and Services:** Red (high) rating for all pumped storage and small hydro options; yellow (medium) rating for six of the seven wind options, one geothermal option, and Gladstone Diversion.
    - **Public Safety, Worker Interaction, Human and Community Health:** Red (high) rating for all pumped storage and small hydro options; yellow (medium) rating for six of the seven wind options, one geothermal option, and Gladstone Diversion.
    - **Community, First Nation and Personal Development:** High positive effects rating for three transmission options, five pumped storage options, four small hydro options, two wind options, and Gladstone Diversion; medium positive effects rating for the three remaining transmission options, the three remaining pumped storage option, the two remaining small hydro options, four of the five remaining wind options, one geothermal option, all non-fossil thermal options, and the LNG fossil thermal options.

Summary by Resource Options

Overall assessments are summarized below by indicator for each of the major sets of resource options:

1. **Fossil Thermal (Diesel and LNG in Whitehorse area):** Each of these resource options is rated green (low) or low positive for all of the social criteria and indicators, except for the following yellow or medium positive ratings:
    a. **First Nation Settlement Lands:** The Takhini substation site is rated yellow (medium), reflecting proximity of such lands to the site and possible transmission access routing.
    b. **Community, First Nation and Personal Development:** The LNG options are rated medium positive, reflecting medium benefit opportunity to facilitate LNG use to displace other fossil fuel use in Whitehorse/Yukon.[8]
2. **Non-Fossil Thermal (Waste-to-energy and Biogas in the Whitehorse area and Biomass in the Haines Junction area):** Each of these resource options is rated green (low) for all of the social criteria and indicators, except for the following yellow or medium positive ratings:
    a. **Aesthetics:** A yellow (medium) rating for the biomass option at Haines Junction, reflecting siting near school as well as commercial and residential areas.
    b. **Land Use and Renewable Resource Plans:** A yellow (medium) rating for the biomass option at Haines Junction, reflecting anticipated need for some zoning variance.

[8] See Appendix D, Page D 6-4 which notes that by comparison diesel has no specific local development opportunities.

c. **Community, First Nation and Personal Development:** A medium positive rating for each of these options, reflecting medium local benefit opportunity to use renewable energy and (except for biogas) and to supply waste heat to displace fossil fuel use.

3. **Other Non-hydro Renewable (Storage Battery in Whitehorse, Solar PV in Whitehorse and Haines Junction, Wind at seven different sites, and Geothermal at two sites):** The storage battery option is rated green (low) or low positive for all social criteria and indicators, and the solar PV option at both sites is also rated green (low) or low positive for all social criteria and indicators other than Footprint Land Area Impact, where it is rated yellow (medium).[9]

   Other non-hydro renewable resource options (wind and geothermal) display common rankings for some of the social indicators, but also display variances. Detailed review of the evaluations for these options is provided below:

   a. **First Nation Settlement Lands/ Interim Protected Lands**

      - Kluane Lake and Sugarloaf Mountain wind options: red (high).
      - Wind option at Miller's Ridge and both geothermal options: yellow (medium).
      - All remaining wind sites: green (low).

   b. **Traditional Lifestyle**

      i. **Footprint Land Area Impact**

         - All wind options other than Kluane Lake, and Vista Mountain geothermal: red (high).[10]
         - Kluane Lake wind option and Vista Mountain geothermal: yellow (medium).

      ii. **Other Traditional Lifestyle Indicators:** All other traditional lifestyle indicators are rated green for all wind and geothermal options.

   c. **Heritage Resources**

      i. **Density of Heritage Resources**

         - All wind and geothermal options are rated green (low).

      ii. **Importance/Cultural Value of Heritage Resources**

         - All wind options other than Cyprus Mine Hill and Kluane Lake and the geothermal option at McArthur Springs: yellow (medium).
         - Cyprus Mine Hill and Kluane Lake wind options and the geothermal option at Vista Mountain: green (low).

   d. **Tourism, Recreation and Other Resources and Land Use:** Variances among these indicators are summarized as follows for wind and geothermal resource options:

[9] See Appendix D, Table D 3-2 for explanation of rating for Solar PV in Whitehorse compared to Haines Junction.
[10] See Appendix D, Table D 3-2 for explanation of rating for Kluane Wind Project compared to other wind projects.

i. **Recreational Values**

- Thulsoo Mountain, Miller's Ridge, and Kluane Lake wind farms, McArthur Springs geothermal: yellow (medium).
- Cyprus Mine Hill, Sugarloaf Mountain, Tehcho, and Mt. Sumanik wind farms; Vista Mountain geothermal: green (low).

ii. **Tourism Values**

- Miller's Ridge and Kluane Lake wind farms, McArthur Springs geothermal: yellow (medium).
- Cyprus Mine Hill, Sugarloaf Mountain, Tehcho, Mt. Sumanik, and Thulsoo wind farms, Vista Mountain geothermal: green (low).

iii. **Aesthetics**

- McArthur Springs geothermal: red (high).
- Thulsoo Mountain, Miller's Ridge, Kluane Lake, Sugarloaf Mountain wind farms: yellow (medium).
- Cyprus Mine Hill, Mt. Sumanik, Tehcho wind farms; Vista Mountain geothermal: green (low).

iv. **Non-Renewable Resources**

- Thulsoo Mountain, McArthur Springs geothermal: yellow (medium).
- Cyprus Mine Hill, Mt. Sumanik, Tehcho, Kluane Lake, and Miller's Ridge wind farms, Vista Mountain geothermal: green (low).

v. **Other Renewable Resources**

- McArthur Springs: yellow (medium).
- All wind options and Vista Mountain geothermal: green (low).

vi. **Land Use and Renewable Resources Plans**

- McArthur Springs geothermal: red (high) (located in protected area).
- Thulsoo Mountain, Miller's Ridge, Sugarloaf Mountain wind farms: yellow (medium).
- Cyprus Mine Hill, Tehcho, and Mt. Sumanik wind farms, Vista Mountain geothermal: green (low).

e. **Cultural and Community Well-being**

i. **Infrastructure and Services**

- All wind options other than Mt. Sumanik, McArthur Springs geothermal: yellow (medium).
- Mt. Sumanik wind option, Vista Mountain geothermal: green (low).

ii. **Public Safety, Worker Interaction, Human and Community Health**

- All wind options other than Mt. Sumanik, McArthur Springs geothermal: yellow (medium).
- Mt. Sumanik wind option, Vista Mountain geothermal: green (low).

iii. **Community, First Nation and Personal Development**

- Kluane Lake and Sugarloaf Mountain wind options: high positive (high benefit potential reflects the need to secure agreements with First Nations for use of settlement lands for each wind farm site).
- All wind options other than Mt. Sumanik, Kluane Lake and Sugarloaf Mountain; McArthur Springs geothermal: medium positive.
- Mt. Sumanik wind option and Vista Mountain geothermal: low positive.

4. **Hydro Generation (Pumped Storage at eight different sites, Small Hydro at six different sites, Other Hydro [Gladstone Diversion, two Storage Enhancement options, Mayo Outlet Channel Dredging], and hydro refurbishment/re-runnering at Mayo A and Aishihik):** Hydro refurbishment/re-runnering and Mayo Lake Outlet Channel Dredging are each rated green (low) or low positive for each of the social criteria and indicators, and Mayo Lake Storage Enhancement is rated green (low) or low positive for all of these same indicators other than Footprint Land Area Impact (where the rating is not relevant as it reflects lake water area, i.e., the resource option at most lowers average lake levels and does not impact new land areas).

   Other hydro generation resource options display common rankings for some of the social indicators, but also display variances as noted below:

   a. **First Nation Settlement Lands/Interim Protected Lands:** These evaluations include consideration of new road and transmission access requirements for these hydro resource options.

      - Three pumped storage options (Squanga-Dalayee, Canyon-Ittlemit, Vangorda Pit), three small hydro options (Wolf River, Finlayson River, and Anvil Creek), Gladstone Diversion, and Southern Lakes Enhanced Storage: red (high).
      - Two pumped storage options (Racine-Mt. Brown and Atlin-Black Mountain) and two small hydro options (Drury Lake and Atlin/Pine Creek): yellow (medium).
      - Remaining hydro generation options: green (low).

   b. **Traditional Lifestyle**

      i. **Footprint Land Area Impact**

      - All pumped storage options, all small hydro other than Tutshi-Windy Arm, Gladstone Diversion, both enhanced storage options (Southern Lakes, Mayo Lake): red (high).
      - Tutshi-Windy Arm small hydro: yellow (medium).

- Aishihik re-runnering, Mayo A refurbishment: green (low).

ii. **Land Area Loss regarding Traditional Lifestyle**

- Vangorda Pit pumped storage, Finlayson River small hydro: yellow (medium).
- All other hydro options: green (low).

iii. **Land Quality Effects on Traditional Lifestyle**

- Canyon-Ittlemit pumped storage, Finlayson River small hydro, Gladstone Diversion, Southern Lakes enhanced storage: yellow (medium).
- All other hydro options: green (low).

iv. **Cabins, Camps and Structures**

- Southern Lakes enhanced storage: red (high).
- All other hydro options: green (low).

v. **Country Foods**

- Gladstone Diversion: red (high).
- Squanga-Dalayee pumped storage, Finlayson River small hydro: yellow (medium).
- All other hydro options: green (low).

c. Heritage Resources

i. **Density of Heritage Resources**

- Atlin-Black Mountain pumped storage and Southern Lakes Enhanced Storage: red (high).
- Three pumped storage options (Lindeman-Fraser, Squanga-Dalayee, Canyon-Ittlemit), four small hydro options (Tutshi-Windy Arm, Finlayson River, Anvil Creek and Atlin/Pine Creek), and Gladstone Diversion: yellow (medium).
- All other hydro options: green (low).

ii. **Importance/Cultural Value of Heritage Resources**

- Three pumped storage options (Lindeman-Fraser, Squanga-Dalayee, and Canyon-Ittlemit), Finlayson River and Anvil Creek small hydro, Gladstone Diversion, and Southern Lakes Enhanced Storage: yellow (medium).
- All other hydro options: green (low).

d. **Tourism, Recreation and Other Resources and Land Use**

i. **Recreational Values**

- Four pumped storage options (Racine-Moon, Racine-Mt. Brown, Squanga-Dalayee, Canyon-Ittlemit) and five small hydro (Drury Lake,

Tutshi-Windy Arm, Finlayson River, Anvil Creek, and Atlin-Pine Creek): red (high).

- Lindeman-Fraser pumped storage, Wolf River small hydro, Gladstone Diversion: yellow (medium).
- Three pumped storage options (Vangorda Pit, Moon Lake [Tutshi-Moon], Atlin-Black Mountain), storage enhancements (Southern Lakes, Mayo Lake), Mayo Lake Outlet dredging, Aishihik re-runnering, Mayo A refurbishing: green (low).

ii. **Tourism Values**

- Three small hydro options (Drury Lake, Finlayson River, and Atlin/Pine Creek): red (high).
- Five pumped storage options (Racine-Moon, Lindeman-Fraser, Racine-Mt. Brown, Squanga-Dalayee, Canyon-Ittlemit), Wolf River and Anvil Creek small hydro: yellow (medium).
- Vangorda Pit, Moon Lake (Tutshi-Moon), Atlin-Black Mountain, storage enhancements (Southern Lakes, Mayo Lake), Mayo Lake Outlet dredging, Aishihik re-runnering, Mayo A refurbishing: green (low).

iii. **Aesthetics**

- Atlin/Pine Creek small hydro: red (high).
- Four pumped storage options (Moon Lake [Tutshi-Moon], Lindeman-Fraser, Squanga-Dalayee, Canyon-Ittlemit), Wolf River and Anvil Creek small hydro, Gladstone Diversion: yellow (medium).
- Vangorda Pit, Racine-Mt Brown, Racine-Moon, Atlin Black Mountain, storage enhancements (Southern Lakes, Mayo Lake), Mayo Lake Outlet dredging, Aishihik re-runnering, Mayo A refurbishing: green (low).

iv. **Non-renewable Resources**

- Atlin/Pine Creek small hydro: red (high).
- Three pumped storage options (Moon Lake [Tutshi-Moon], Racine-Moon, Racine-Mt. Brown), Finlayson River and Anvil Creek small hydro, Gladstone Diversion: yellow (medium).
- Vangorda Pit, Lindeman Fraser, Atlin-Black Mountain, Squang-Dalayee, Canyon-Ittlemit, storage enhancements (Southern Lakes, Mayo Lake), Mayo Lake Outlet dredging, Aishihik re-runnering, Mayo A refurbishing: green (low).

v. **Other Renewable Resources**

- All hydro options: green (low).

vi. **Land Use and Renewable Resources Plans**

- Three pumped storage options (Racine-Moon, Racine-Mt. Brown, Atlin-Black Mountain): red (high).
- Four pumped storage options (Moon Lake [Tutshi-Moon], Lindeman-Fraser, Squanga-Dalayee, Canyon-Ittlemit), all small hydro options other than Atlin/Pine Creek, Gladstone Diversion: yellow (medium).
- Vangorda Pit pumped storage, Atlin/Pine Creek small hydro, storage enhancements (Southern Lakes, Mayo Lake), Mayo Lake Outlet dredging, Aishihik re-runnering, Mayo A refurbishing: green (low).

e. **Cultural and Community Well-being**:

i. **Infrastructure and Services**

- All pumped storage and small hydro options: red (high).
- Gladstone Diversion: yellow (medium).
- Storage enhancements (Southern Lakes, Mayo Lake), Mayo Lake Outlet dredging, Aishihik re-runnering, Mayo A refurbishing: green (low).

ii. **Public Safety, Worker Interaction, Human and Community Health**

- All pumped storage and small hydro options: red (high).
- Gladstone Diversion: yellow (medium).
- Storage enhancements (Southern Lakes, Mayo Lake), Mayo Lake Outlet dredging, Aishihik re-runnering, Mayo A refurbishing: green (low).

iii. **Community, First Nation and Personal Development**

- Five pumped storage options (Lindeman-Fraser, Atlin-Black Mountain, Moon Lake [Tutshi-Moon], Racine-Moon, Racine-Mt. Brown), all small hydro options other than Drury Lake and Anvil Creek, Gladstone Diversion (potential benefit arrangements with First Nations): high positive (indicating high potential benefits).
- Three pumped storage options (Squanga-Dalayee, Canyon-Ittlemit, and Vangorda Pit) and two small hydro options (Drury Lake and Anvil Creek): medium positive.
- Storage enhancements (Southern Lakes, Mayo Lake), Mayo Lake Outlet dredging, Aishihik re-runnering, Mayo A refurbishing: low positive.

5. **Transmission Corridors (Six Transmission Corridor Options)**

a. **First Nation Lands**

- Whitehorse-Atlin, Whitehorse-Skagway, Whitehorse-Teslin options: red (high).
- Remaining three options: yellow (medium).

b. **Traditional Lifestyle**

   i. **Footprint Land Area Impact:** all options rated red (high) (this indicator simply reflects total areas and does not address Traditional Lifestyle effects directly).

   ii. **All Other Traditional Lifestyle Indicators**

   - Whitehorse-Skagway: yellow (medium) for Cabins, Camps and Structures.
   - All other transmission options and indicators: green (low).

c. **Heritage Resources**

   i. **Density of Heritage Resources**

   - Faro-Watson Lake transmission option: green (low).
   - All transmission options other than Faro-Watson Lake: yellow (medium).

   ii. **Importance/Cultural Value of Heritage Resources**

   - Whitehorse-Skagway transmission option: yellow (medium).
   - All transmission options other than Whitehorse-Skagway: green (low).

d. **Tourism, Recreation and Other Resources and Land Use** - all transmission options are rated green (low) for all indicators.

e. **Cultural and Community Well-being**

   i. **Infrastructure and Services** – green (low) of all transmission options.

   ii. **Public Safety, Worker Interaction, Human and Community Health**: green (low) of all transmission options.

   iii. **Community, First Nation and Personal Development**

   - Faro-Watson Lake, Aishihik-Destruction Bay, and Stewart-Keno City transmission options: high positive (indicating high potential benefits).
   - Whitehorse-Atlin, Whitehorse-Skagway, Whitehorse-Teslin transmission options: medium positive.

Photo courtesy of: InterGroup Consultants Ltd.

Figure 3: Evaluation of RP Resource Options - Social Criteria & Indicators

High
Medium
Low

Resource Options	First Nation Lands (S1)	Traditional Lifestyle (S2)					Heritage Resources (S3)		Tourism, Recreation & Other Resources and Land Use (S4)						Cultural & Community Well-being (S5)		
	First Nation Settlement Lands/ Interim Protected Lands (S1-1)	Footprint Land Area Impact (S2-1)	Land Area Loss Re: Traditional Lifestyle (S2-2)	Land Quality Effects on Traditional Lifestyle (S2-3)	Cabins, Camps & Structures (S2-4)	Country Foods (S2-4)	Density of Heritage Resources (S3-1)	Importance/ Cultural Value of Heritage Resources (S3-2)	Recreational Values (S4-1)	Tourism Values (S4-2)	Aesthetics (S4-3)	Non-renewable Resources (S4-4)	Other Renewable Resources (S4-5)	Land Use & Renewable Resources Plans (S4-6)	Infrastructure & Services (S5-1)	Public Safety, Worker Interaction, Human & Community Health (S5-2)	Community, First Nation & Personal Development (S5-3) Positive Effects
Fossil Thermal																	
Diesel: 20 MW - Whitehorse																	Low Positive
Diesel: 20 MW - Takhini																	Low Positive
LNG: 20 MW - Whitehorse																	Medium Positive
LNG: 20 MW - Takhini																	Medium Positive
Non-Fossil Thermal																	
Waste to Energy																	Medium Positive
Biogas (CHP)																	Medium Positive
Biomass 0.5 MW Boiler / Steam Turbine																	Medium Positive
Other Non-Hydro Renewable																	
Storage Battery: 8 MW/40 MWh (lithium ion, 5hrs)																	Low Positive
Solar PV: Whitehorse Fixed Tilt: 10 MW																	Low Positive
Solar PV: Haines Junction Fixed Tilt: 5 MW																	Low Positive
Wind: Cyprus Mine Hill, 20 MW																	Medium Positive
Wind: Kluane Lake, 20 MW																	High Positive
Wind: Millers Ridge, 20 MW																	Medium Positive
Wind: Mt. Sumanik , 20 MW																	Low Positive
Wind: Sugarloaf Mountain, 20 MW																	High Positive
Wind: Tehcho (Ferry Hill), 20 MW																	Medium Positive
Wind: Thulsoo Mountain, 20 MW																	Medium Positive
Geothermal: McArthur Springs (3.8 MW Av.)																	Medium Positive
Geothermal: Vista Mountain (1.6 MW Av.)																	Low Positive
Hydro Generation																	
Pumped Storage: Moon Lake (Tutshi-Moon)																	High Positive
Pumped Storage: Racine - Moon																	High Positive
Pumped Storage: Lindeman-Fraser																	High Positive
Pumped Storage: Racine - Mt. Brown																	High Positive
Pumped Storage: Atlin - Black Mountain																	High Positive
Pumped Storage: Squanga - Dalayee																	Medium Positive
Pumped Storage: Canyon - Ittlemit																	Medium Positive
Pumped Storage: Vangorda Pit																	Medium Positive
Small Hydro: Drury Lake																	Medium Positive
Small Hydro: Tutshi - Windy Arm																	High Positive
Small Hydro: Wolf River																	High Positive
Small Hydro: Finlayson River																	High Positive
Small Hydro: Anvil Creek																	Medium Positive
Small Hydro: Atlin/Pine Creek																	High Positive
Other Hydro: Gladstone Diversion																	High Positive
Other Hydro: Southern Lakes Storage																	Low Positive
Other Hydro: Mayo Lake Storage																	Low Positive
Other Hydro: Mayo Dredging																	Low Positive
Aishihik Re-runnering																	Low Positive
Mayo A Refurbishment																	Low Positive
Transmission Corridors																	
Transmission: Whitehorse - Atlin (138 kV)																	Medium Positive
Transmission: Whitehorse - Skagway (230 kV)																	Medium Positive
Transmission: Whitehorse - Teslin (138 kV)																	Medium Positive
Transmission: Faro - Watson Lake (230 kV)																	High Positive
Transmission: Aishihik - Destruction Bay (230 kV)																	High Positive
Transmission: Stewart-Keno City (138 kV & substations)																	High Positive

2.4 ECONOMIC EVALUATION OF RESOURCE OPTIONS

Figure 4 provides the summary evaluation of the RP resource options for the Economic criteria and indicators, building on the outcomes of the environmental and social evaluations.

- The first criteria (Local Economic Impacts) focuses on potential economic benefit effects during construction and operation of the resource options, as well as overall community and other development opportunities related to these options.
- The second criteria (Climate Change Risk) focuses on the potential effects of various climate change risks on resource option construction or operation, i.e., an overview of resource option financial attributes' relative vulnerability to these risks.

Economic indicators for the Local Economic Impacts criteria (Ec1) address potential positive effects from resource options. The ratings in such instances are highlighting where the magnitude or nature of potential positive effects is material. All effects for other economic criteria are rated adverse.

Summary by Criteria and Indicators

Red or yellow ratings in Figure 4 highlight resource options that have high or medium levels of adverse effects on an indicator. High and medium adverse and positive ratings are summarized as follows:

- **Local Economic Impacts:** High and/or medium positive ratings for all pumped storage options, most small hydro and wind options, most transmission options, waste-to-energy option, other thermal options other than diesel, one geothermal option and Gladstone Diversion.
    - **Yukon Opportunities during Construction:** High positive rating for all pumped storage options, two small hydro options, and two transmission options; medium positive rating for three of the four remaining transmission options, two of the four remaining small hydro options, one geothermal option and one wind option.
    - **Yukon Opportunities during Operation:** High positive rating for seven pumped storage options, all small hydro options, two wind options, and waste-to-energy option; medium positive rating for the one remaining pumped storage option, the five remaining wind options, and one geothermal option.
    - **Community and Other Development Opportunity**: High positive rating for three transmission options, five pumped storage options, four small hydro options, two wind options, and Gladstone Diversion; medium positive rating for the three remaining transmission options, the two remaining small hydro options, the three remaining pumped storage options, four of the five remaining wind options, one geothermal option, all of the non-fossil thermal options, and the LNG fossil thermal option.
- **Climate Change Risk Affecting Resource Financial Attributes:** Red (high) and/or yellow (medium) adverse effects ratings are noted for transmission options, hydro options, wind options, one geothermal option and the biomass option.

- **Susceptible to Extreme Heat/Drought:** Red (high) rating for all pumped storage and small hydro options, and Gladstone Diversion; yellow (medium) rating for three transmission options, both hydro storage enhancement options, and the biomass option.
- **Susceptible to Extreme Precipitation - Flood/Snow:** No red (high) ratings; yellow (medium) rating only for all transmission options.
- **Susceptible to Extreme Wind Events:** No red (high) ratings; yellow (medium) rating for all transmission options and all wind options.
- **Susceptible to Ice Related Processes/Events:** Red (high) rating for six of the seven wind options; yellow (yellow) rating for all transmission options.
- **Conditions Susceptible to Climate Change (Permafrost Conditions):** Red (high) rating for one wind option, one small hydro option, and one transmission option; yellow (medium) rating for all remaining transmission options, all remaining small hydro options, six of the eight pumped storage options, and one geothermal option.

Summary by Resource Options

Overall assessments are summarized below by indicator for each of the major sets of resource options:

1. **Fossil Thermal (Diesel and LNG in Whitehorse area)**: Each of these resource options is rated green (low) or low positive for all of the economic criteria and indicators, except for the following ratings:
    a. **Local Economic Impacts - Community and Other Development Opportunity**
        - LNG resource option: medium positive (reflects medium local benefit opportunities facilitated by the option [through its development of an LNG supply chain] to use LNG to displace other fossil fuel use in Whitehorse/Yukon).
        - Diesel resource option: low positive (reflects low local economic benefit impacts from this option).
2. **Non-Fossil Thermal (Waste-to-energy and Biogas in the Whitehorse area, and Biomass in the Haines Junction area)** - Each of these resource options is rated green (low) or low positive for all of the economic criteria and indicators, except for the following ratings:
    a. **Local Economic Impacts**
        i. **Yukon Opportunities during Operation**
            - Waste-to-energy: high positive (reflecting relatively high level of operating jobs and Opex cost level).
            - Biogas and biomass: low positive (relatively low local economic benefits).
        ii. **Community and Other Development Opportunity**
            - All non-fossil thermal options: medium positive (reflecting local opportunity to use renewable energy and [except for biogas] and to supply waste heat to displace fossil fuel use).

b. **Climate Change Risk**

i. **Susceptible to Extreme Heat/Drought**

- Biomass: yellow (forest fire risks).

3. **Other Non-Hydro Renewable (Storage Battery in Whitehorse, Solar in Whitehorse and Haines Junction, Wind at seven different sites, and Geothermal at two sites)**, **Storage Battery and Solar PV.**

a. **Local Economic Impacts:** Ratings tend to be similar across the site options for a resource technology option:

i. **Yukon Opportunities during Construction**

- Kluane Lake wind option, McArthur Springs geothermal: medium positive (Kluane Lake wind rating reflects added requirement for new transmission line to connect to grid at Haines Junction or Aishihik).
- All other non-hydro renewable options – low positive.

ii. **Yukon Opportunities during Operation, and Community and Other Development Opportunity**

- Kluane Lake and Sugarloaf Mountain wind options: high positive for both indicators (reflects added opportunities for First Nation lease revenues and [for Kluane Lake] the benefits of the added transmission connection which will allow Destruction Bay and likely Burwash Landing to stop relying on diesel generation).
- All other wind farm site options, except for Mt. Sumanik (for Community and Other Development Opportunity), and McArthur Springs geothermal option: medium positive for both indicators.
- Mt. Sumanik wind option (for Community and Other Development Opportunity) and Vista Mountain geothermal, Solar PV, storage battery for both indicators: low positive (reflecting relatively low local economic impacts).

b. **Climate Change Risk**

i. **Susceptible to Ice-related Processes/Events**

- All wind farm options other than Kluane Lake: red (high susceptibility risk).
- Kluane Lake wind option (reflects lower elevation and better weather conditions), storage battery, solar options, and both geothermal options: green (low susceptibility risk).

ii. **Susceptible to Extreme Heat/Drought** and **Susceptible to Extreme Precipitation (flood/snow):** all of the other non-hydro renewable options are rated green (low) for these indicators.

iii. Susceptible to Extreme Wind Events

- All wind options: yellow (medium).
- Storage battery, solar PV options, and both geothermal options: green (low).

iv. **Conditions Susceptible to Climate Change**: This indicator is focused entirely on relative risks related to permafrost.[11]

- Kluane Lake wind option: red (high) (reflects permafrost risks in this region).
- McArthur Springs geothermal option: yellow (medium).
- All wind options other than Kluane Lake, storage battery, solar PV options, and Vista Mountain geothermal option: green (low).

4. **Hydro Generation (Pumped Storage at eight different sites, Small Hydro at six different sites, Other Hydro [Gladstone Diversion, two Storage Enhancement options, Mayo Lake Outlet Channel Dredging], and hydro refurbishment/re-runnering at Mayo A and Aishihik):** The economic criteria and indicator ratings tend to be very similar for various site options within each hydro generation resource option:

a. **Local Economic Impacts**

i. Yukon Opportunities during Construction

- All pumped storage options, two small hydro options (Wolf River, Finlayson River): high positive.
- Three small hydro options (Tutshi-Windy Arm, Anvil Creek, Atlin/Pine Creek): medium positive.
- Drury Lake small hydro option, all other hydro options, Aishihik re-runnering, Mayo A refurbishment: low positive.

ii. Yukon Opportunities during Operation

- All pumped storage options other than Moon Lake, all small hydro options: high positive.
- Moon Lake (Tutshi-Moon) pumped storage: medium positive.
- All other hydro options, Aishihik re-runnering, Mayo A refurbishment: low positive.

iii. Community and Other Development Opportunity

- Five pumped storage options that each provide high development opportunity benefits related to major new transmission (Moon Lake, Racine-Moon, Lindeman-Fraser, Racine-Mt. Brown, Atlin- Black Mountain), all small hydro options except Drury Lake and Anvil Creek

[11] For discussion of ratings see Table E3-1.

(each of these four options require major new transmission), Gladstone Diversion (reflects opportunity for local First Nation income benefits if this option developed): high positive.

- Three pumped storage options (Squanga-Dalayee, Canyon-Ittlemit, and Vangorda Pit), Drury Lake and Anvil Creek small hydro: medium positive.
- Storage enhancement options (Southern Lakes, Mayo Lake), Mayo Lake Outlet Channel Dredging, Aishihik re-runnering, Mayo A refurbishment: low positive.

b. **Climate Change Risk**

i. Susceptible to Extreme Heat / Drought

- All pumped storage options, all small hydro options, Gladstone Diversion: red (high susceptibility).
- Storage enhancement option (Southern Lakes, Mayo Lake): yellow (medium).
- Mayo Lake Outlet Channel Dredging, Aishihik re-runnering, Mayo A refurbishment: green (low susceptibility).

ii. Conditions Susceptible to Climate Change (permafrost risks)[12]

- Drury Lake small hydro: red (high).
- All pumped storage options other than Canyon-Ittlemit and Vangorda Pit, all small hydro options other than Drury Lake: yellow (medium).
- Two pumped storage options (Canyon-Ittlemit and Vangorda Pit), all Other Hydro options, Aishihik re-runnering, Mayo A refurbishment: green (low).

iii. **All other Climate Change Risk indicators** - All hydro options are rated green for all other Climate Change Risk indicators (low susceptibility to Extreme Precipitation, to Extreme Wind Events, and to Ice Related Processes/Events).

5. **Transmission Corridors (Six Transmission Corridor Options):** Transmission corridor options tend to have similar economic criteria and indicator ratings, with a few exceptions as noted below:

a. **Local Economic Impacts**: variable ratings among these options reflect varying scales of development (capital costs), as well as related impacts known today from each development:

[12] For discussion of ratings see Table E 3-1. Each option other than Drury Lake has a medium rating reflecting potential permafrost conditions affecting material new transmission access development requirements. Drury Lake has a red rating based on geotechnical risks and presence of permafrost noted in previous KGS reports.

i. **Yukon Opportunities during Construction**

- Whitehorse-Skagway and Faro-Watson Lake Transmission Corridor options: high positive (high opportunities).
- Whitehorse-Atlin and Whitehorse-Teslin Transmission Corridor options: medium positive.
- Stewart-Keno City options: low positive.

ii. **Yukon Opportunities during Operation** - all of the Transmission Corridor options are rated low positive, indicating relatively low local economic impact opportunities.

iii. **Community and Other Development Opportunity**

- Three Transmission Corridor options (Faro-Watson Lake, Aishihik-Destruction Bay, and Stewart-Keno City): high positive (reflecting opportunities to displace local diesel generation (or sustain existing transmission capacity to do this), as well as to facilitate new mining and renewable generation (hydro or wind) development.
- Three remaining Transmission Corridor options (Whitehorse-Skagway, Whitehorse-Atlin, Whitehorse-Teslin): medium positive (reflecting potential local development impacts if the option facilitates renewable generation [pumped storage and small hydro] and, in the case of the Skagway connection, potential sale of summer renewable generation [hydro or wind] to cruise ships).

b. **Climate Change Risk**

i. **Susceptible to Extreme Heat/Drought** - this risk includes increased risk of forest fires:

- Three Transmission Corridor options (Faro-Watson Lake, Aishihik-Destruction Bay, and Stewart-Keno City): yellow (medium).
- Three Transmission Corridor options (Whitehorse-Atlin, Whitehorse-Skagway, Whitehorse-Teslin): green (low) (reflecting the extent that each route covers well developed areas and/or mountain areas).

ii. **Conditions Susceptible to Climate Change**[13]

- Aishihik-Destruction Bay Transmission Corridor: red (high) (risks regarding permafrost).
- All other Transmission Corridor options: yellow (medium).

iii. **All Other Climate Change Risk Indicators** - All Transmission Corridor options are rated yellow for all other Climate Change Risk indicators (medium susceptibility to Extreme Precipitation, to Extreme Wind Events, and to Ice Related Processes/Events).

[13] For discussion of ratings see Table E 3-1.

Figure 4: Evaluation of RP Resource Options - Economic Criteria & Indicators

High

Medium

Low

Resource Options	Installed Capacity MW	Annual Average Energy GWh	Assumed Economic Life (years)	Local Economic Impacts (Ec1) (Positive Effects)			Climate Change Risk affecting Resource Financial Attributes (Ec2)				
				Yukon Opportunities During Construction (Ec1-1) Positive Effects	Yukon Opportunities during Operation (Ec1-2) Positive Effects	Community & Other Development Opportunity (Ec1-3) Positive Effects	Susceptible to Extreme Heat/Drought (Ec2-1)	Susceptible to Extreme Precipitation - flood/snow (Ec2-2)	Susceptible to Extreme Wind Events (Ec2-3)	Susceptible to Ice Related Processes/ Events (Ec2-4)	Conditions Susceptible to Climate Change (Ec2-5)
Fossil Thermal											
Diesel: 20 MW - Whitehorse	20.0	up to >150	25-40	Low Positive	Low Positive	Low Positive					
Diesel: 20 MW - Takhini	20.0	up to >150	25-40	Low Positive	Low Positive	Low Positive					
LNG: 20 MW - Whitehorse	20.0	up to >150	25-40	Low Positive	Low Positive	Medium Positive					
LNG: 20 MW - Takhini	20.0	up to >150	25-40	Low Positive	Low Positive	Medium Positive					
Non-Fossil Thermal											
Waste to Energy	1.6	10	25	Low Positive	High Positive	Medium Positive					
Biogas (CHP)	0.2	0.4	20	Low Positive	Low Positive	Medium Positive					
Biomass 0.5 MW Boiler / Steam Turbine	0.5	3	20	Low Positive	Low Positive	Medium Positive					
Other Non-Hydro Renewable											
Storage Battery: 8 MW/40 MWh (lithium ion, 5hrs)	8.0	0.04	30	Low Positive	Low Positive	Low Positive					
Solar PV: Whitehorse Fixed Tilt: 10 MW	10.0	10	30	Low Positive	Low Positive	Low Positive					
Solar PV: Haines Junction Fixed Tilt: 5 MW	5.0	5	30	Low Positive	Low Positive	Low Positive					
Wind: Cyprus Mine Hill, 20 MW	20.0	51	20	Low Positive	Medium Positive	Medium Positive					
Wind: Kluane Lake, 20 MW	20.0	49	20	Medium Positive	High Positive	High Positive					
Wind: Millers Ridge, 20 MW	20.0	59	20	Low Positive	Medium Positive	Medium Positive					
Wind: Mt. Sumanik , 20 MW	20.0	43	20	Low Positive	Medium Positive	Low Positive					
Wind: Sugarloaf Mountain, 20 MW	20.0	33	20	Low Positive	High Positive	High Positive					
Wind: Tehcho (Ferry Hill), 20 MW	20.0	35	20	Low Positive	Medium Positive	Medium Positive					
Wind: Thulsoo Mountain, 20 MW	20.0	56	20	Low Positive	Medium Positive	Medium Positive					
Geothermal: McArthur Springs (3.8 MW Av.)	4.0	25	30	Medium Positive	Medium Positive	Medium Positive					
Geothermal: Vista Mountain (1.6 MW Av.)	1.8	11	30	Low Positive	Low Positive	Low Positive					
Hydro Generation											
Pumped Storage: Moon Lake (Tutshi-Moon)	20.2	54	65	High Positive	Medium Positive	High Positive					
Pumped Storage: Racine - Moon	15.0	50	65	High Positive	High Positive	High Positive					
Pumped Storage: Lindeman-Fraser	15.0	50	65	High Positive	High Positive	High Positive					
Pumped Storage: Racine - Mt. Brown	15.0	50	65	High Positive	High Positive	High Positive					
Pumped Storage: Atlin - Black Mountain	15.0	50	65	High Positive	High Positive	High Positive					
Pumped Storage: Squanga - Dalayee	25.0	100	65	High Positive	High Positive	Medium Positive					
Pumped Storage: Canyon - Ittlemit	25.0	100	65	High Positive	High Positive	Medium Positive					
Pumped Storage: Vangorda Pit	40.0	134	50-65	High Positive	High Positive	Medium Positive					
Small Hydro: Drury Lake	8.1	32	65	Low Positive	High Positive	Medium Positive					
Small Hydro: Tutshi - Windy Arm	7.2	57	65	Medium Positive	High Positive	High Positive					
Small Hydro: Wolf River	20.0	96	65	High Positive	High Positive	High Positive					
Small Hydro: Finlayson River	17.6	139	65	High Positive	High Positive	High Positive					
Small Hydro: Anvil Creek	9.8	41	65	Medium Positive	High Positive	Medium Positive					
Small Hydro: Atlin/Pine Creek	5.7	36.3 avail to Yukon	65	Medium Positive	High Positive	High Positive					
Other Hydro: Gladstone Diversion	NA	37	65	Low Positive	Low Positive	High Positive					
Other Hydro: Southern Lakes Storage	1.0	6	NA	Low Positive	Low Positive	Low Positive					
Other Hydro: Mayo Lake Storage	NA	2 to 4	NA	Low Positive	Low Positive	Low Positive					
Other Hydro: Mayo Dredging	NA	1 to 2	NA	Low Positive	Low Positive	Low Positive					
Aishihik Re-runnering	1.0	3	na	Low Positive	Low Positive	Low Positive					
Mayo A Refurbishment	2.3	10	65	Low Positive	Low Positive	Low Positive					
Transmission Corridors	Transfer Capacity										
Transmission: Whitehorse - Atlin (138 kV)	97	NA	45	Medium Positive	Low Positive	Medium Positive					
Transmission: Whitehorse - Skagway (230 kV)	443	NA	45	High Positive	Low Positive	Medium Positive					
Transmission: Whitehorse - Teslin (138 kV)	95	NA	45	Medium Positive	Low Positive	Medium Positive					
Transmission: Faro - Watson Lake (230 kV)	190	NA	45	High Positive	Low Positive	High Positive					
Transmission: Aishihik - Destruction Bay (230 kV)	484	NA	45	Medium Positive	Low Positive	High Positive					
Transmission: Stewart-KenoCity (138 kV & substations)	NA	NA	45	Low Positive	Low Positive	High Positive					

3.0 SUMMARY AND CONCLUSIONS

This study supports Yukon Energy's current 2016 Resource Plan update by providing a comparative evaluation of more than 45 power generation and transmission resource options in Yukon and northern British Columbia against more than 40 environmental, social and economic indicators.

The evaluation approach displays key differences among the resource options, rather than attempting an overall ranking of these options. The ratings for each criteria and indicator show on a common scale (low, medium, and high) which indicators are particularly relevant to each resource option. A high rating identifies when potential effects on an indicator are high for a specific resource option compared with the other resource options under review at this time. Medium ratings indicate when potential effects on an indicator are medium for a specific resource option, and therefore meriting attention as compared to options with a low rating. The indicators vary in focus; some highlight the need to manage potential adverse effects (where red indicates a high effect and yellow indicates a medium effect), while others highlight the need and opportunity to manage potential positive effects (no colours are used for these positive effect ratings in order to avoid possible confusion with the adverse effect ratings).

No attempt is made in this study to evaluate resource options in the context of forecast grid loads. Resource portfolio option definition and assessment in the context of long-term load forecasts will be done subsequently by Yukon Energy as part of the current Resource Plan update.

The more than 45 electricity resource options reviewed reflect a diverse range of technologies, scales of development, and locations within Yukon and northern British Columbia. Each option's assessment includes consideration of new transmission and/or road access requirements.

Ratings vary for different sets of resource options (e.g., thermal versus non-thermal, wind versus hydro or solar renewables), and for different renewable sites within each set of resource options. Tables 3, 4, 5 and 6 provide a summary of high and medium ratings for each of the major sets of resource options:

- **Thermal Generation Options (Table 3):** Fossil (diesel and LNG) and non-fossil (waste-to-energy, biogas and biomass) thermal generation options have high or medium ratings for only a few indicators:
    - **Environmental Indicators:** Red or yellow (high or medium adverse) ratings for Air Quality indicators for all of these options, and yellow rating for biomass option effects on Wildlife Key Areas. Air emission effects are sensitive to actual operation of the resource options.
    - **Social Indicators:** Yellow (medium adverse) ratings for the Takhini site (fossil thermal options) proximity to First Nation Lands and for biomass option effects on Aesthetics and Land Use and Renewable Resources; medium positive ratings for Community, First Nation and Personal Development indicator for the LNG, waste-to-energy, biogas and biomass options.
    - **Economic Indicators:** High or medium positive ratings for Local Economic Impacts for waste-to-energy, LNG, biogas and biomass options; yellow (medium adverse) rating for biomass option susceptibility to Extreme Heat/Drought.

- **Other Non-hydro Renewable Options (Table 4):** Storage battery, solar PV, wind and geothermal options have high or medium ratings that in many instances may be affected by specific site options:
    - **Environmental Indicators:** Red or yellow (high or medium adverse) ratings for various Terrestrial Species and Habitat indicators and Terrestrial Footprint and Land Area indicators occur for all wind options, one geothermal option, and (for only one indicator) the largest solar PV option.
    - **Social Indicators:** Red or yellow (high or medium adverse) ratings for various Social indicators occur for each of these resource options other than the storage battery option, but ratings for specific indicators typically vary among the different site options for a resource option; high or medium positive ratings for the Community, First Nation and Personal Development indicators occur for seven of eight wind options and for one geothermal option.
    - **Economic Indicators:** High or medium positive ratings for Local Economic Impact indicators occur for all wind options and one geothermal option and red or yellow (high or medium adverse) ratings occur for all wind options and one geothermal option with regard to at least one Climate Change Risk indicator.
- **Hydro Generation Options (Table 5):** Pumped storage, small hydro, Gladstone Diversion, and hydro storage enhancement options have high or medium ratings that in many instances may be affected by specific site options:
    - **Environmental Indicators:** Red or yellow (high or medium adverse) ratings for a range of Aquatic environment and Terrestrial environment indicators occur for all hydro resource options that require modified water regimes, with variations as to ratings among different site options.
    - **Social Indicators:** Red or yellow (high or medium adverse) ratings for various Social indicators occur for all hydro resource options that require modified water regimes, with variations as to ratings among different site options; high or medium positive ratings for the Community, First Nation and Personal Development indicators occur for all pumped storage and small hydro options and the Gladstone diversion option.
    - **Economic Indicators:** High or medium positive ratings for Local Economic Impact indicators occur for all pumped storage and small hydro options and the Gladstone diversion option and red or yellow (high or medium adverse) ratings for all pumped storage, small hydro, Gladstone Diversion and storage enhancement options occur with regard to at least one Climate Change Risk indicator.
- **Transmission Corridor Options (Table 6):** The six transmission corridor options have high or medium ratings that in many instances may be affected by the specific site option:
    - **Environmental Indicators:** Red or yellow (high or medium adverse) ratings for some of the terrestrial environment indicators occur for all transmission options (red ratings apply with regard to all of these options for Footprint Terrestrial Area and Linear Development, and yellow ratings apply for all of these options with regard to Wildlife Key

Areas; red or yellow ratings apply to only some transmission options for some of the other Terrestrial indicators).

- **Social Indicators:** Red or yellow (high or medium adverse) ratings for First Nation Lands and Footprint Land Area Impact occur for all transmission options, and yellow ratings also occur for some of these options with regard to a few other Traditional Lifestyle and Heritage Resources indicators; high or medium positive ratings for the Community, First Nation and Personal Development indicator occurs for all transmission options.
- **Economic Indicators:** High or medium positive ratings for at least one of the Local Economic Impact indicators occur for all transmission options and red or yellow (high or medium adverse) ratings for all transmission options occur with regard to several of the Climate Change Risk indicators.

Table 3: Summary of Thermal Generation Option High & Medium Evaluations

Criteria and Indicators	High	Medium
Fossil Fuel Thermal (Diesel & LNH in Whitehorse Area)		
Environmental		
Air Quality - GHG Emissions (with & without biogenic CO_2)	Diesel, LNG	
Air Quality - Other Emissions		Diesel, LNG
Social		
First Nation Lands		Takhini Site (Diesel & LNG)
Community, First Nation & Personal Development (positive effect)		LNG
Economic		
Community & Other Development Opportunity (positive effect)		LNG
Non Fossil Fuel Thermal (Waste-to-energy and Biogas in Whitehorse and Biomass in Haines Junction)		
Environmental		
Wildlife Key Areas		Biomass
Air Quality - GHG Emissions (with biogenic CO_2)	WTE, Biogas, Biomass	
Air Quality - GHG Emissions (without biogenic CO_2)		WTE, Biogas
Air Quality - Other Emissions		WTE, Biogas, Biomass
Social		
Aesthetics, Land Use & Renewable Resource Plans		Biomass
Community, First Nation & Personal Development (positive effect)		WTE, Biogas, Biomass
Economic		
Yukon Opportunities - Operation (positive effects)	WTE	
Community and Other Development Opportunity (positive effect)		WTE, Biogas, Biomass
Susceptible to Extreme Heat/Drought		Biomass

Table 4: Summary of Other Non-Hydro Renewable Option High & Medium Evaluations

Criteria and Indicators	High	Medium
Environmental		
Terrestrial Species at Risk & Habitat		All W sites ex Tehcho
Protected & Conservation Areas	G (McA S site)	W (Kluane L)
Wildlife Key Areas	W (Kluane L, Mt.Sumanik, Sugarloaf M)	W (Miller's R, Tehcho, Thulsoo M), G (McA S site)
Caribou Ranges		W (Cyprus Mine H, Miller's R, Sugarloaf M), G (McA S)
Footprint Land Area	All W, G (McA S site)	
Linear Development for Roads/Transmission		W (all sites), G (McA S site)
Social		
First Nation Lands	W (Kluane L, Sugarloaf M)	W (Miller's R), G
Footprint Land Area Impact	All W sites ex Kluane L, G at (McA S)	S sites, W (Kluane L), G (Vista M)
Importance/Cultural Importance of Heritage Resources		All W (ex Cyprus M, Kluane L), G (McA S)
Recreational Values, Tourism Values		W (Kluane L, Miller's R, Thulsoo M for rec.), G (McA S)
Aesthetics, Land Use & Renewable Resource Plans	G(McA S site)	W (Kluane L for aes., Miller's R, Thulsoo M)
Non-Renewable Resources, Other Renewable Resources		W (Thulsoo M for non-renewable), G (McA S)
Infrastructure & Services		All W (ex M Sumanik), G (McA S)
Public Safety, Worker Interaction & Community Health		All W (ex M Sumanik), G (McA S)
Community, First Nation & Personal Development (positive effect)	W (Kluane L, Sugarloaf M)	All W (ex M Sumanik, Kluane L, Sugarloaf M), G (McA S)
Economic		
Yukon Opportunities - Construction (positive effect)		W (Kluane L), G (McA S)
Yukon Opportunities - Operation (positive effect)	W (Kluane L, Sugarloaf M)	All W (ex Kluane L, Sugarloaf M), G (McA S)
Community and Other Development Opportunity (positive effect)	W (Kluane L, Sugarloaf M)	All W (ex M Sumanik, Kluane L, Sugarloaf M), G (McA S)
Susceptible to Ice-Related Processes/Events	W (all sites ex Kluane L)	
Susceptible to Extreme Wind Events		All W
Conditions Susceptible to Climate Change (permafrost risk)	W (Kluane L)	G (McA S)

Key: **Storage Battery (SB) in Whitehorse,**
Solar PV (S) in Whitehorse and Haines Junction,
Wind (W) at seven different sites, and Geothermal (G) at two sites.

Table 5: Summary of Hydro Generation Option High & Medium Evaluations

Criteria and Indicators	High	Medium
Environmental		
Salmon & Salmon Habitat	PS (Vangorda P)	SH (Drury L, Wolf R, Anvil Ck), Southern L Storage
Aquatic Species at Risk & Habitat	PS (Squanga-Dalayee)	SH (Finlayson R)
Commercial, Recreational, & Aboriginal Fisheries Species & Hab	All PS (ex Tutshi-Moon, Atlin-BM), all SH (ex Wolf R, Atlin/PC), GD, Southern Lakes & Mayo L St.	PS (Tutshi-Moon, Atlin-BM), SH (Wolf R, Atlin/PC)
Relative Scale of Impoundment/Flooding	All PS, SH (Finlayson R, Anvil Ck)	SH (Drury L, Tutshi WA)
Flow Changes	GD, Southern Lakes & Mayo L Storage	All PS, all SH
Terrestrial Species at Risk & Habitat	GD and Southern Lakes	All PS (ex. Vangorda P), all SH, Mayo L St.
Terrestrial Protected & Conservation Areas	PS (Lindeman-Fraser) and Southern Lakes	PS (Squanga-D), SH (Wolf R)
Wildlife Key Areas	PS (Squanga-D), GD, Southern Lakes	All PS (ex. Squanga-D), SH (Tutshi-WA, Finlayson R, Wolf R)
Caribou Ranges		All PS (ex. Canyon-I), SH (Tutshi-WA, Finlayson R, Anvil Ck), GD
Footprint Land Area	All PS, all SH, GD	
Linear Development for Roads/Transmission		All PS (ex.Tutshi-Moon, Atlin-BM), all SH, GD
Permafrost		PS (Racine-MB, Canyon-I, Vangorda-P), SH (Finlayson R), GD
Wetlands	Southern Lakes Storage	PS (Tutshi-Moon, Racine-M, Squanga-D, Vangorda P), SH (Wolf F)
Social		
First Nation Lands	PS (Squanga-D, Canyon-I, Vangorda P), SH (Wolf R, Finlayson R, Anvil Ck), GD, Southern Lakes Storage	PS (Racine-MB, Atlin-BM), SH (Drury L, Atlin/PC)
Footprint Land Area Impact	All PS, all SH (ex.Tutshi-WA), GD, Southern L & Mayo L St.	SH (Tutshi-WA)
Land Area Loss for Traditional Lifestyle		PS (Vangorda P), SH (Finlayson R)
Land Quality Effects on Traditional Lifestyle		SH (Finlayson R), GD, Southern L Storage
Cabins, Camps, & Structures	Southern Lakes Storage	
Country Foods	Gladstone Diversion	PS (Squanga-D), SH (Finlayson R)
Density of Heritage Resources	PS (Atlin-Black M), Southern Lakes Storage	PS (Lindeman-F, Squanga D, Canyon-I), SH (Tutshi-WA, Finlayson R, Anvil Ck, Atlin/PC), GD
Importance/Cultural Importance of Heritage Resources		PS (Lindeman-F, Squanga D, Canyon-I), SH (Finlayson R, Anvil Ck), GD, Southern Lakes
Recreational Values	PS (Racine-M, Racine-MB, Squanga-D, Canyon-I), SH (Drury L, Tutshi-WA, Finlayson R, Anvil Ck, Atlin/PC)	PS (Lindeman-F), SH (Wolf R), GD
Tourism Values	SH (Drury L, Finlayson R, Atlin/PC)	PS (Racine-M, Lindeman-F, Racine-MB, Squanga-D, Canyon-I), SH (Wolf R, Anvil Ck)
Aesthetics	SH (Atlin/PC)	PS (Tutshi-Moon, Lindeman-F, Squanga-D, Canyon-I), SH (Tutshi-WA, Anvil Ck), GD
Non-Renewable Resources	SH (Atlin/PC)	PS (Tutshi-Moon, Racine-Moon, Racine-MB, Atlin-BM, Squanga-D), SH (Finlayson R, Anvil Ck), GD
Land Use & Renewable Resource Plans	PS (Racine-M, Racine-MB, Atlin-BM)	PS (Tutshi-Moon, Lindeman-F, Squanga-D, Canyon-I), all SH (ex. Atlin/PC), GD
Infrastructure & Services	All PS, all SH	Gladstone Diversion
Public Safety, Worker Interaction & Community Health	All PS, all SH	Gladstone Diversion
Community, First Nation & Personal Development (positive effect)	All PS (ex.Squanga-D, Canyon-I, Vangorda P), all SH (ex.Drury L), GD	PS (Squanga-D, Canyon-I, Vangorda P), SH (Drury L, Anvil Ck)
Economic		
Yukon Opportunities - Construction (positive effect)	All PS, SH (Wolf R, Finlayson R)	SH (Tutshi-WA, Anvil Creek, Atlin/PC)
Yukon Opportunities - Operation (positive effect)	All PS (ex. Tutshi-Moon), all SH	PS (Tutshi-Moon)
Community and Other Development Opportunity (positive effect)	All PS (ex.Squanga-D, Canyon-I, Vangorda P), all SH (ex.Drury L, Anvil Ck), GD	PS (Squanga-D, Canyon-I, Vangorda P), SH (Drury L, Anvil Ck)
Susceptible to Extreme Heat/Drought	All PS, all SH, GD	Southern Lakes and Mayo L Storage
Conditions Susceptible to Climate Change (permafrost risk)	SH (Drury L)	All PS (ex. Canyon-I, Vangorda P), all SH (ex. Drury L)

Key: Pumped Storage (PS) at 8 sites,
Small Hydro (SH) at 6 sites,
Other Hydro (Gladsone Diversion [GD], Southern Lakes & Mayo L Storage, Mayo Dredging),
Hydro refurbishment/re-runnering (HRR) at Mayo A and Aishihik.

Table 6: Summary of Transmission Corridor Option High & Medium Evaluations

Criteria and Indicators	High	Medium
Environmental		
Terrestrial Protected & Conservation Areas	Aishihik-Destruction Bay	Whitehorse-Atlin
Wildlife Key Areas		All Transmission Corridor options
Caribou Ranges	Faro-Watson L	
Footprint Land Area	All Transmission Corridor options	
Linear Development for Roads/Transmission	All Transmission Corridor options	
Permafrost		Faro-Watson L, Aishihik-Destruction Bay, Stewart-Keno City
Social		
First Nation Lands	Whitehorse-Atlin, Whitehorse-Teslin, Whitehorse-Skagway	Faro-Watson L, Aishihik-Destruction Bay, Stewart-Keno City
Footprint Land Area Impact	All Transmission Corridor options	
Cabins, Camps, & Structures		Whitehores-Skagway
Density of Heritage Resources		All Transmission Corridor options (ex. Faro-Watson Lake)
Importance/Cultural Importance of Heritage Resources		Whitehorse-Skagway
Community, First Nation & Personal Development (positive effect)	Faro-Watson L, Aishihik-Destruction Bay, Stewart-Keno City	Whitehorse-Atlin, Whitehorse-Teslin, Whitehorse-Skagway
Economic		
Yukon Opportunities during Construction (positive effect)	Whitehorse-Skagway, Faro-Watson L	Whitehorse-Atlin, Whitehorse-Teslin, Aishihik-Destruction Bay
Community and Other Development Opportunity (positive effect)	Faro-Watson L, Aishihik-Destruction Bay, Stewart-Keno City	Whitehorse-Atlin, Whitehorse-Teslin, Whitehorse-Skagway
Susceptible to Extreme Heat/Drought		Faro-Watson L, Aishihik-Destruction Bay, Stewart-Keno City
Susceptible to Extreme Precipitation - Flood/Snow		All Transmission Corridor options
Susceptible to Ice-Related Processes/Events		All Transmission Corridor options
Susceptible to Extreme Wind Events		All Transmission Corridor options
Conditions Susceptible to Climate Change (permafrost risk)	Aishihik-Destruction Bay	All Transmission Corridor options (ex. Aishihik-Destruction Bay)

APPENDICES

APPENDIX A:
PROJECT SUMMARIES

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1.0 INTRODUCTION

This appendix provides a summary of key information for resource options that is relevant to the evaluations, including identification of the specific sites and cases to be evaluated and the relevant report information to be utilized.

The project summaries are based on publicly available information and information from inventoried resource option project reports supplied by Yukon Energy Corporation (Yukon Energy). Geographic information system (GIS) and mapping information on each site option and its footprint (including road access and transmission interconnection) that is currently available for each resource option has been provided by Yukon Energy separately as required for each member of the Study Team to proceed with the resource options evaluation.

The current Resource Plan focuses in most instances on generation options that do not exceed 20 MW in scale. Referenced resource option project reports often examine a range of sites, scales of development, and different financial attributes, including interest cost assumptions. In order to simplify the resource options evaluation, key information for each resource option has been limited or assumed as noted below:

- **Sites** - Sites used for the evaluation of each resource option, when identified, are limited to those specifically noted below. In cases where referenced resource option project reports screened a wide range of site options, the following resource options evaluation typically focuses on the short list of top-ranked sites identified in the reports.
- **Linkage with Required Transmission Corridor Developments** - Referenced generation resource option reports include transmission interconnection to the grid as required for development of each site option; however, in several instances, the scope for the referenced report assumes separate development of a new transmission corridor that has been examined separately. For the purpose of the current resource options evaluation, it is necessary to highlight where a generation site development option presumes development of a new transmission corridor and/or an added transmission connection to the current grid (and to identify the linked transmission connection so that it is evaluated concurrently with the generation site option).
- **Development Scale** - Where a range of scales for development (e.g., MW or GWh/year) was examined in a referenced resource option project report, the following resource options evaluation focuses on one scale (usually the largest scale examined). In some cases (e.g., geothermal resource options), where uncertainty exists regarding the potential scale for development (due to the need for further site investigation), the resource options evaluation for convenience adopts where relevant the average of the potential scales that have been identified. For some pumped storage site options, two scales of development are included in the evaluation. For solar PV options, various scales of development for each site are included in the evaluation.
- **Utilization of Resource Options** - The resource options evaluation is being done without reference to any forecast grid load or economic opportunities for new generation or transmission, i.e., each renewable resource option (regardless of scale) is assumed to be fully utilized, unless it is designed to be dispatchable in response to load requirements (e.g., fossil or biomass thermal

generation). In practice, final selection of any resource option for development would require evaluation of its ability to supply forecast grid capacity and energy loads (including provision to meet capacity reliability requirements) on a least cost basis relative to all other available resource options.

- **Weighted Average Cost of Capital for Resource Development** - All resource options are assumed for this evaluation to be developed by Yukon Energy (rather than another party) at the Yukon Energy weighted average cost of capital (WACC) specified for the resource option reports, i.e., 3.38%/year real cost of capital (net of inflation). This WACC is used in the referenced resource reports to define one case for Levelized Cost of Energy (LCOE) and Levelized Cost of Capacity (LCOC) for each resource option over its assumed economic life (assuming full utilization of the resource over this period).

Summaries are grouped by four general sets of resource options as follows (as noted, there are multiple resource options within each set, and several of these resource options include multiple sites, i.e., approximately 51 different options overall are identified for discussion in this appendix):

1. **Fossil Fuel Thermal Generation:** (two resource options [diesel and LNG], each in Whitehorse - two sites are examined for each).
2. **Non-hydro Renewable Generation:**
    a. **Non-fossil Thermal Generation** (three resource options: biomass in Haines Junction, biogas in Whitehorse, and waste-to-energy [WTE] in Whitehorse);
    b. **Energy Storage Facility** (batteries) in Whitehorse;
    c. **Solar PV** (two site options are examined: Haines Junction and Whitehorse, each with various scales of development [total of five options]);
    d. **Wind Farms** (seven site options are examined); and
    e. **Geothermal** (two site options are examined).
3. **Hydro Renewable Generation:**
    a. **Pumped Storage** (nine site options are examined; two site options include two scales of development);
    b. **Small Hydro Projects** (five site options are examined, one of which is run-of-river and four of which include storage);
    c. **Gladstone Diversion** (feasibility work was done separately from the current Resource Plan, the project would enhance hydro generation at Aishihik);
    d. **Hydro Storage Enhancements** (two options: Mayo Lake Storage Enhancement to improve winter generation at Whitehorse Hydro [YESAB submission already been prepared], and Southern Lakes Storage Enhancement to improve winter generation at Mayo Hydro [considerable assessment and feasibility work has been done separately from the current Resource Plan]);
    e. **Mayo Lake Outlet Channel Dredging** (ongoing investigation of issues and options related to sediment build up in Mayo Lake Outlet Channel); and

f. **Refurbish Existing Hydro Generation** (two options: Mayo A Refurbishment, and Aishihik Re-runnering).

4. **Transmission Corridor Options:**

a. **New Transmission Corridors** (five options are examined - several of these would facilitate specific pumped storage and small hydro project sites, as well as one wind site. In several instances, segments of a project would enhance an existing transmission corridor); and

b. **Stewart-Keno Transmission Project** - (this project, which enhances an existing transmission corridor wherein a major segment is at end-of-life, has recently completed YESAB review and recommendation).

Each resource option project summary only includes information relevant to the current assessment and aims for simplicity across all projects. The information also reflects the specific stage of each Yukon Energy resource option report, i.e., many reports provided to the study team were still at draft stage and may have been materially changed thereafter in the process of being finalized.[1]

For convenience, a final section provides a summary of the specific options to be included in the current resource options evaluation.

[1] Cost estimates and LCOE estimates in particular may change materially between draft and final reports, and therefore specific numbers provided in this report may not reflect final numbers that are provided to Yukon Energy in other referenced reports. Given the broad rating approach used for this evaluation study, it is not expected that updated costs for specific projects would materially change ratings and conclusions in this evaluation study.

2.0 FOSSIL THERMAL GENERATION

A Stantec report is available for fossil fuel thermal generation ("2016-007 - Thermal Energy Plant Development Study", November 21, 2016).

Stantec examined stand-alone, greenfield installation on a four hectare parcel of new diesel or natural gas (LNG) thermal generation adjacent to brownfield sites in Whitehorse that are not near the existing Whitehorse Generating Station. The two sites examined were the Whitehorse Landfill (assumes use of brownfield land, owned by the City of Whitehorse near the McIntyre substation) and the Mayo Road Substation (a vacant greenfield site on Commissioner's Land adjacent to Takhini S164). Based on the potential site locations selected for the study, there are no existing potential heat customers nearby.

Plant capacities were examined at each site at 5 MW, 10 MW and 20 MW. These resource options provide dispatchable generation with no requirement for high utilization, waste heat sales or subsidy support in order to be economic (waste heat use and boil off gas use [for LNG storage] may be considered when such options are relevant).

The current resource option evaluation focuses only on the 20 MW options at each site:

- Diesel thermal generation has similar capital cost estimate ($62.2 to $62.5 million) at each site for 20 MW. Site layouts were provided for each site.
- Natural gas thermal generation has similar capital cost estimate ($100.0 to $100.1 million) at each site for 20 MW. Site layouts were provided for each site.

Assumed economic life for fossil thermal generation units is very dependent on assumed annual use levels, reflecting the adaptability and reliability of this option. Full use averaging 95% of capacity at 20 MW would provide 166.4 GWh/year for an assumed 20 year economic life (per the Stantec report). Fossil thermal generation on Yukon Energy's hydro grid, however, tends to provide backup generation for peak, winter, emergency or drought period use, resulting in low average annual generation and an economic life of 40 years.

The Stantec report estimated annual O&M costs (excluding fuel) for a 20 MW reciprocating engine facility at $1.19 million, excluding insurance, property taxes or asset management. This estimate assumed high annual usage of the facility (e.g., average 95% capacity factor for each year). Retaining the same use levels and a 20 year life for 20 MW options (WACC at 3.38% real), the Stantec report estimated LCOO at $349-$350/kW for natural gas generation and $217-$218/kW for diesel generation (lower cost for Takhini site). LCOE excluding fuel was estimated based on these same assumptions at $0.049/kW.h for natural gas generation and $0.033/kW.h for diesel generation.

Fossil fuel thermal generation includes material waste heat that is potentially available for heating uses that could displace other fossil fuels. However, such waste heat use tends to be uneconomic unless the thermal generation is expected to be operated throughout periods when the waste heat is required and the thermal generation is also located relatively close to a site able to use the waste heat. In light of these considerations, Yukon Energy's current resource studies have not examined waste heat use options for fossil fuel thermal generation.

3.0 NON-HYDRO RENEWABLE GENERATION

3.1 NON-FOSSIL FUEL THERMAL GENERATION

Three resource options are included in this resource option grouping for non-fossil thermal generation: waste-to-energy at Whitehorse (1.6 MW, no specific site), biomass at Haines Junction (0.5 MW if rely only on beetle-kill biomass, a site identified near school), and biogas at Whitehorse (0.2 MW, located at municipal landfill). Although these options are each technically dispatchable, economic assessments assume full utilization, i.e., these options are not suited to peaking or backup generation use. With the exception of biogas, Yukon Energy assessments of these options have assumed high levels of waste heat use in order to enhance project economics.

Overall, each of these options involves a small scale facility in either Whitehorse or Haines Junction that would be economically feasible only with material waste heat sales for biomass and WTE, tipping fees for WTE and biogas, and material capital cost subsidy for biomass and biogas.

There is limited basis for providing detailed environmental or social evaluations of these resource options, and GIS-related site details are not relevant to the current resource options evaluation.

For reference, the following summary information is noted for each of these resource options:

- **Waste-to-Energy Generation (WTE)** plant in Whitehorse (Morrison Hershfield [MH] report, "Waste to Energy Updated Design Basis and Business Case Analysis", April 24, 2012 for 1.6 MW plant option generating 9,975 MWh/year with controlled-air two-stage technology; Nov. 13, 2015 MH letter reviewing business case). The following are summarized from these MH reports:
    - The option assumes use of municipal solid waste (MSW) as fuel, augmented with higher cost wood biomass during winter when MSW volume is reduced, and potential to use waste heat from the electricity generation in a future District Energy System (DES).
    - Available MSW volumes was assumed to be reduced significantly coinciding with Zero Waste program in the City's Solid Waste Action Plan (City of Whitehorse 2013). Wood biomass was assumed to be obtained from a variety of sources (including spruce beetle-killed wood, local brushing and clearing, construction and demolition waste).
    - It was considered premature to select a 2 ha site for this option within Whitehorse (the 2012 report assumed site in the Marwell Industrial area because of proximity to potential heat customers, access to municipal services and compatibility with adjacent land uses).
    - Revenues from this option in the 2012 business case analysis were highly dependent on revenues from both MSW tipping fees (assumed $108 per tonne of MSW received) and sale of heat to a future DES in Whitehorse ($81/MWh derived from a DES study completed for Yukon Energy in 2013, "Whitehorse Community Energy Project: Community Energy System Feasibility Study Report", FVB Energy Inc).

- Base case cost of power was estimated at $0.31/kWh, assuming a 25 year economic life.[2] This cost would be lower if able to secure federal grants for about 39% of the capital cost ($0.21/kWh was estimated).
- WTE facilities have emissions to air, land and water (in the form of stack emissions, ash and waste water). Air emissions controls can account for up to one-third of facility capital costs. The most probable carbon credit opportunities are for emissions avoided from the displacement of fossil fuel electricity generation and oil and propane for heating.
- The facility has an annual water demand of 14,500,000 litres.

- **Wood Biomass Generation** plant near Haines Junction (Stantec report, "Final FEED Report, Front End Engineering Design [FEED] Study, Yukon Bioenergy Demonstration Project in Haines Junction. Yukon", Oct. 18, 2013; Jan. 15, 2016 "Biomass Technology Update" Stantec letter).

  The following are summarized from the 2016 and 2013 Stantec reports (for the current resource option evaluation, only the smaller 0.5 MW option [using 3,000 oven dry tonnes/year] is considered as it is likely able to proceed solely using beetle-kill biomass, plus forest harvest and sawmill residues):

  - A screening assessment was provided for options in the range of 0.5 to 2.0 MW, using gasification technology to combust biomass (wood chips) to heat a fluid for use in a turbine-generator. Beetle-kill biomass would offer a much lower moisture content (15%) than green (live) biomass (50%). The smaller plant option could likely be supplied with minimal impact to existing operators/policies (sawmill residues and forest harvesting residues, mostly dead trees from the spruce beetle infestation until that supply runs out); in contrast, the larger plant operation would require additional biomass supplied by new harvesting operations/policies and would extend into harvesting green trees sooner.
  - The 2013 Stantec report considered plant siting, noting the likely need to consider waste heat use options and a 400 m buffer zone around buildings that could use the waste heat. A location near the school was recommended to capture the school waste heating load.
  - A conventional boiler/steam turbine option was estimated (2016 Stantec) to have the following characteristics for the 0.5 and 2.0 MW scales (two other technology options were also examined):
    - Annual net generation 3,224 MWh to 14,708 MWh;
    - Capital cost of $11.3 to $14.9 million;
    - Annual operations and maintenance (O&M) cost of $615,000 to $750,000, excluding any biomass feedstock cost; and
    - A 20-year economic life is assumed.

[2] Assumed capital cost of $34.6 million (annual capital cost of $2.6 million assuming 25-year life and 5.5% interest), non-fuel operating cost of $3.3 million/year (including 18 staff), wood biomass cost of $0.8 million/year (7,652 wet tonnes/year), heat sales revenue of $1.9 million/year ($81/MWh), and tipping fees revenue of $1.7 million/year (16,098 tonnes MSW/year). Absent sale of waste heat the cost of power would be higher at $0.34/kW.h (with 625/kWh per tonne of biomass or 14,844 MWh/year and 2.0 MW capacity).

  - Assuming full utilization of the energy provided, financial viability depends on subsidization of a large portion of the initial capital cost (2013 Stantec).
  - The 2013 Stantec report included a draft Environmental and Socio-economic Impact Assessment.

- **Biogas Generation** plant in Whitehorse (WSP Canada Inc. [WSP], "Biogas Plant in Whitehorse, Feasibility Study", January 2016). The following are summarized from the 2016 WSP report:
  - The plant of about 200 kW capacity, with annual energy initially at about 0.4 GWh (increasing over 20 year life) would treat residential and commercial source separated organic (SSO) waste and utilize the biogas to produce power and/or heat. About 65% of generation would be in the warmer months from May to October.
  - The plant would be located at the Whitehorse municipal landfill next to the existing composting site (footprint of about 1800 m^2). Waste heat sale is not recommended given the location and seasonality issues.
  - Estimated capital cost is $7.1 million, with annual operating cost of $255,000.
  - Revenues would come from gate fees (assumed $38/tonne), electricity sales (assumed $0.21/kWh) and heat savings (assumed $12/GJ). Based on current market price assumptions, the project is not viable and would require significant capital subsidy support (e.g., 70%).

3.2 ENERGY STORAGE FACILITY (BATTERIES)

Energy storage facilities can enhance opportunities for renewable generation options that may be affected by interruptions to the resource, e.g., solar and wind. Non-hydro energy storage options were examined as part of the current Resource Plan. Pumped storage hydro options have been examined separately (see Section 4.1 below).

Trans Grid Solutions Inc. (TGS) provided Yukon Energy with a report "Energy Storage Technologies," April 18, 2016 that examined a wide range of energy storage options, including mechanical, chemical, electrochemical, high temperature batteries, electrical field, magnetic field and thermal. The report identified the following electrochemical battery technology options as the optimum options using lead acid batteries or lithium ion batteries to supply power and energy demands during peak load conditions, as well as mitigating power quality concerns on the grid:

- 3 lead acid based systems rated at 4 MW/40 MWh, 6 MW/60 MWh, and 8 MW/80 MWh; and
- 1 lithium ion based system rated at 8 MW/40 MWh.

Over an assumed 30 year life all of these Battery Energy Storage System (BESS) options had significantly higher costs compared to their respective benefits.[3] The smallest lead acid based system and the lithium

[3] Capital cost (including replacements and balance of plant) estimated at $39.1 million for lead acid based system (4000 kW, 10h) and $49.5 million for lithium ion system (replacements needed in 15 and 20 years respectively at $17.4 million and $22.1 million). Annual O&M at $210k and 260k per year respectively. Annual energy use estimated at 2.4 GW.h for lead acid based system and 2.8 GW.h for lithium ion system (about 60 and 70 days of operation respectively). LCOE in nominal values (5.45% WACC) estimated at

ion system had the best net present values. Footprints for these two facility options approximate 6,400 m^2 and 4,200 m^2, respectively. No specific site option was specifically examined, but Yukon Energy advises that this resource option is assumed to be located at the Takhini Substation (the facility footprint would be about 15% larger than can be accommodated on the existing substation site and some adjacent land already zoned for utility use would be required).

It is not expected that this option will require material evaluation under environmental, social or economic criteria in the existing study.

3.3 SOLAR PV

The Solvest final report is available for the utility scale photovoltaic (PV) solar energy resource option ("Solar Site Inventory," May 2016). Review of solar resource irradiance data for various communities in Yukon showed a variance of only 9% across all communities connected to the grid and only 6% variance from Whitehorse. Based on this information, two communities were selected (Whitehorse and Haines Junction) in order to control construction costs and keep the facility close to existing electrical infrastructure and points of use.

The Solvest report examines a range of PV technologies for modules, inverters and racking. Solar efficiency declines with lower temperatures. Overall, for both sites and the range of solar plant scales, the report indicates the lowest LCOE generally occurs with First Solar cells, the central inverter from ABB, and fixed tilt racking.[4] Plant scales were examined at 1 MW, 5 MW and (for Whitehorse site only due to site limits) 10 MW, assuming the above technology combination as a reflection of lowest LCOE cost. The 10 MW option displayed higher LCOE due to added complexities and the need to incorporate batteries.

Table A 3-1 summarizes the available information on energy production and economics for the options at each site with the lowest LCOE. Annual energy production for these options tends to range between 10% and 15% of installed capacity. The report provides a breakdown of this energy production by month, highlighting that low production can be expected during November through February (due to both sun availability and cold temperatures).[5]

The following summary information is provided on the two selected sites (global positioning system [GPS] coordinates are provided in the Solvest report for each site):

- **Whitehorse Quarry Site (120 acres, with about 110 acres useable for solar farm configuration)** - Located on the old tailings pile for the Whitehorse Copper Mine within Whitehorse city limits, with established road access and 120 acres of open land with minimal fluctuations in elevation across the pile. The site is 2.8 km from Mount Sima substation (connection will be at 34.5 kV). Estimated site area required for the option with the lowest LCOE i.e., First Solar with ABB central inverter at 1 MW is about 11 acres, at 5 MW is about 51.2 acres with fixed tilt tracking (71.2 acres with single axis tracking), and at 10 MW is about 102.4 acres

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$1.01/kW.h and $1.06/kW.h respectively. [LCOE in real terms (3.38% WACC) would approximate $0.79/kW.h and $0.83/kW.h respectively.]

[4] The report suggests that this technology option with single axis tracking for 5 MW at the Haines Junction site may yield a very slightly lower LCOE ($0.141/kW.h) than with fixed tilt tracking ($0.142/kW.h).

[5] Information in the report suggests that irradiation is relatively strong in March through August.

with fixed tilt tracking (142.4 acres if using single axis tracking, i.e., single axis tracking with 10 MW First Solar does not fit on this site - only Sunpower, Panasonic HIT, or Prism Bi-facial would fit with single axis tracking).

- **Haines Junction Site North of Dump (65 acres, with about 55 acres useable for solar farm configuration)** - Located 1 km from the Haines Junction dump, in a largely open area with thin tree cover, minimal fluctuation in elevation across the site, and close proximity to the highway (500 m) and substation (3.4 km). Estimated site area required for the option with the lowest LCOE at 1 MW is about 11 acres, and at 5 MW is about 51.2 acres (71.2 acres if use single axis tracking, i.e., single axis tracking with 5 MW First Solar does not fit on this site - only Sunpower, Panasonic HIT, or Prism Bi-facial would fit with single axis tracking).

Table A 3-1: Solar PV Energy Production & Economics (2015$)
(Assumes First Solar Cells, ABB Central Inverter - 30 year life)

Solar Site Option	Net MW	Annual Energy GWh/year[1]	Average Capital Costs ($million)	Average O&M Costs ($million year 1)	LCOC ($million/MW-year)	LCOE ($/kWh)
Whitehorse (with fixed tilt tracking) Heliene Poly[2]	1 MW 5 MW 10 MW	1.076 5.239 11.471	$3.3 $12.7 35.6	0.0315 0.1426 0.3732	$0.658 $0.491 $0.804	$0.174 $0.141 $0.200
Haines Junction (with fixed tilt racking)	1 MW 5 MW	1.111 5.232	$2.9 $12.8	$0.0315 $0.1426	$0.553 $0.493	$0.147 $0.142

Notes:
1. Energy production is reduced materially from September through February, i.e., estimates indicate only 21% to 26% of annual energy for these options occurs in six months from September to February inclusive, and about 50% to 52% of annual energy in 5 months from June to October inclusive. Peak energy generation is in March-May period (37% to 41% of total annual generation is in these three months).
2. Heliene Poly is lowest LCOE of 10 MW options at Whitehorse with an estimated LCOE. Report does not provide cost or energy estimates for First Solar option at 10 MW at Whitehorse.

3.4 WIND FARMS

The Canadian Biomass Energy Research Ltd. (CBER), with ENVINT Consulting and V3 Energy, LLC, provided Yukon Energy with a final report on wind farm options ("Yukon Wind Site Inventory", August 24, 2016), identifying five potential new wind project sites near existing and planned power infrastructure plus the Tehcho and Mt. Sumanik sites, which Yukon Energy had previously examined in some detail.

Wind farms include the following infrastructure: towers with turbines, access road, turbine road, and transmission line to connect to the grid. The CBER study developed estimates of annual net generation, capital costs and annual operating costs for each of the seven identified sites at 6 MW, 10 MW and 20 MW scales of development. The CBER study provided estimates of monthly distribution of annual generation at each of the seven sites, indicating a clear pattern for each site of lower monthly mean power production during the summer months compared to winter (on average, three-fourths of wind energy generated for the seven sites would be during the seven months from October to April). The

study commented on reliable capacity contributions from wind farms[6], but did not address the potential requirements for other new facilities on the grid for reliability requirements.[7]

The current evaluation assumes the 20 MW capacity case from the CBER study for each site option, with 10 turbines each of 2 MW capacity with a 90-metre rotor diameter, and 80-metre hub height. For the representative wind turbine layouts provided in the CBER study, an approximate turbine separation of five rotor diameters, or 450m, was consistently assumed and was reported to be the conservative end of the three to five rotor diameter separation ranges generally recommended within the wind power industry for turbines oriented perpendicular to the prevailing wind.

The following seven short-listed 20 MW wind farm sites from the CBER report are to be evaluated (GIS information has been provided on these sites). See Table A 3-2 for summary of generation, capital cost, O&M annual cost, and LCOE for each site over an assumed 25 year life. Information on long-term average power generation by month will be provided in future.

- **Cyprus Mine Hill** - Located north of Faro mine on a brownfield site previously developed for this mine with 7.6 km transmission line to existing transmission and 12.5 km access road and turbine road.
- **Kluane Lake (west shore)** - Located on west side of Kluane Lake, northwest of Haines Junction and south of Destruction Bay, with transmission at 58.6 km to Haines Junction and 21.4 km underwater. Costing in Table A 3-2 assumes that the required transmission from the wind farm to the grid is developed independently of this wind farm project, e.g., the Aishihik-Destruction Bay transmission corridor would address this requirement. The CBER report indicates that this is the only relatively low elevation location in Yukon with projected high wind speeds, and it is at much lower elevation than the six other shortlisted sites. CBER notes that the lower elevation would mean that the wintertime rime icing that would be an operational challenge at the higher elevation sites would likely not exist at Kluane Lake or be significantly less problematic.
- **Miller's Ridge** - Located west of (and close to) Carmacks, with 13.6 km transmission to grid and 8.19 km access road and turbine road.
- **Sugarloaf Mountain** - Located south east of Carcross, with 3.77 km transmission to grid and 5.57 km access road and turbine road.
- **Mount Sumanik** - Located northwest of (and close to) Whitehorse, with 3.13 km transmission to grid and 10.64 km access road and turbine road. Yukon Energy has prior studies on this site.
- **Tehcho (Ferry Hill)** - Located north of (and close to) Stewart Crossing, with 3.30 km transmission to grid (upgrade) and 3.79 km access road and turbine road. Yukon Energy has prior studies on this site option.

[6] The study estimated reliable winter capacity as being equal to the mean annual power output, and estimates (based on all seven wind farms examined) that this would equal 5.2 MW (26% capacity factor) for a 20 MW wind farm. The study noted that additional wind farms would lower the capacity credit per farm but could also increase the ability of wind to provide base load power (firm capacity) when they are geographically distant.

[7] The 2011 Yukon Energy Resource Plan assumed that a 5 MW diesel rotary uninterruptible power (DRUPS) unit would be required for a 20 MW wind farm connection to provide for grid reliability requirements.

- **Thulsoo Mountain** - Located close to the Aishihik hydro generation station, with 10.6 km transmission to grid and 12.75 km access road and turbine road.

It has been noted by Yukon Energy that Kluane Lake and Tehcho are sites that obviously require clearing. To the extent other sites are located on mountain ridges, less clearing may be required for the turbines. The Cyprus Mine site is a brownfield site.

Table A 3-2: Wind Farm Sites Energy Production & Economics (2015$) (25-year life)[8]

Wind Site Option	MW	Annual Net Capacity Factor[1] (%)	Annual Net Energy GWh/year	Capital Costs ($million)	O&M Costs ($million/ year)[3]	LCOC ($million/ MW-year)	LCOE ($/kWh)[3]
Cyprus Mine	20 MW	28.3%	49.6	69	1.360	N/A	0.117
Kluane (ex. trans. to grid)[2]	20 MW	27.3%	47.8	62	1.307	N/A	0.110
Miller's Ridge	20 MW	32.7%	57.3	73	1.442	N/A	0.107
Sugarloaf	20 MW	18.4%	32.3	62	0.984	N/A	0.153
Sumanik	20 MW	23.7%	41.5	64	1.119	N/A	0.124
Tehcho	20 MW	19.1%	33.4	64	0.972	N/A	0.151
Thulsoo	20 MW	31.0%	54.4	72	1.390	N/A	0.109

Notes:
1. CBER estimates of annual average wind generation per site, less wake loss, and losses for de-icing electricity and turbine stalling, low-temperature downtime, transformer losses, sub-optimal performance, and maintenance.
2. Costs exclude capital and O&M adjustments for transmission connection from the local area to the grid (see Section 5.1 of this Appendix for current cost estimates).
3. O&M costs based on variable O&M costs for first five years at $15/MW.h gross generation (2015$) without provision for expected increases of variable O&M costs thereafter (the study estimates that variable O&M costs [2015$] will increase to $25/MW.h from years 6 to 10 and then to $30 after that).

3.5 GEOTHERMAL

The KGS Group provided YEC with a final report for the geothermal resource option ("Geothermal Review and Site Inventory", September 2016). After review of available information, this study concluded that two sites (Vista Mountain and McArthur Springs) have the largest production capacity for sites located close (i.e., within about 25 km) to Yukon Energy's existing and future planned grid infrastructure. As the exact amount of production capacity is unknown (i.e., no exploration wells have been drilled yet at either site), a best and worst case scenario (in terms of water production) was considered for each location.

A geothermal facility at either site includes the plant site (building and related fenced area), two production wells and one induction well (the wells are about 1 km apart), plus the access road and transmission connection to the grid. Geothermal production capability is higher in winter (lower temperatures) than in summer (the report provides generation by month). Energy generation and

[8] Estimates are per Tables 8 and 18 and Appendix D of CBER study.

capacity degenerate over time unless added maintenance wells are drilled - the study assumes 2% per year degeneration over an assumed 30 year project life. Operating employment is estimated at a half-time FTE for each plant option.

The following summary information is noted for the two site options identified (see Table A 3-3):

- **Vista Mountain** - This site requires about 5 km of new transmission (34.5 kV) for connection to the existing grid. It is close to the Whitehorse load centre, the existing Klondike Highway and the Takhini substation. It is located on Crown land and has the highest inferred temperature of options examined within 25 km of existing infrastructure. The plant site footprint is estimated to range from 1,840 to 2,900 m^2 (depending on the ultimate capacity that is confirmed).

  Expected plant annual average net capacity in first year of operation ranges from 0.9 MW to 2.3 MW (low and high estimates), with initial annual energy generation ranging from 8.15 GWh/year to 20.95 GWh/year (after 30 years this degenerates to the range of 4.54 GWh/year to 11.66 GWh/year). Average annual energy over the 30 year life is 11.03 GWh/year. Project capital cost for this range of capacity is $37.8 million to $45.2 million, and annual fixed operating costs range from $0.35 million to $0.8 million (2015$).

  LCOE estimates (2015$) over the 30 year life at 3.38% WACC range from $0.194 to $0.368 per kWh, depending on plant capacity, with the highest LCOE cost being associated with the low capacity.

- **McArthur Springs** - This site was the most promising of the options reviewed (highest inferred temperature), but it is located more than 25 km from the existing grid (estimated transmission and road development connection distance of 43 km with transmission at 138 kV). The site is located east of Highway no. 2, southeast of Stewart Crossing. It is located within the Ddhaw Ghro Habitat Protection Area, in an area designated for mine development by Selkirk First Nation. The plant site footprint is estimated to range from 2,900 to 5,000 m^2 (depending on the ultimate capacity that is confirmed).

  Expected plant annual average net capacity in first year of operation ranges from 2.1 MW to 5.5 MW (low and high estimate), with initial annual energy generation ranging from 18.62 GWh/year to 48.24 GWh/year (after 30 years this degenerates to the range of 10.37 GWh/year to 26.85 GWh/year). Average annual energy over the 30 year life is 25.33 GWh/year. Project capital cost for this range of capacity is $114 million to $127 million, and annual fixed operating costs range from $0.8 million to $1.8 million (2015$).

  LCOE estimates (2015$) over the 30 year life at 3.38% WACC range from $0.225 to $0.469 per kWh, depending on plant capacity, with the highest LCOE cost being associated with the low capacity estimate.

Table A 3-3: Geothermal Site Production & Economics (2015$) (30-year life)

Geothermal Site Option	Net MW (Average annual, initial year)[1]	Annual Energy GWh/yr. (initial year)[1]	Capital Costs ($million)	O&M Costs ($million/ year)	LCOC ($million/ MW-yr.)	LCOE ($/kWh)
Vista Mountain	0.9 to 2.3 MW Average 1.6 MW	8.15 to 20.95 GWh 1st yr. Average 14.55 GWh Lifetime average 11.03 GWh	$37.8 to $45.2 Average $41.5	$0.350 to $0.8 Average $0.575	$1.1 to $2.3 Average $1.71	$0.19 to $0.37 Average $0.281
McArthur Springs	2.1 to 5.5 MW Average 3.8 MW	18.62 to 48.24 GWh 1st year Average 33.43 GWh Lifetime average 25.33 GWh	$114 to $127 Average $120.5	$0.8 to $1.8 Average $1.3	$1.4 to $3.2 $2.30	$0.22 to $0.47 Average $0.347

Note:
1. Net capacity and annual energy degenerate at 2%/year over 30 year life; net capacity is higher in winter than in summer.

4.0 HYDRO RENEWABLE GENERATION

4.1 PUMPED STORAGE PROJECTS

Pumped storage resource options are identified below from three separate sets of reports.

Knight Piesold Report

Knight Piesold Consulting (KP) provided Yukon Energy with a report on pumped storage options ("Pumped-Storage Assessment, Preliminary Assessment", September 30, 2016), identifying viable pumped storage sites (outside parks and protected areas) within a 25 km radius of existing and proposed transmission infrastructure.

The pumped storage sites were assumed in the KP assessment to provide seasonal pumping from May through to September and seasonal generation from October through to April. Aside from an assumed variable O&M cost of $0.005/kWh, energy required for pumping is assumed in the KP report to have no cost, implicitly assuming adequate surplus renewable energy on the grid from May through September. Surplus renewable energy on the Yukon grid is affected by assumed grid loads, long-term average hydro generation by season, and renewable wind or solar generation. With current renewable generation, seasonal surplus generation is typically focused in the period from late May to early November.

Out of 473 potential reservoir basins and approximately 200 technically viable sites, the following 7 sites were selected by KP for further evaluation (see Table A 4-1 below for summary of capacity and energy options assessed by KP for each site that is retained for the current evaluation, including pumping annual energy requirements, resulting capital and O&M cost estimates, and resulting LCOE and LCOC estimates):[9]

- **Tutshi-Moon** - located near Tutshi Lake, BC (study assumed existence of Whitehorse-Skagway transmission corridor only 2.6 km from site. Without this line, the distance to the nearest point of intersection increases by approximately 35 km and that would only connect to the 34.5 kV network).
- **Racine-Moon** - located near Racine Lake, BC (study assumed existence of Whitehorse-Skagway transmission corridor 20.6 km from site. Without this line, the distance to the nearest point of intersection increases by approximately 35 km and that would only connect to the 34.5 kV network). KP only examined the 50 GWh/year option for this site.
- **Racine-Mt. Brown** - located near Racine Lake, BC (study assumed existence of Whitehorse-Skagway transmission corridor 24 km from site. Without this line, the distance to the nearest point of intersection increases by approximately 35 km and that would only connect to the 34.5 kV network).

[9] KP did not show comparative areas for natural versus flooded for these options. Reservoir areas with each project site show increase for the upper reservoir area in some cases if examine 100 GWh versus 50 GWh options, e.g., Tutshi-Moon goes from 500 to 61 ha, Racine-Mt. Brown goes from 210 to 290 ha, and Atlin-Black mountain goes from 230 to 313 ha; however, the lower reservoir changes are generally much more muted for these three sites when the larger option is examined.

- **Lindeman-Fraser** - located near Fraser, BC (study assumed existence of Whitehorse-Skagway transmission corridor only 5 km from site. Without this line, the distance to the nearest point of intersection increases by approximately 45 km and that would only connect to the 34.5 kV network). KP only examined the 50 GWh/year option for this site.
- **Atlin-Black Mountain** - located near Atlin, BC (study assumed existence of Whitehorse-Atlin transmission corridor within less than 1 km from site. Without this line, the distance to the nearest point of intersection increases by over 40 km and that would only connect to the 34.5 kV network).
- **Squanga-Dalayee** - located between Johnson's Crossing and Jake's Corner, Yukon (study assumed existence of Whitehorse-Teslin transmission corridor less than 2 km from site (the existing transmission is 34.5 kV). KP only examined a 100 GWh storage option for this site.
- **Canyon-Ittlemit** - located near Canyon Lake and the Aishihik Hydro Facility, Yukon (transmission connection 13.9 km to existing 138 kV grid). KP only examined a 100 GWh storage option for this site.

The KP report concluded as follows with regard to pumped storage site options and configurations:

- Tutshi-Moon site option was the most cost-effective option for all cases examined. The Atlin-Black Mt. and Racine-Mt. Brown options also have similarly competitive costs, particularly for the 50 GW.h configurations.
- Racine-Moon and Lindeman-Fraser site options have technical constraints that make them less promising.
- Squanga-Dalayee and Canyon-Ittlemit site options are less cost-effective than Tutshi-Moon, but have the advantage of being relatively closer to existing Yukon Energy infrastructure. It was noted that it is not known at this stage whether a viable project configuration can be found for the Canyon-Ittlemit facility that does not negatively impact the existing Aishihik Hydro Facility.
- Preliminary site visits were recommended as a next step to five of the short-listed sites, which excluded Racine-Moon and Lindeman-Fraser sites.
- The lowest LCOE ($0.19/kWh) is achieved with the 15 MW/100 GWh configuration; however, the lowest LCOC ($650/KW/year) is achieved with the 25 MW/50 GWh configuration. These costs exclude new transmission required from the site area to the Whitehorse grid.
- KP noted that reducing energy storage further may provide a lower cost of capacity and would be more in line with the development trend in pumped storage facilities worldwide (short duration storage of hours to days rather than seasonal storage, focusing on rapid response with variable-speed units, which make a facility able to provide grid stability, frequency control, voltage regulation, spinning reserve and other grid support ancillary services).

Sites were identified in the KP report with 15 to 25 MW and (for each capacity) 50 and 100 GWh/year energy storage. Annual pumping energy required can vary materially among site options depending on site features. For the purpose of the current resource options evaluation, Yukon Energy has requested

that the 15 MW capacity with 50 GWh/year option and the 25 MW with 100 GWh/year option be included.

Based on the above request, the 15 MW option with 100 GWh/year and the 25 MW option with 50 GWh/year are not included at any site in the current resource options evaluation (see Table A 4-1).

The current resource options evaluation also excludes the KP version of the Tutshi-Moon site option and instead looks at the Moon Lake resource option as examined in the Midgard report (see below).

Midgard Report

The Tutshi-Moon site in the KP desktop study is the same site assessed by Midgard Consulting Inc. (Midgard) in an earlier, more detailed conceptual study for Yukon Energy ("Moon Lake - Pumped Storage Conceptual Study Report", December 14, 2015). Yukon Energy has requested that the Midgard study be used for the Moon Lake pumped storage site option in the current evaluation study.

The following are noted from the Midgard study (see Table A 4-1 below for a summary of capacity and energy options assessed by Midgard for the Moon Lake site option assuming 54 GWh/year of annual energy generation for use on the grid, 48 GWh/year pumping annual energy requirements, resulting capital and O&M cost estimates, and resulting LCOE and LCOC estimates):

- Assumed 48 GWh/year of available pumping energy from weeks 20 to 44 (late May to early November, based on Yukon Energy 2022 forecast for surplus hydro and assumed wind generation - this forecast also indicated diesel generation to be displaced at 23.75 GWh). Surplus energy available for pumping with current renewable capacity declines as grid load increases (2030 forecast showed reduction to 31 GWh/year), and the report assumes adequate new renewable generation is provided to retain the surplus energy needed for this pumped storage site option.
- Assumed facility has 31m high, 700m long earth dam at outflow of Moon Lake, a 5.5 km long, 0.5m diameter buried steel penstock, and a concrete and structural steel powerhouse 400m below on the shore of Tutshi Lake. The project will create a 690 ha reservoir over the existing Moon Lake, and this reservoir level will vary from minimum operating level (MOL) of 1,114m [3.44 km^2 area] and a full supply level (FSL) of 1,125m [6.9 km^2 area]. Over 45 years of water records, water in the reservoir is estimated to spill 18 years and draw down to MOL 2 years.
- Capital cost and O&M cost estimates for this site option are lower than for the KP report, and the LCOE is also notably lower (assumed 65-year life with constant energy levels and WACC at 3.38%/year net of inflation).
    - Capital cost is $217.6 million in the Midgard report, compared with $237.6 million in the KP report for 15 MW and 50 GWh of pumped storage.
    - O&M cost is $1.896 million/year in the Midgard report, compared with $4.784 million/year in the KP report for 15 MW and 50 GWh of pumped storage. [KP O&M cost assumes 2.0% of capital cost before IDC plus $0.005/kWh variable cost for generation and pumped energy, without specific consideration of BC resource fees. Midgard's O&M cost estimate includes BC resource fees and explicit provision for general O&M, major

maintenance allowance, management/ administration/ overhead, insurance and property tax].

- LCOE is $0.189/kWh in the Midgard report, compared with $0.28/kWh in the KP report for 15 MW and 50 GWh of pumped storage.

EP Report

In addition to the above, EMC^2-Picacho (EP) provided Yukon Energy with a conceptual assessment of seasonal pumped storage options at the Faro Mine Complex (EP Technical Memo, May 16, 2016).

The overall approach in the EP report assumes the use of the existing infrastructure of the Faro Mine Complex (e.g., pits, roads, transmission) to develop seasonal pumped storage to provide four to five months of winter generation. The upper reservoir would be created in or close to existing or future (i.e., if future development occurred of the unexploited Grizzly Deposit) waste rock dumps and would involve appropriate measures to provide the necessary environmental protection and a watertight reservoir. The EP study concluded that the following two options potentially could be economically viable only when the upper reservoir costs are shared by a mining operation (all costs in US$2015):

- **Scheme A: Faro Pit** - A 4 MW option with 9.6 GWh pumped storage (winter generation supply) with the upper reservoir located on top of the existing waste rock dump south of the Faro Pit and with the Faro Pit serving as the lower reservoir. The scheme will have a pump/turbine in the pit area that will pump stored water to the waste dump reservoir; in return, the water will drop via a penstock pipe to the pump/turbine installed on a floating barge on the pit lake (total available head of at least 300 m). The summer energy required for pumping is 11.7 GWh.

  Estimated cost of the Faro Pit scheme is US$89 million as a stand-alone project, with 50 year assumed life and annual O&M cost of approximately US$0.233 million plus an assumed summer pumping cost of US$0.351 million (assumes summer power cost of US$0.03/kWh). The study noted that if the mine picked up 50% of the reclamation costs (i.e., regarding the upper reservoir side slopes and lining the upper reservoir with an 80 mil HDPE geomembrane), then the capital cost reduces to US$48 million. Similarly, the study noted that if the mine picked up all of the upper reservoir costs, which is work that the study stated they would do anyway to close the dump, then the scheme would cost US$4.5 million.

  The EP study did an economic assessment using a different approach than that adopted for the KP and Midgard assessments of pumped storage options. Using the KP approach with the EP cost estimates and energy generation, a 50 year life, no cost for summer energy, and a WACC of 3.38% yields an LCOE of US$0.413/kWh for the stand-alone project and US$0.232/kWh if the mine picked up 50% of the reclamation costs.

- **Scheme C: Vangorda Pit** - A 40 MW option with 134 GWh of pumped storage (annual winter generation) with two reservoirs: the upper reservoir with a storage volume capacity 123 million m^3 (built on the generally flat plateau east of the Vangorda Pit, abutting the waste dump on the south side of the Vangorda Pit), and a lower reservoir with a storage capacity of 70 million m^3 (located in a very narrow region of the stream below the upper reservoir). The total available head is 390 m with a 1,780m long penstock leading to the powerhouse located next to the lower embankment. The summer energy required for pumping is 163.4 GWh.

Water from Vangorda Pit operations could be blended into the 106 million m^3 per year of natural inflow volume from the upper and lower catchments, which blending would be beneficial to the mine treatment operations currently ongoing at the pit. Just west of the upper reservoir is the Grizzly Deposit, an unexploited zinc/lead/nickel deposit previously identified as a potentially viable deposit, which if and when developed would enable the upper reservoir embankment to be created from mine waste at almost no extra cost to the mining operations.

The estimated cost of the Vangorda Pit scheme in the EP study is US$392.8 million as a stand-alone project, with a 50 year assumed life and annual O&M cost of approximately US$1.160 million plus an assumed summer pumping cost of US$4.902 million (assumes summer power cost of US$0.03/kWh). The study noted that if the Mine operation related to Grizzly Pit development picked up 50% of the cost for the dam, then the capital cost reduces to US$230.4 million (at Mine support for 75% of this cost, the capital cost overall reduces to US$176 million).

The EP study did an economic assessment using a different approach than that adopted for the KP and Midgard assessments of pumped storage options. Using the KP approach with the EP cost estimates and energy generation, a 50 year life, and a WACC of 3.38% with a cost for summer power of US$.03/kWh yields an LCOE of US$0.168/kWh (US$0.131/kWh if no cost summer power) for the stand-alone project and US$0.117/kWh (US$0.080/kWh if no cost summer power) if the Mine picked up 50% of the reclamation costs.

Both of the above options are assumed to require considerable funding of capital costs by the mine site. The Faro Pit option is also relatively small, while the Vangorda Pit option, at 40 MW, is well beyond the 20 MW cap for resource options being examined for the current Resource Plan.

Yukon Energy has requested that only the Vangorda Pit option be included in the current evaluation without assuming any related mine development. To be consistent with the other projects reviewed, cost related assumptions for the Vangorda Pit are included in Table A 4-1 based on the above EP cost estimates assuming 1$CAN equals $0.75US, as well as assuming a 50 year life with O&M cost for pumped storage energy at only $0.005/kWh.

Table A 4-1: Pumped Storage Sites Energy Production & Economics (2015$) (65-year life)

Pumped Storage Site Option	Net MW	Annual Energy Supply GWh/year	Annual Pump Energy Required GWh/year	Capital Costs ($million)	O&M Costs ($million/year)	LCOC ($million/MW-year)	LCOE ($/kWh)
Moon (Midgard report) (ex. trans. to grid)[1]	20.2 MW	54	48	217.6	1.893 with 0.168 BC resource fees	N/A	0.189
Racine-Moon (KP report) (ex. trans. to grid)[1]	15 MW	50	31.8	473.0	9.2	1.80	0.54
Racine-Mt. Brown (KP report) (ex. trans. to grid)[1]	15 MW 25 MW	50 100	51.8 113.6	284.0 486.0	5.8 10.1	1.1 1.1	0.33 0.29
Lindeman-Fraser (KP report) (ex. trans. to grid)[1]	15 MW	50	55.8	483.8	9.5	1.9	0.56
Squanga-Dalayee (KP report) (ex. trans. to grid)[1]	25 MW	100	119.7	613.4	12.5	1.4	0.36
Atlin-Black Mountain (KP report) (ex. trans. to grid)[1]	15 MW 25 MW	50 100	59.5 121.3	253.8 464.4	5.2 9.7	1.0 1.1	0.30 0.27
Canyon-Ittlemit (KP report)	25 MW	100	119.9	691.2	13.9	1.60	0.40
Vangorda Pit (EP Report-50 year life)[2]	40 MW	134	163.4	523.8	2.4	N/A	0.18

Notes

1. Costs exclude capital and O&M adjustments for transmission connection from the local area to the grid (see Section 5.1 of this Appendix for current cost estimates). Capital costs include interest during construction.
2. Cost, life and LCOE assumptions are not necessarily compatible for this site and other sites.

4.2 SMALL HYDRO PROJECTS

Small hydro resource options are identified from three separate sets of reports below.

Knight Piesold Report

KP provided Yukon Energy with a report on small hydro resource options ("Small Hydroelectric Projects Screening Assessment", October 7, 2016), which screened a wide range of site options and identified five preferred projects and related conclusions based on a desktop level assessment of location, project layout, site characteristics, capacity, energy and cost. The initial study as drafted in April 2016 included Surprise Lake as one of five top projects screened for more intensive assessment. The final report removed Surprise Lake from the top five and included Anvil Creek (Surprise Lake is addressed separately in the MH report summarized below).

Key conclusions from the final KP report include:

- The five most attractive or preferred projects as examined by KP are Drury Lake, Finlayson River, Anvil Creek, Tutshi-Windy Arm, and Wolf River. All of these are storage projects, except for Wolf River (which is a run-of-river project). See Tables A 4-2 and A 4-3 for summary information from the KP report on these preferred projects. Cost estimates for transmission assume that proposed new transmission corridors are in place as noted in Table A 4-2.
- Based on a stand-alone assessment of hydropower development and interconnection to the closest existing or proposed transmission line, the most attractive small hydro sites as assessed in the KP report are the Finlayson River, Wolf River, and Tutshi-Windy Arm. Drury Lake and Anvil Creek appear to be more expensive on a cost of energy basis.
- The initial installed capacities for the Finlayson River, Tutshi-Windy Arm and Wolf River projects are likely in the order of double those used in the present study (where 20 MW was the upper limit):
    - Finlayson River optimum cost to benefit scale could perhaps be in the order of 40 to 45 MW (versus 17.8 MW assumed in this study, which operates at 100% capacity factor).
    - Tutshi-Wind Arm optimum cost to benefit scale could perhaps be in the order of 15 MW (versus 7.2 MW assumed in this study, which operates at 100% capacity factor).
    - Wolf River optimum cost to benefit scale could perhaps be in the order of 40 to 45 MW (versus 20 MW cap assumed in this study). An earlier 1991 study also noted the potential opportunity for storage at Wolf Lake, which could improve winter generation and the plant capacity factor.
- The Tutshi-Windy Arm project has the additional benefit (as a result of storing water for increased winter use) of increasing the winter generation at the Yukon Whitehorse Generating Station on the Yukon River downstream of these small hydro projects:
    - An earlier KGS study estimated an increase of 6 GWh/year in Whitehorse winter generation from control of Tutshi Lake outflows.

  - The initial draft KP study estimated that similar downstream benefits from the Surprise Lake project would be slightly less than 3 GWh/year.

- If the Moon Lake-Tutshi Lake pumped storage project is developed, it may have material synergies with development of the Tutshi-Windy Arm small hydro project, including provision of added downstream winter generation benefits at the Whitehorse Generating Station.

The five small hydro preferred sites in the final KP report are included in the summary information shown in Tables A 4-2 and A 4-3.

Morrison Hershfield Report

The Surprise Lake project assessed in the initial draft KP report is similar to a small hydro project (Atlin project) at this site that Morrison Hershfield (MH) recently examined in more detail ("Atlin Hydro Expansion Pre-Feasibility Study" for Atlin Tlingit Economic Limited Partnership, Revised June 23, 2016). Yukon Energy has directed that the MH study rather than the KP study be used for the current evaluation of this small hydro project.

Comparison of the MH assessment with the initial KP assessment for this site indicates the following:

- Similar design flow, but MH assumes lower gross head than KP (163.3m versus 238.0m).
- MH has lower assumed capacity (7.8 MW versus 14.2 MW with KP), as well as lower annual generation (44.6 GWh versus 58.8 GWh with KP).
- MH capital cost of $120.7 million includes $40.9 million for 100 km of 69 kV transmission; the KP capital cost of $165.7 million excludes any similar transmission connection to the Yukon grid.
- LCOE with MH is $0.144/kWh excluding transmission connection, compared with 0.18/KWh LCOE with KP.

The following MH report information is summarized for the Atlin project (see also Tables A 4-2 and A 4-3):

- The 2.1 MW Atlin Hydro Project on Pine Creek (about 4 km east of the community of Atlin) began commercial power production on April 1, 2009. It is owned by a partnership which is 100% owned by Taku River Tlingit First Nation. The community of Atlin is not connected to any external electrical power grid. Power created by this current project is sold to BC Hydro on a 25-year energy purchase agreement (which includes an obligation to provide 8.3 GWh/year by 2032). The existing project, which currently meets all of the community's electrical power needs and has additional underutilized generating capacity, only develops a portion of the hydropower potential of this site.
- The MH study provided a preliminary assessment of increasing hydropower production for export to the Yukon electrical grid. It looked at expanding the current powerhouse with two additional turbines of 1.45 MW each with related added penstock and intake structure (bringing the total powerhouse capacity to 5 MW) and developing a second lower powerhouse on Atlin Lake (with related new penstock, head pond and intake structure, to provide an additional 2.5 MW to 3 MW [2.8 MW assumed] of capacity). A new 69 kV transmission line of approximately 100 km is

assumed to connect the project with the Yukon electrical grid at Jake's Corner. Modifications were also assumed to the existing Surprise Lake control structure and weir to increase water storage range. A small diversion ditch will divert Spruce Creek into the new lower head pond just upstream up the mouth of creek into Pine Creek.

- Long-term average annual power generation from the project (including existing capacity) was estimated (assuming 2.5m storage at Surprise Lake) at 44.6 GWh/year, with 30.8 GWh (69%) of this generation in the six months from November 1 to April 30; the upper plant contributed 28.2 GWh of the estimated annual generation, and the lower plant contributed 16.3 GWh. Net of an 8.3 GWh/year obligation to BC Hydro, the project can provide long-term average generation of 36.3 GWh/year for export to Yukon. Line losses from transmission would reduce the useable electricity in Yukon: losses of 2.2% are estimated for delivery to Jake's Corner (existing 34.5 kV system in Yukon), and about 5.7% for delivery to Whitehorse (assuming current Yukon grid).[10]
- A capital cost estimate for the project of +/-30% (pre-feasibility) in 2016$ was provided of $79.7 million for the hydroelectric generation component, and $120.7 million including 69 kV transmission required to connect with the Yukon system at Jakes Corner with ability to supply power to Yukon Energy at Whitehorse (when it is not used on the ATCO portion of the southern grid).
- The MH study did not provide any estimate of annual O&M costs for the project. [An O&M cost estimate developed on a basis comparable to the KP study is included in Table A 4-3, assuming a fixed annual cost at 2.0% of capital cost excluding interest during construction (assume this approximates $1.59 million per year based on $79.7 million cost estimate for the project excluding the 100 km transmission line) plus $0.005/kWh variable cost ($0.181 million/year based on 36.3 GW.h new energy for Yukon), or a total O&M cost of $1.771 million/year].
- Assuming 65 year life, 3.38% WCC, the above capital and O&M cost estimates, and 36.3 GWh/year generation for export to Yukon, the estimated LCOE is $0.133/kWh excluding 100km transmission connection cost and $0.176/kWh including the transmission connection cost (2016$). A lower O&M cost than adopted using the KP approach would reduce the LCOE (see separate comments earlier re Moon pumped storage costs based on the Midgard study).

The current resource evaluation study will include the Atlin resource option as described in the MH report. It is noted that costs for transmission connection to the grid as developed in the MH report are not necessarily compatible with cost estimates for this portion as developed for the transmission corridor assessment of the Whitehorse-Atlin Transmission Corridor option (see Section 5.1 below of Appendix A). YEC advises that it expects to use the transmission assessment cost estimates for transmission-related cost elements related to the Atlin project.

[10] The MH study examined transmission connection options linking to a 138 kV new line from Whitehorse to Carcross, which would reduce line loss for transmission to Whitehorse. The study concluded that the option to connect at Jake's Corner, with interconnection on the existing 34.5 kV ATCO line to Yukon Energy's 138 kV grid at Whitehorse, is the most viable option available today for this project.

Earlier Studies regarding Moon Lake Small Hydro Site Option

The KP study of small hydro options excluded the Moon Lake site, which was addressed under pumped storage hydro resource options. The following information is noted from other earlier studies regarding a small hydro option at Moon Lake (this option is not examined further in the current evaluation):

- A conventional Moon Lake site option was included in the study that Midgard (Midgard recently provided for Yukon Energy on the Moon Lake project ("Moon Lake - Pumped Storage Conceptual Study Report", December 14, 2015). Based on Midgard's estimated generation (20 GWh/year), capital cost ($155 million) and related O&M costs (likely about $1.5 million/year based on Midgard's approach), the LCOE for this Moon Lake small hydro option would be very high compared to other options examined in the KP study (i.e., about $0.371/kWh) even before considering transmission connection costs for supply to the current grid.
- An earlier AECOM study[11] for Yukon Energy, using information from the 2007 KGS study, estimated annual generation of 32.9 GWh/year and a LCOE (2009$) of $0.146/kWh excluding transmission connection costs and $0.199/kWh including transmission connection costs (55 km connection).

[11] AECOM, "2009 Large Hydro Stage 1: Initial Investigation", November 2010 (Table 4.4).

Table A 4-2: Small Hydro Site Options - Physical Requirements

Project	Type	Flood Areas (km^2 of New Impoundment)	Design Flow (m^3/s)	Gross Head (m)	Location	Distance (km) to Transmission Lines	Access Road (km)
Drury (KP report)	With Storage	27.9 (new area flooded 1.9)	9.3	99.0	On Drury Creek between Drury Lk and Little Salmon Lk	0.5 to existing	5.3
Finlayson (KP report)	With Storage	10.6 (Wolverine Lk); 23.0 (Finlayson Lk) (new area flooded 5.4)	13.3	150.0	On Finlayson River upstream of Frances Lk. 300 km NE of Whitehorse (relocate 3 km of Highway due to flooding)	155.3 to existing; 5.1 to proposed (Faro-Watson L TL)	17
Atlin (Pine Creek) (MH report)	With Storage	Not applicable (no increase to FSL at Surprise Lake, increase to LSL)	6 to 7	163.1	On Pine Creek between Surprise Lk and Atlin Lk near Atlin, BC. (Upper 5.0 MW [2.9 MW new], lower 2.8 MW)	100 to existing Yukon 34.5 kV transmission	N/A
Tutshi-Windy Arm (KP report)	With Storage	55.0 (Tutshi Lk) (new area flooded 3.1)	15.0	51.0	Between Tutshi Lk and Windy Arm of Tagish Lk in northern BC. 45 km south of Carcross	24.8 to existing; 0.5 to proposed (Whitehorse-Skagway TL)	23.5
Wolf River (KP report)	Run of the River	Not applicable	37.7	60.0	On Wolf River near river mouth and 22 km NE of Teslin and Alaska Hwy	55.1 to existing; 23 to proposed (Whitehorse-Teslin TL)	23
Anvil Creek (KP report)	With Storage	5.9 (new area flooded 0.6)	8.2	13.5	On Anvil Creek approx. 4.7 km downstream of Anvil Lake outlet and upstream of Anvil Creek-Blind Creek confluence (control dam at Anvil Lake outlet)	11 to existing	3.5 new access road

Table A 4-3: Small Hydro Sites Energy Production & Economics (2015$) (65-year life)

Small Hydro Site Options	Installed Capacity (MW)	Net Annual Generation (GWh)	Capital Costs ($million)	O&M Costs ($million/ year)	LCOC ($million/MW-year)	LCOE ($/kWh)
Drury (KP report)	8.1 (8.1 firm winter)	31.7 (100% Nov.-April) (100% firm)	103.3	2.103	0.7	0.19
Finlayson (KP report) (ex. trans. to grid)[1]	17.6 (17.6 firm winter)	138.9 (about 50% Nov.-April) (100% firm)	282.5	6.015	1.0	0.12
Atlin (Pine Creek) (MH report)[1]	7.8 (5.7 new)	44.6 (36.3 available for Yukon - about 70% Nov.-April)	79.7 (excludes cost for 100 km connection)	1.771 (estimated based on KP methods)	N/A	0.133 ex. TL (estimated per KP approach)
Tutshi-Windy Arm (KP report) (ex. trans. to grid)[1]	7.2 (7.2 firm winter)	56.6 (about 50% Nov.-April) (100% firm)	133.2	2.791	1.1	0.14
Wolf River (KP report) (ex. trans. to grid)[1]	20.0 (2.2 firm winter)	95.6 (about 20% Nov.-April) (91% firm)	233.8	4.881	0.7	0.14
Anvil Creek (KP report)	9.8 (2.5 firm winter)	41.3 (about 32% Nov.-April) (75% firm)	116.0	2.391	0.7	0.17

Note:
1. Costs exclude capital and O&M adjustments for transmission connection from the local area to the grid (see Section 5.1 of this Appendix for current cost estimates). Atlin capital cost estimate is in 2016$.

4.3 GLADSTONE DIVERSION

Considerable assessment and feasibility work was done for the Gladstone Diversion project prior to the last Yukon Energy General Rate Application (GRA), including a report by AECOM ("Gladstone Diversion Concept Conceptual Design", May 2011). Based on this earlier work and Yukon Energy filings during its 2012/13 GRA before the Yukon Utilities Board, the following are noted for this project:

- The project proposes to divert water from the headwaters of Gladstone Creek into the Aishihik Lake system and would increase the amount of water available for hydroelectric generation at

the Aishihik Hydro Facility. The project is within the traditional territory of the Champagne and Aishihik First Nations. Kluane First Nation and White River First Nation also have interests in the vicinity of the project on or near Gladstone Creek near Kluane Lake.

- The project concept includes two diversion structures to divert the headwaters of Gladstone Creek into Isaac Creek, which flows into Sekulmun Lake (the primary storage reservoir of Yukon Energy's 37 MW Aishihik Hydro Facility).
- The project is forecast to provide sufficient water for up to an additional 36.6 GWh (on average) of production from the Aishihik facility, focused in the winter months. The project would not add to firm winter capacity on the grid.
- Based on feasibility studies prior to Yukon Energy's last GRA, project cost was estimated at $40 million (2010$) and LCOE over the 65 year project life estimated at 5.7 ¢/kWh (assuming full utilization of added energy generation of up to 36.6 GWh/year during the winter months at the current Aishihik plant and an assumed Yukon Energy blended capital cost averaging 6.56%/year).
- Prior work indicated concerns from the Department of Fisheries and Oceans (DFO) as well as from local First Nations.
- DFO indicated that it had a concern that the proposed Gladstone concept will result in significant effects to fish and fish habitat in the Yukon and Alsek river systems, both of which support high value fisheries. According to DFO, effects would be due particularly to transfer of pathogens and parasites from one watershed to the other. DFO suggested that Yukon Energy revise its concept to eliminate the interbasin water transfer and reduce negative effects to fish habitat. Yukon Energy advised DFO that the concept is still in the very early stages of study/planning, specifically the collection of baseline information and preliminary engineering development to gain an understanding of the feasibility of the concept. Specifically, Yukon Energy noted its intention as part of the baseline studies to gather sufficient information regarding the presence of pathogens and parasites and the risk associated with potential transfer of any pathogens and parasites after all mitigation measures are considered. Once this information is available and the preliminary assessment of risk can be completed, Yukon Energy intends to share this with DFO staff for further discussion and analysis. Yukon Energy reported that the results of a full year of baseline studies provide no evidence to date to support a concern regarding interbasin pathogen transfer.
- Yukon Energy committed as a first priority in 2012 to work with the local First Nations until they make a decision as to whether or not they will support the project.
- The Overview of the 20-year Resource Plan: 2011-2030 from July 2012 recommended that Yukon Energy plan within the next 6 to 12 months to reach a final determination regarding whether the project is feasible to pursue at this time, based on discussions with local First Nations and regulators. Yukon Energy has continued to work with the local First Nations to seek support for this project, given its potential long-term benefits for the system.

4.4 HYDRO STORAGE ENHANCEMENTS

Considerable assessment and feasibility work has been done or is ongoing separate from the current Resource Plan process to examine potential hydro storage enhancement options at Mayo Lake and the Southern Lakes. In the case of the Mayo Lake Enhanced Storage Project, a YESAB submission was filed in 2015 (information from that submission is used for the summary below of this project).

- **Mayo Lake Enhanced Storage Project** – This project would revise the existing Mayo Lake Water Licence to allow up to 1 metre lower supply level (LSL), thereby enabling added long-term average hydro generation at the Mayo hydro generating station (particularly related to enhanced retention of water that would otherwise be spilled during high run off years).

  The specific project proposed serves to increase the long-term average hydro generation potential to displace fossil fuel generation on the Yukon system by approximately 2 to 4 GWh/year[12] (the specific yearly benefit will depend on the overall load level on the Yukon grid, flow conditions throughout Yukon, the Mayo Lake LSL then allowed under the AMP, and the extent of future new renewable generation on the grid).

  The proposed Project requires no new physical works. It will utilize the Mayo Lake Control Structure facilities already in-service for the existing Mayo hydro generation, and ongoing maintenance activities of the structure and associated infrastructure from Mayo Lake to the Mayo Lake Control Dam.[13] Hydro power generation will occur at the existing Yukon Energy facilities at Mayo A and B.

  Mitigation measures proposed for the project are focused on addressing potential adverse effects on fish and fish habitat in the Mayo Lake area (whitefish and lake trout in particular). Changes to water releases would likely enhance downstream salmon spring habitat below the Mayo hydro generating facilities.

  For the first three years of project operation, the lake will be operated with an additional 0.5 m storage range (i.e., between the existing FSL of 665.84 m to a revised LSL of 662.75 m which is 0.5 m below the current LSL of 663.25 m).[14] After the first three years, the results of monitoring and the proposed Adaptive Management Plan will be used to determine if and how to proceed with up to a full metre extra storage (lowering the LSL to 3.59 m below the FSL of 665.84 m) or if the storage range should be reduced to less than 3.09 m.

[12] By way of example, at loads ranging from of 437 to 454 GWh/year, additional long-term average fossil fuel displacement due to the Project's enhancement of long-term average hydro generation ranges from 1.9 to 2.8 GWh/year with 0.5 m enhanced Mayo Lake storage and from 3.4 to 4.2 GWh/year with 1.0 m enhanced Mayo Lake storage. Within the load range of about 460 to 480 GWh/year, fossil fuel generation displacement benefits with 0.5 m enhanced Mayo Lake storage range between 2.9 and 3.2 GWh/year.

[13] Maintenance activities noted here refer to any ongoing works required to keep the control structure operational. See Mayo Outlet Channel Dredging Project.

[14] The current controlled range reflects that under certain water conditions, it is possible for the water level of Mayo Lake to be outside of the stated range due to drought or flood conditions. Under those circumstances, Yukon Energy would be required to operate its facilities at the lake so as to not further exacerbate the elevation conditions. In particular, Clause 25 of the Mayo Water Licence requires that when the lake elevation exceeds the licensed maximum range, Yukon Energy is required to have all of the gates open; a similar practice would be exercised in the event the licensed minimum range was exceeded, consistent with minimum downstream flow requirements.

The project YESAB filing has been delayed pending Yukon Energy addressing the separate maintenance requirement for dredging of sediment built up in the Mayo Outlet Channel. This sediment reduces long-term average hydro generation of the existing facility, and needs to be removed in order for the Mayo Lake project to operate (see Section 4.5 below). The Mayo Lake project in contrast enhances the economic benefit of actions to remove channel sediment and reduce the risk of added future sediment additions to this area.

- **Southern Lakes Enhanced Storage Project** – This project would revise the existing Marsh Lake Water Licence to allow 30 cm higher FSL (656.53 m asl) and 10 cm lower LSL (653.70 m asl) in order to enhance storage in the fall for increased winter use at the Whitehorse hydro generating station. No new dam or generating facilities are required – any works would be related to mitigation measures for shoreline erosion protection or other mitigation.

  The Overview of the 20-year Resource Plan: 2011-2030 in July 2012 estimated that this project would increase long-term average winter hydro generation by up to 6.4 GWh/year, and enhance reliable winter capacity by about 1 MW, at an estimated capital cost of $10.5 million (2010$).

  Marsh Lake water levels can have influence upstream on both Tagish and Bennett Lakes when its lake levels are above about 654.2 m when flows are receding in winter, and above 655.5 m when inflows are increasing in summer. Atlin Lake, along with other higher elevations lakes in the Southern Lakes region are not, and will not be affected by higher levels on Marsh Lake.

4.5 MAYO LAKE OUTLET CHANNEL DREDGING

The Mayo Lake Outlet Channel Dredging Project would remove an old cofferdam as well as sedimentation that has infilled in the Mayo Lake Outlet Channel over the past 63 years since the original Mayo hydro generation was developed and address measures to mitigate potential future sediment infill in this outlet channel.

Current sediment infill is restricting the full hydro capability of the downstream Mayo A and B hydro generation. In addition, this infill plus the cofferdam remnants are preventing any benefit from the Mayo Lake Enhanced Storage project from being realized. There is a risk that additional material sediment infill can occur in response to a major wind event, which would further reduce Mayo hydro long-term average generation capability through further erosion of the cliffs along the north shore of the lake within about 700 m of the mouth of the outlet channel.

Ongoing investigations are required to assess issues and cost effective options to remove existing sedimentation and to minimize the risks of near-term new sedimentation build up in this channel. Maintenance measures to remove sediment infill could involve dredging to move approximately 40,000 to 80,000 m^3 of sediment from the channel to an acceptable nearby land location and/or using releases from the lake at low lake levels that create velocities of flow in the channel, facilitating the occurrence of a natural process of sediment erosion. Mitigation to control future sediment infill could involve shoreline stabilization (in the nearby lake cliff areas and/or in the channel), jetties to control ingestion of sediment-laden plums into the channel or combinations of these measures. Work on this maintenance project would be required to protect fish and fish habitat and water quality. Terrestrial effects would be limited to local areas on the north side of the channel used for access and/or the deposit of sediment removed from the channel.

4.6 REFURBISH EXISTING HYDRO GENERATION

- **Mayo A Refurbishment Project** – A KGS Group draft report is available for Mayo A refurbishment ("Mayo Hydro [MHO] Future Facility Option – Concept Design Report", May 2016). This report covers a conceptual scope of work economic assessment and cost estimate for the following four options for the aged 5 MW Mayo A hydro facility. In all options, the existing dam would remain. The assessments address asset conditions that require action.
  - Option 1: Replace Mayo A hydro station, retaining the foundations and other embedded parts and providing one new turbine and generator, powerhouse, and other facilities.
  - Option 2: Refurbish Mayo A hydro station, retaining the foundations and other embedded parts of the Unit 2 turbine and providing one new generator (2.3 MW, annual energy of 10.2 GWh), turbine support systems, new turbine inlet valves (TIV), balance of plant systems, support systems, control room and surge tank. Repairs/upgrades to the existing powerhouse superstructure and cranes are required. Geotechnical work would be included to stabilize slopes, repair roads and trailrace.
  - Option 3: Remove the powerhouse (excluding the foundation) and the surge tanks, including permanently plugging the penstock upstream of the surge tank take-off and backfilling the powerhouse foundation and tailrace to return the site to near greenfield conditions.
  - Option 4: Abandon the powerhouse in place. The facility would be made safe for abandonment, the penstock would be permanently plugged upstream of the surge tank, and the tailrace would be backfilled.

  Option 2 (the refurbishment option) was found to be the most economical and is the preferred option to be included in the current resource options evaluation. Total project capital cost was estimated at $27.4 million, with an assumed 65-year life span and present value costs during operation of $2.5 million. The report estimated LCOE at $0.147/kWh.

- **Aishihik Rerunnering Project** - The KGS Group final report is available for Aishihik turbine rerunnering ("Aishihik Turbines Uprate Study," February 2016). The study examined two options, both of which would keep plant discharge within existing maximum flows and would not affect hydraulic stability during start-up and shut-down. The options are:
  - Option 1: Uprate only turbine AH2 (estimated capital cost of $3.0 million; 0.7 MW increase in capacity; 2.15 to 2.26 GWh/year benefit of increased energy, varying depending on load; payback estimated in 6 years); and
  - Option 2: Uprate both turbines AH1 and AH2 (estimated capital cost of $4.7 million; 1.3 MW increase in capacity; 2.74 to 3.04 GWh/year benefit of increased energy, varying depending on load; payback estimated in 6 to 7 years).

  Option 2 is assumed for the purpose of the current study, i.e., assumed re-runnering of units AH1 and AH2, providing increased capacity of about 1 MW and increased annual energy of about 3 GWh.

5.0 TRANSMISSION CORRIDOR OPTIONS

5.1 NEW TRANSMISSION CORRIDORS

Midgard has examined for Yukon Energy[15] the following five transmission corridor transmission options (related substation requirements are not addressed in this existing information):[16]

- **Whitehorse-Atlin Corridor** (172 km [reliable transfer capacity 97 MW], 138 kV): Route is assumed to go via Jake's Corner area existing distribution line routing). This option would provide transmission connection into northern BC for the pumped storage option at Atlin-Black Mt. and the small hydro option at Atlin (Pine Creek). Estimated capital expenditure (Capex) at $158 million, estimated operating expense (Opex) at $236k/year; includes 34.5 kV underbuild for 79 km.
- **Whitehorse-Skagway Corridor** (170 km [reliable transfer capacity 443 MW with 230 kV, 114 MW reliable transfer capacity with 138 kV): This corridor would be routed via that Carcross area. This option would provide transmission connection for pumped storage and hydro-related options in northern BC (Moon, Racine-Moon, Racine-Mt. Brown, Lindeman-Fraser, Tutshi-Windy Arm), as well as potential new summer loads (cruise ships) and other new hydro generation options at Skagway. Estimated Capex at $251 million for 230 kV and $166 million for 138 kV, estimated Opex at $285k/year; includes 34.5 kV underbuild for 68 km.
- **Whitehorse-Teslin Corridor** (174 km [reliable transfer capacity 95 MW], 138 kV): This option would provide transmission connection for the Wolf River small hydro option and the Squanga-Dalayee pumped storage option. Estimated Capex at $165 million, estimated Opex at $239k/year; includes 34.5 kV underbuild for 174 km.
- **Faro-Watson Lake Corridor** (414 km [reliable transfer capacity 190 MW], 230 kV); if developed, this option would allow Watson Lake to no longer be a diesel community, and would provide transmission connection for the Finlayson small hydro option as well as larger next generation hydro options in this region. Estimated Capex at $597 million, estimated Opex at $613k/year.
- **Aishihik-Destruction Bay Corridor** (157 km [reliable transfer capacity 484 MW with 230 kV. 122 MW reliable transfer capacity with 138 kV) – a distribution line assumed then from Burwash Landing to Destruction Bay): If developed, this option would allow Burwash Landing and Destruction Bay to no longer be diesel zone communities and would provide transmission connection for the Kluane Lake wind farm option as well as for potential future mine developments in this region. Estimated Capex at $241 million for 230 kV and $167 million for 138 kV, estimated Opex at $217k/year; includes 34.5 kV underbuild for 49 km.

Economic life for new transmission is assumed at 45 years.

[15] Midgard Consulting Inc. (Midgard), "Transmission Options Evaluation", November 8, 2016. All cost estimates in 2016$.
[16] Currently there is no grid in Yukon above 138 kV. The corridor options going south from Whitehorse include adding 138 kV to the existing distribution line voltages (25/34 kV) to Carcross and Teslin.

The Midgard study also provided the following additional assessments of transmission options to connect various project options to the Yukon grid:

- **Faro-Finlayson connection** (233 km with reliable transfer capacity 84 MW at 138 kV; estimated Capex at $221 million, estimated Opex at $351k/year.
- **Whitehorse-Squanga-Dalayee connection** (105 km with reliable transfer capacity 134 MW at 138 Kv; estimated Capex at $100 million, estimated Opex at $143k/year); includes 34.5 kV underbuild for 105 km.
- **Whitehorse-Atlin-Black Mt connection** (127 km with reliable transfer capacity 131 MW at 138 kV; estimated Capex at $119 million, estimated Opex at $174k/year); includes 34.5 kV underbuild for 79 km.
- **Whitehorse-Tutshi Windy Arm connection** (96 km with reliable transfer capacity 135 MW at 138 kV; estimated Capex at $94 million, estimated Opex at $143k/year); includes 34.5 kV underbuild for 68 km.
- **Whitehorse-Racine Mt. Brown; Moon Lake; and Tutshi-Moon Lake connections** (112 km with reliable transfer capacity 132 MW at 138 kV; estimated Capex at $108 million, estimated Opex at $168k/year); includes 34.5 kV underbuild for 68 km.
- **Whitehorse-Lindeman-Fraser connection** (129 km with reliable transfer capacity 129 MW at 138 kV; estimated Capex at $125 million, estimated Opex at $200k/year); includes 34.5 kV underbuild for 68 km.

Centreline GIS information has been provided for each transmission corridor, confirming that each would generally follow existing highway corridors. Each corridor (regardless of voltage variances) is assumed to require a 60 m right-of-way (ROW), with the cleared area constituting only about half of this ROW. The corridor for possible routing options is assumed for current study purposes at 500 m. In general, transmission routing will typically offer ample opportunity to mitigate environmental and socio-economic adverse effects specific to the terrain.

5.2 STEWART KENO CITY TRANSMISSION PROJECT

The Stewart-Keno City Transmission Project is well advanced in terms of permitting assessments. A project proposal was submitted to YESAB in the past year, and a YESAB Screening Report and Recommendation was issued on May 31, 2016.

The project involves the installation of a new 138 kV transmission line from Stewart Crossing to Keno City (about 112 km, located mainly within the existing ROW with the exception of five substantive deviations along the way), along with decommissioning of the existing 69 kV transmission line between Mayo and Keno City and accessory activities, such as the construction of new and modified sub-stations.

The project would replace end-of-life existing 69 kV transmission between Mayo and Keno City with voltage capability able to serve potential future new mine and/or renewable hydro generation connections and extend the 138 kV Yukon grid north beyond Stewart Crossing. Possible options include initial development of only the Mayo to Keno City segment at 138 kV with operation initially at 69 kV.

Yukon Energy's estimated capital cost for the full project (2015$) is approximately $86 million, with $59 million for line construction; $21 million for substation construction; and $5 million for planning, permitting and engineering. About 22% of the estimated transmission line costs is for equipment and about 50% for its installation, while about 25% of the substation costs is for materials and installation.

6.0 SUMMARY OF PROJECTS TO BE EVALUATED

The following summarizes the resource project options to be included in the current evaluation:

1. **Fossil Fuel Thermal Generation:**
    a. Diesel option at 20 MW new facility in Whitehorse, with energy generation dispatchable as required up to 166 GWh/year. Two sites are specified (Whitehorse landfill and Takhini substation). Economic life varies from 20 to 40 years, depending on average annual use of capacity.
    b. LNG option at 20 MW new facility in Whitehorse, with energy generation dispatchable as required up to 166 GWh/year. Specifies same two sites as diesel option. Economic life varies from 20 to 40 years, depending on average annual use of capacity.
2. **Non-Hydro Renewable Generation:**
    a. **Non-fossil Thermal Generation:**
        i. Waste-to-energy (WTE) at Whitehorse. 1.6 MW facility with 10 GWh annual generation, using solid MSW augmented with wood biomass during winter. It is currently premature to select site as viability is greatly enhanced by the sale of waste heat in district waste heating systems. Economic life is 25 years).
        ii. Wood Biomass at Haines Junction. 0.5 MW facility with 3.2 GWh annual net generation, located near school for waste heat use. Uses beetle-kill biomass feedstock. Economic life is 20 years).
        iii. Biogas at Whitehorse. 0.2 MW new facility, with 0.4 GWh initial annual energy. Plant located at municipal landfill next to existing composting site. Footprint is about 1800 m^2. Economic life is 20 years.
    b. **Energy Storage Facility:** (batteries) in Whitehorse (4 MW/40 MWh lead acid-based system or 8 MW/40 MWh lithium ion system). Assumed to be located at Takhini substation with some use of adjacent land. Economic life is 30 years.
    c. **Solar PV:**
        i. Whitehorse: 1 MW, 5 MW and 10 MW options (3 separate options, each at Whitehorse Copper Mine Quarry Site). Annual energy at 1.1 GWh, 5.2 GWh and 10.3 GWh, respectively. 30 year economic life.
        ii. Haines Junction; 1MW, 5 MW options (2 separate options, each located about 1 km from Haines Junction dump on site from the report). Annual energy at 1.1 GWh and 5.2 GWh, respectively. 30 year economic life.

d. **Wind Farms:**

i. Seven site options are examined, each with 25 year economic life:

- Sugarloaf: 20 MW with 32.3 GWh annual energy;
- Tehcho: 20 MW with 33.4 GWh annual energy;
- Mt. Sumanik: 20 MW with 41.5 GWh annual energy;
- Kluane: 20 MW with 47.8 GWh annual energy;
- Cyprus Mine: 20 MW with 49.6 GWh annual energy;
- Thulsoo: 20 MW with 54.4 GWh annual energy; and
- Miller's Ridge: 20 MW with 57.3 GWh annual energy.

ii. Transmission for each site to connect to grid is addressed on stand-alone basis (Kluane Lake option requires consideration of added transmission from what is in Wind report), assuming current centrelines and 60 m ROW, with 30 m cleared and corridor for selecting ROW at 500m width.

e. **Geothermal:** 2 site options, energy capacity at each is the average of potential range in first year of operation. At each site, 2% per year decline in net capacity and energy over 30 year economic life is assumed.

i. Vista Mountain near Takhini substation: Installed capacity average of 1.6 MW with average annual energy of 11.0 GWh over 30 year life.

ii. McArthur Springs south east of Stewart Crossing: Installed capacity of average 3.80 MW with average annual energy of 25.0 GWh over 30 year life.

3. **Hydro Renewable Generation:**

a. **Pumped Storage:** eight site options are examined, and two site options include two scales of development. Transmission for each site to connect to grid is addressed for the evaluation on stand-alone basis without estimating added transmission corridor costs (Canyon-Ittlemit and Vangorda sites are the only options that do not require consideration of added transmission costs according to the Midgard or KP reports), assuming current centrelines and 60 m ROW, with 30 m cleared and corridor for selecting ROW at 500m width. Specific site options are as follows (65 year economic life for each option except Vangorda Pit, where 50 to 65 years is assumed):

i. Midgard report: 1 option: Moon Lake at 20.2 MW and 54 GWh/year;

ii. KP report: 6 sites, 8 options:

- Racine-Moon (1 option): 15 MW with 50 GWh annual energy;
- Lindeman-Fraser (1 option): 15 MW with 50 GWh annual energy;
- Racine-Mt Brown (2 options): 15 MW with 50 GWh annual energy and 25 MW with 100 GWh annual energy;

- Atlin-Black Mountain (2 options): 15 MW with 50 GWh annual energy and 25 MW with 100 GWh annual energy;
- Squanga-Dalayee (1 option): 25 MW with 100 GWh annual energy; and
- Canyon-Ittlemit (1 option): 25 MW with 100 GWh annual energy.

iii. EP report: 1 option: Vangorda Pit: 40 MW with 134 GWh/year of annual energy, without any concurrent mine development.

b. **Small Hydro Projects:** five site options are examined, one of which is run of river and four of which include storage. Transmission for each site to connect to grid addressed for the evaluation on a stand-alone basis without estimating added transmission corridor costs (Drury and Anvil Creek are the only options that do not require consideration of added transmission costs according to the KP or MH reports), assuming current centrelines and 60 m ROW, with 30 m cleared and corridor for selecting ROW at 500m width. Specific site options are as follows (65 year economic life assumed for each option):

i. KP report: 5 sites (includes site added after initial report):

- Drury: 8.1 MW with 31.7 GWh annual energy;
- Tutshi-Windy Arm: 7.2 MW with 56.8 GWh annual energy;
- Wolf River: 20 MW with 95.8 GWh annual energy;
- Finlayson: 17.5 MW with 138.9 GWh annual energy and
- Anvil Creek: 9.8 MW with 41.3 GW.h annual energy (this site added after initial report).

ii. MH report: 1 site: Atlin/Pine Creek: 5.7 MW new capacity with 36.3 GWh/year annual energy for Yukon.

c. **Gladstone Diversion:** One option to enhance hydro generation at Aishihik by up to 36.6 GWh per year. Assumes 65 year economic life (generation at Aishihik generating station).

d. **Hydro Storage Enhancements:** Two options:

i. Mayo Lake Storage Enhancement through a water licence change (without new facilities) to improve winter generation at Mayo hydro on average by 2 to 4 GWh per year, depending on grid load and the outcomes of adaptive management plan activities (YESAB submission has already been prepared).

ii. Southern Lakes Storage Enhancement through a water licence change to improve winter generation at Whitehorse hydro by up to 6.4 GWh/year.

e. **Mayo Lake Outlet Channel Dredging:** one option: maintenance work to remove sediment build up and an old cofferdam in the Mayo Lake Outlet Channel and mitigation measures to inhibit future sediment infill in the channel. This option will restore Mayo B long-term average generation that is currently being restricted and enable the Mayo Lake Storage Enhancement to provide added long-term average hydro generation benefits.

f. **Refurbish Existing Hydro Generation:** Two options:

i. Mayo A Refurbishment: Refurbish Mayo A hydro station, retaining the foundations and other embedded parts of the Unit 2 turbine and providing one new generator (2.3 MW, annual energy of 10.2 GWh); and

ii. Aishihik Re-runnering: Re-runner units AH1 and AH2, providing increased capacity of about 1 MW and increased annual energy of about 3 GWh.

4. **Transmission Corridor Options:**

a. **New Transmission Corridors:** Five options are examined, including segments of a project that would enhance an existing transmission corridor. Each option assumes 60m ROW, with 30 m cleared and corridor for selecting ROW at 500m width (250 m on each side of centreline). Specific site options are as follows (assume 45 year economic life):

i. Whitehorse- Atlin at 138 kV;

ii. Whitehorse Skagway at 230 Kv;

iii. Whitehorse- Teslin at 138 kV;

iv. Faro- Watson Lake at 230 kV; and

v. Aishihik-Destruction Bay at 230 Kv.

b. **Stewart-Keno City Transmission Project:** As recommended in the YESAB Executive Committee Screening Report of May 31, 2016, a new 138 kV transmission line from Stewart Crossing to Keno City (about 112 km, located mainly within the existing ROW with the exception of five substantive deviations along the way), along with decommissioning of the existing 69 kV transmission line between Mayo and Keno City and accessory activities such as the construction of new and modified sub-stations.

When evaluating various renewable generation options, it is relevant to also note comparative scales of energy and/or capacity impacts for the grid.

- Fossil fuel thermal generation provides firm capacity and a wide range of dispatchable energy generation, i.e., up to 166 GW.h per year for 20 MW facility.
- Non-fossil thermal generation options, as well as geothermal options, are each relatively small in terms of capacity (0.2 to 4.0 MW); annual energy generation ranges from 0.4 GWh/year (biogas) to 33.4 GWh/year (geothermal option at McArthur Springs).
- Other renewable energy options show a wide range of annual energy generation:
    - Solar PV is relatively small (1.1 to 10.2 GWh/year), with energy focused from March to August;
    - Wind at 20 MW ranges from 32.8 to 59.0 GWh/year;
    - Small storage hydro ranges from 31.7 to 138.9 GWh/year;
    - Pumped storage hydro ranges from 50 to 134 GWh/year, focused in winter months (these options each need adequate non-winter surplus energy for the required pumping);

- Gladstone Diversion provides up to 36.6 GWh of winter energy; and
- Other hydro projects range from 2 to 10 GWh/year.

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APPENDIX B:
EVALUATION APPROACH – CRITERIA AND INDICATORS

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1.0 INTRODUCTION

An initial task in this study was to review the environmental, social and economic criteria, indicators and metrics in a Draft IRP Resource Option Evaluation Matrix and provide recommendations on removing and/or adding evaluation criteria, potentially changing criteria definitions, and on changing, adding or removing indicators and/or their associated metrics. A rating scheme was also to be developed in collaboration with Yukon Energy Corporation (Yukon Energy) for each of the three attributes in the Evaluation Matrix, and data sources identified for the evaluation.

The Resource Option Evaluation approach is reviewed below as follows:

1. RFP Draft Resource Option Evaluation Matrix;
2. Considerations for Review of Evaluation Approach;
3. Environmental Criteria and Indicators;
4. Social Criteria and Indicators;
5. Economic Criteria and Indicators; and
6. Resource Options Ratings for Each Indicator.

2.0 RFP DRAFT RESOURCE OPTIONS EVALUATION MATRIX

Yukon Energy's Request for Proposal (RFP) 2016-010 for the Resource Options Evaluation (the RFP) provided a Draft IRP Resource Option Evaluation Matrix (the Draft Evaluation Matrix) for review of the various 2016 Resource Plan resource options (see Attachment 1). The Draft Evaluation Matrix includes three separate sets of evaluation criteria:

- **Environmental Criteria:** 4 Environmental criteria, each with 1 to 4 indicators (each indicator needs 1 or more metric for a total of 21 metrics).
- **Social Criteria:** 4 Social criteria, each with 2 to 5 indicators (each indicator needs 1 or more metrics for a total of 13 metrics).
- **Economic Criteria:** 1 Economic criteria with 3 indicators and 5 metrics.

The RFP anticipated that the Draft Evaluation Matrix would be used to evaluate 40 different resource options, including thermal generation options (fossil and non-fossil fuel), solar PV options, geothermal options, wind farm options, pumped storage options, small hydro options, other hydro options, and transmission corridor options.

An initial task for the current resource options evaluation study was to review the Draft Evaluation Matrix and provide recommendations on removing and/or adding evaluation criteria, potentially changing criteria definitions, and on changing, adding or removing indicators and/or their associated metrics.

3.0 CONSIDERATIONS FOR REVIEW OF EVALUATION APPROACH

The resource options evaluation approach has been reviewed in the context of the specific requirements for the current evaluation of the broad range of 2016 Resource Plan resource options.[1]

Basic issues to address for the required study approach include the following:

- The environmental effects must often be characterized as "potential" given that the evaluation is based on secondary sources and additional baseline studies would be required to verify presence or absence of a species or habitat feature.
- The socio-economic evaluation of the priority sites can potentially focus on various forms of land tenure and dispositions, historic and archaeological resources, jobs and gross domestic product (GDP), and qualitative assessments of potential effects on local labour supply, traditional Aboriginal activities and community well-being. The evaluation can also potentially include broad indicators of potential effects, given the many opportunities that exist to mitigate adverse effects and enhance positive ones.
- The comparative ranking of different resource options will need to highlight the key advantages or disadvantages between the options, representing the positive effects that could occur and might need to be enhanced and the negative effects that will likely require attention through design and further mitigation. Initial consideration might be given to using a "Higher," "Moderate" and "Lower" rating scheme to provide a preliminary indication of the level of constraint relative to other priority sites that is likely to be associated with the proposed development:
    - **Higher** ratings in this context would mean that an option may result in negative effects and/or offers the least potential for positive effects. In some cases, this rating could also mean that the effects are of greater magnitude relative to other sites. This rating would imply requirements for a greater level of future investigation, the potential requirement for site-specific design features, and a likely need for greater effort in the design of mitigation, compensation and enhancement measures.
    - **Moderate** ratings would mean that the option has a mix of positive and negative effects.
    - **Lower** ratings in this context would mean that an option has less potential for negative effects and/or offers greater potential for positive socio-economic effects than other sites; however, this rating would not necessarily mean that a site is constraint free or will require less attention through further assessment, design and mitigation.

[1] The study team also reviewed the approach adopted in a similar prior assessment for the Yukon Development Corporation by SLR Consulting Global Environmental Solutions (SLR) of six large hydro priority site options ("Yukon Next Generation Hydro and Transmission Viability Study - Positive and Negative Environmental and Socio-economic Effects - Technical Paper", November 2015).

The resource options evaluation approach has also been reviewed in the context of the following four specific considerations, keeping in mind the requirement to review here a very broad range of resource options with varying capacity scales and characteristics:

- **Risk and Opportunity Comparative Focus** – Meaningful evaluation of diverse options at a preliminary state of assessment needs to compare distinct risks and opportunities to facilitate the selection of options meriting further work, recognizing that future work will be needed to reach more definitive assessments as to feasibility and potential effects. The highlighting of adverse effect risks for a resource option also provides a focus on the varying regulatory review challenges for the different options, recognizing that mitigation measures will be required to address these risks before a resource option can be implemented and noting that some resource options or project elements (e.g., transmission corridors or interconnections, access roads) may offer greater opportunities to mitigate (by varying site location) than other resource options or project elements dependent on the use of a specific site (e.g., pumped hydro storage reservoir options).
- **Comparative Assessments by Separate Criteria –** Comparative assessment needs to be retained for each of the separate criteria defined for each of the three attributes (i.e., environmental, social and economic attributes), recognizing the importance at this stage of displaying key differences among the resource options rather than attempting an overall ranking of these options across very different criteria. Separate evaluation matrix tables are accordingly developed for the environmental, social and economic evaluations. In each table, the key criteria are separately retained in any final assessment (showing comparative ranking of each resource option for each of these criteria).
- **Comparative Assessment of Resource Options versus Project Options –** Meaningful and easily understood comparison of very different resource options (e.g., widely varying generation options, storage options, and transmission corridor options) is required, as well as comparative assessment of project options specific to each type of resource option (e.g., different hydro sites or different wind sites, as well as different potential scales or cases for development of a specific option). In the current study, an important related consideration is clarity in showing when a generation resource project option is dependent on a specific transmission corridor project option.
- **Comparative Assessment of Resource Options with Different Technical and Financial Attributes –** Where feasible, meaningful comparison of resource options needs to consider material differences in technical attributes (e.g., capacity and energy scales, dependability, seasonal variability, timing for development) and financial attributes (e.g., capital costs and related risks, operating and maintenance costs, levelized costs of energy and capacity). Useful comparative evaluation is enhanced when resource options are sorted by similar technical and financial attributes.

The criteria were also reviewed and compared to address the following concerns:

- Avoid double counting of criteria (i.e., not use two or more criteria to measure the same thing). This is particularly important within each of the three main assessments (e.g., separate

environmental, social and economic evaluations). In some cases, information from the environmental evaluation may also be useful for the social and economic evaluations.

- Add, delete or shift criteria and/or indicators to improve or optimize assessment. Suggested additions or deletions are reviewed in greater detail for environmental, social and economic categories.
- A survey document has already been issued using the criteria developed and included in the Draft Evaluation Matrix included as Attachment 1, and it is therefore necessary that the final criteria adopted at least reflect or include the thrust points of the criteria used in the Draft Evaluation Matrix (i.e., additional criteria may be added, but the initial criteria must also be represented).

It was considered desirable to adopt a simple standard scale for the evaluation of each criteria to optimize the comparative evaluation of the various resource options separately for environmental, social and economic criteria. Initial planning looked in most cases at a Low/Medium/High or three-part numerical scale, with provision for showing whether effects are beneficial (+) or adverse (-), and with Low representing low adverse effects overall and High representing high adverse effects or concerns overall.

Based on the above considerations, the following 2016 Resource Plan Resource Option Evaluation Matrix tables have been prepared:

- Table B 4-1 - Resource Option Evaluation Matrix - Environmental Criteria & Indicators;
- Table B 5-1 - Resource Option Evaluation Matrix - Social Criteria & Indicators; and
- Table B 6-1 - Resource Option Evaluation Matrix - Economic Criteria & Indicators.

Key factors affecting each of the three attributes are reviewed below. To simplify each matrix, complex descriptions and objectives sections of the Attachment 1 Draft table are excluded and attention is directed solely at the criteria and indicators used to evaluate resource options for each attribute and the metrics used to evaluate each indicator.

4.0 ENVIRONMENTAL CRITERIA AND INDICATORS

Table B 4-1 includes the following key changes to Yukon Energy's initial list of environmental criteria and indicators (summarized in the Draft Evaluation Matrix included as Attachment 1 to this appendix):

- For **En1 (Species and Habitat)** and **En2 (Land/Resource Use Intensity and Naturalness)** as set out in Attachment 1, it is noted that many elements considered under each criteria are difficult to define as separate (e.g., footprint effects under En2 affect species and habitat under En1).

  The changes to the environmental criteria and indicators consider many of the same issues, but the presentation is simplified for the following reasons: to be consistent with the basic requirements for this evaluation as reviewed in Section 3 above and to be consistent with how these matters would be considered, addressed and understood as part of an environmental assessment (i.e., focus on effects to the aquatic environment, terrestrial environment and air quality).

  Species and Habitat and **Land Use/Resource Use Intensity and Naturalness** are still explicitly considered, but now as part of the separate consideration of the aquatic environment and the terrestrial environment.

  The criteria and indicators for the draft versions of En1 and En2 are now as follows (see Table B 4-1 for the metrics related to each indicator):

  - **En1 – Fish and Fish Habitat**: This will include consideration of the following indicators:
    - Salmon and Habitat;
    - Species at Risk and Habitat; and
    - Commercial, Recreational or Aboriginal Fishery Species and Habitat.

    For each of the above, the assessment will include consideration of the presence or absence of the species (Yes/No), as well as the relative effect (positive or negative effects and L/M/H assessments).
  - **En2 – Water Quality and Quantity**: This will include consideration of the following indicators:
    - Consumptive Water Use;
    - Relative Scale of New Impoundment/Flooding; and
    - Flow Changes.
  - **En3 – Terrestrial Species and Habitat**: This will include consideration of the following indicators:
    - Species at Risk and Habitat;
    - Protected and Conservation Areas;
    - Wildlife Key Areas; and

- Caribou Ranges.

For each of the above, where relevant the assessment will include consideration of the presence or absence of the species (Yes/No), as well as the relative effect (positive or negative effects and L/M/H assessments).

- **En4 – Terrestrial Footprint and Land Use**: This will include consideration of the following indicators:
  - Footprint Terrestrial Areas, including access and new flooding;
  - Linear Development for roads, transmission;
  - Permafrost; and
  - Wetlands.

It is also noted that **Visual Aesthetics** (considered under Land and Resource Use Intensity and Naturalness in Attachment 1) is shifted from the environmental assessment to the social assessment (aesthetics in environmental assessments typically relates to people's relationship to the environment, and is therefore included under the social matrix). This also reduces duplication between the environmental assessment and the social assessment.

- **En3 (Pollution and Contamination)** as set out in Attachment 1 is not considered as a separate criteria in the environmental assessment, but instead will be considered as follows:
  - Effects related to greenhouse gas (GHG) and other emissions will be considered as part of **En5 (Air Quality)**.
  - Other effects related to the risk of unintended release of pollutants are typically considered and addressed as part of planning for each project as part of the assessment of accidents and malfunctions (and are not intended outcomes of the proposed project). As such, there is less importance to considering these risks when evaluating different resource options at this initial planning stage. However, in the event that a specific option involves enhanced risks that merit attention, these can be addressed in the evaluation either with regard to risks to specific species and/or habitats or specific social effect concerns.
  - Other contamination risks that may arise from implementation of a project, such as mercury contamination due to impoundment, will be considered as part of the effects due to the relative scale of new impoundment/flooding (as well as social evaluations related to human and community health and traditional lifestyle activities).
- **En4 (Climate Change Adaptation/Resiliency)** as set out in Attachment 1 addresses the effects of the environment on the project (as opposed to effects of the project on the environment, which is the focus of all other environmental criteria). As such, this has been included as an economic criteria for this assessment (as opposed to being an environmental criteria) to address potential risks related to project design and operation. Overall, a project will need to be planned to address risks imposed by environmental factors such as flood, drought, wind and climate change. This requirement will affect construction and operating costs for the project.

Table B 4-1: Resource Options Evaluation Matrix - Environmental Criteria & Indicators

	ID	Criteria	Indicator	Metric ID	Metric
	Environmental Criteria				
Aquatic Environment	**En1**	**Fish and Fish Habitat**	Salmon & Habitat	En1-1	Presence or absence (Y/N) & Relative Impact (+/-)
			Species at Risk & Habitat	En1-2	Presence or absence (Y/N) & Relative Impact (+/-)
			Commercial, Recreational or Aboriginal Fishery Species & Habitat	En1-3	Presence or absence (Y/N) & Relative Impact (+/-)
	En2	**Water Quantity & Quality**	Consumptive Water Use	En2-1	Water Use Intensity (m3/day)
			Relative Scale of New Impoundment/ Flooding	En2-2	Presence or absence (Y/N) & Relative Scale (L/M/H)
			Flow changes	En2-3	Presence or absence (Y/N) & Relative Scale (Run of River; Storage; Pumped Storage)
Terrestrial Environment	**En3**	**Terrestrial Species & Habitat**	Species at Risk & Habitat	En3-1	Presence or absence (Y/N) & Relative Impact (+/-)
			Protected & Conservation Area	En3-2	Proximity to Protected & Conservation Areas (L/M/H)
			Wildlife Key Areas	En3-3	Proximity to WKAs (L/M/H)
			Caribou Ranges	En3-4	Proximity to Caribou Ranges (L/M/H)
	En4	**Terrestrial Footprint & Land Use**	Footprint Terrestrial Area including access & new flooding (Total km2)	En4-1	Area of Project Terrestrial Footprint (km2)
			Linear Development for roads, transmission (km)	En4-2	Total length of linear features (km)
			Permafrost	En4-3	Presence or absence (Y/N) & Relative Scale (L/M/H)
			Wetlands	En4-4	Presence or absence (Y/N) & Relative Scale (L/M/H)
Air	**En5**	**Air Quality**	GHG Emissions (in Yukon)	En5-1	Intensity (per kWh)
			Other Air Pollutants	En5-2	Intensity (per kWh)

5.0 SOCIAL CRITERIA AND INDICATORS

The criteria and indicators presented in Table B 5-1 maintain in most respects the original criteria provided by Yukon Energy (as summarized in Attachment 1 to this appendix) with the following key changes:

- Addition of a new criteria to address **First Nations Settlement Lands** (S1 First Nations Lands). This will consider whether there is an overlap with or effect on access to Settlement Lands or Interim Protected Lands.
- The criteria **Traditional Lifestyle** and **Heritage Resources** are maintained but are numbered separately (now S2 and S3, respectively). The indicators are refined as follows:
    - **Footprint Land Area Impact** will consider, as a point of reference, the total hectares (ha) of direct land loss (provided as part of the environment assessment Footprint Terrestrial Area [En4-1]).
    - **Land Area Loss regarding Traditional Lifestyle and Land Quality Effects on Traditional Lifestyle -** will provide a more qualitative assessment related to effects on access or direct loss of traditional areas due to impoundments or other issues related to project footprint effects. This corresponds to the **Land Quality Effects** indicator in Attachment 1.
    - **Cabins, Camps and Structures** – This addresses the **Land Tenure** indicator included in Attachment 1. It is considered that the revised title better indicates what is being examined.
    - **Country Foods** – This addresses the **Diet** indicator included in Attachment 1, but clearly shows that country foods, meat and fish are being combined into one assessment. The assessment will rely in part on information collected for the environmental assessment under Commercial, Recreational or Aboriginal Fishery Species and Habitat (En1-3).
- **Heritage Resources Potential**: The proposed criteria and indicators follow the criteria and indicators included in Attachment 1.
- **Tourism and Recreation** (S2 in Attachment 1) is maintained as a criteria but expanded in scope to include **Other Resources and Land Use**. The indicators are refined as follows:
    - **Recreational Values:** Existing and new recreational values/opportunities were considered as separate indicators in the Attachment 1 matrix. These are combined into one indicator in order to simplify the evaluation.
    - **Tourism Values:** This follows the original indicator as presented in Attachment 1.
    - **Aesthetics:** Attachment 1 considered effects on visual and auditory aesthetics as part of the environmental assessment (En2-2 in Attachment 1) or as part of Heritage Resource Potential (S3-1 in Attachment 1). This has been shifted to be considered as part of the assessment of tourism, recreation and other resources and land use.

- **Other Renewable Resources and Non-renewable Resources**: This was not included in Attachment 1, but consideration of effect on all other resources and resource use due to new access being created (or other effects of the resource option) is warranted.
- **Land Use and Renewable Resources Plans**: This was not included in Attachment 1, but consideration of land use and consistency with renewable resources plans is considered warranted.

- **Cultural and Community Well-being** is maintained with the following refinement to indicators (undertaken to be consistent with matters typically considered as part of socio-economic assessments):
  - **Infrastructure and Services**: Potential effects to infrastructure and services were considered in part under **Community value** (under the **Other Value Generation and Distribution Criteria**, Ec1-5) in Attachment 1; this is now broken into its own indicator under Cultural and Community Well-being. Effects can be positive or negative.
  - **Public Safety, Worker Interaction, Human and Community Health:** Considers issues over construction and operation (as opposed to only construction effects) and clarifies that worker interaction, as well as human and community health, are also included.
  - **Community, First Nation and Personal Development:** The key change in indicators compared to Attachment 1 is to shift consideration of employment and education opportunities from being separate indicators to being considered as part of Community and Personal Development indicator. Overall, there is concern that at this stage in project development, there will be limited information available related to employment, training and other educational opportunities. Further, such effects are typically included under economic criteria. As revised, the indicator allows for broad consideration of overall effects on local community and personal development. Effects can be positive or negative.

Table B 5-1: Resource Option Evaluation Matrix - Social Criteria & Indicators

ID	Criteria	Indicator	Metric ID	Metric	Rating Scheme
Social Criteria					
S1	**First Nation Lands**	Settlement Lands, Interim Protected Lands	S1-1	Overlap and/or access with these lands (Y/ Potential/N)	
S2	**Traditional Lifestyle**	Footprint land area impact	S2-1	Total area (ha) of direct land loss	
		Land area loss re Traditional Lifestyle	S2-2	Total area (ha) of Traditional Use land area loss	
		Land Quality Effects on Traditional Lifestyle	S2-3	Indirect effects on land or access for such pursuits (+/- and L/M/H)	
		Cabins, Camps & Structures	S2-4	Number of cabins, camps, homesteads, etc. in footprint (corridor for linear access) that may be affected (n)	
		Country Foods	S2-5	Effects to the opportunity to harvest country foods (+/- and L/M/H)	
S3	**Heritage Resources**	Heritage Resource Potential	S3-1	Density (number of discrete) known or potential archeological, palaeontological, ethnological, prehistoric, or historic resources (L/M/H)	
			S3-2	Importance/Cultural Value of heritage resources, including areas of land containing heritage resources. (L/M/H)	
S4	**Tourism, Recreation & Other Resources and Land Use**	Recreational Values	S4-1	Effect on nature and scale of existing and new Recreational Values. (+/- and L/M/H)	
		Tourism Values	S4-2	Effect on nature and Scale of Tourism Values. (+/- and L/M/H)	
		Aesthetics	S4-3	Effect on auditory or visual aesthetics. (+/- and L/M/H)	
		Non-renewable Resources	S4-4	Effect on Non-Renewable Resources. (+/- and L/M/H)	
		Other Renewable Resources	S4-5	Effect on other Renewable Resources. (+/- and L/M/H)	
		Land Use & Renewable Resources Plans	S4-6	Consistent with Land Use& Renewable Resources Plans (Y/N, NA)	
S5	**Cultural and Community Well Being**	Infrastructure & Services	S5-1	Effect on Infrastructure & Services (+/- and L/M/H)	
		Public Safety, Worker Interaction, Human and Community Health	S5-2	Risks to Community Health & Safety - construction & operation (L/M/H)	
		Community, First Nation & Personal Development	S5-3	Effects on local jobs, business, training & development (+/- and L/M/H)	

6.0 ECONOMIC CRITERIA AND INDICATORS

Economic criteria were reviewed to consider added criteria to address separate key risks and concerns related to economic effects throughout the economic life of each resource option.

The following concerns and interests are addressed in the Table B-6-1 economic criteria and indicators:

- Reliance on economic indicators such as GDP and Gross Progress Indicator (GPI) have limited use at this time based on available information and use in Yukon, duplication with other indicators/criteria and overall usefulness within the economic criteria evaluation of the different resource options to be examined at this time. Local Economic Effects can be addressed through other indicators based on information developed to date or otherwise available for the resource options.
- Effects of the environment on the resource option are relevant to economic evaluations of resource options (as such effects could affect costs and risks for specific options). In the context of the 2016 Resource Plan, this climate change risk assessment involves assessing climate change risk effects on financial attributes of resource options.

Economic evaluation for any socio-economic assessment of a resource option in Yukon would normally also include effects on ratepayers, i.e., costs of power, and any related risks and other development effects, e.g., risks of fixed costs adversely affecting ratepayers and other ratepayer risks related to potential resource underutilization. These considerations are addressed elsewhere in Yukon Energy's 2016 Resource Plan process are therefore are not included in Table B 6-1.[2]

In summary, Table B-6-1 includes the following economic criteria:

- **Ec1 – Local Economic Impacts:** Considers opportunities during construction and operation as well as community and other development opportunities (similar to **Economic Opportunity** and **Community Value** indicators included in Attachment 1).
- **Ec2 – Climate Change Risk Affecting Resource Financial Attributes:** As discussed in Section 4, each resource option will need to be planned to address risks imposed by environmental factors such as flood, drought, wind and climate change. These factors may affect construction and operating costs and economic risks for the project resource option.

[2] These considerations were not included in the Attachment 1 matrix, reflecting the fact that the 2016 Resource Plan process is currently addressing these matters separately as "Technical Attributes" and "Financial Attributes."

Table B 6-1: Resource Options Evaluation Matrix - Economic Criteria & Indicators

ID	Criteria	Indicator	Metric ID	Metric
Economic Criteria				
Ec1	**Local Economic Impacts**	Yukon Opportunities during Construction	Ec1-1	Capital Cost - Civil and Other Local Share (L/M/H)
		Yukon Opportunities during Operation	Ec1-2	Operation Costs - Yukon Labour & Business Opportunity (L/M/H)
		Community & Other Development Opportunity	Ec1-3	Community, Industry Development Opportunity (L/M/H)
Ec2	**Climate Change Risk Affecting Resource Financial Attributes**	Susceptibility to Extreme Weather Events/Conditions	Ec2-1	Susceptible to Extreme Heat/Drought (L/M/H)
			Ec2-2	Susceptible to Extreme Precipitation - flood/snow
			Ec2-3	Susceptible to Extreme Wind Events (L/M/H)
			Ec2-4	Susceptible to Ice Related Processes/Events (L/M/H)
		Conditions Susceptible to Climate Change	Ec2-5	Extent of Permafrost in project footprint (L/M/H)

7.0 RESOURCE OPTIONS RATINGS FOR EACH INDICATOR

The range of resource options to be evaluated and the groupings adopted for these options are summarized in Section 6 of Appendix A. For certain resource options, a range of sites and/or scales of potential development are also included in the evaluation.

The evaluation of each resource option is reported separately for each indicator adopted to assess environmental, social and economic criteria. This approach recognizes the importance at this stage of displaying key differences among the resource options rather than attempting any overall ranking of these options across very different key indicators.

Separate evaluation matrix tables are provided for the three main attributes (i.e., environmental, social and economic attributes) using the criteria and indicators as set out in Tables B 4-1, B 5-1 and B 6-1 of this appendix. In each evaluation matrix table, each resource option is ranked for each indicator adopted to evaluate the separate criteria.

Rating approaches for each indicator were developed separately, as appropriate, for the criteria adopted to evaluate resource options for each main attribute (see Appendix C for Environmental, Appendix D for Social and Appendix E for Economic for the technical analysis supporting each evaluation).

The overall framework for reporting on the ranking evaluation for each indicator follows the colour-coded rating system described below.

The overall objective of the evaluation approach is to identify on a common scale (low, medium, and high) which indicators are particularly relevant to each resource option. A high rating indicates that potential effects on an indicator are high for a specific resource option compared with the other resource options under review. A low rating indicates that potential effects on an indicator are low for a specific resource option compared with the other resource options under review A medium rating indicates an evaluation that falls between the high and low ratings.

The evaluation approach involves criteria that address a diverse range of risks, benefits, and potential linkages with the resource options. The following examples demonstrate this range, and highlight the need to consider in each instance the nature of the indicator when interpreting the ratings of high, medium or low for different resource options:

- **Adverse Effects Indicators -** Many of the environmental and social criteria and indicators focus on potential risks of adverse effects on specific criteria and indicators, where a high or red rating means a high relative risk of an adverse effect, e.g., effects on fish and fish habitat, effects on terrestrial species and habitat, effects on air quality, effects on First Nation lands, effects on traditional lifestyle, effects on heritage resources, and some indicators related to cultural and community well-being. When rating adverse effects for a resource option on an indicator, red means a high rating, yellow means a medium rating, and green means a low rating.
- **Positive Effects Indicators -** Some social and economic indicators focus on potential beneficial effects on specific criteria and indicators, where a high rating means a high relative level of potential benefits, e.g., effects on criteria such as Local Economic Impacts and Community, First

Nation and Personal Development. In this instance, a red colour rating as adopted for adverse effects indicators might suggest (incorrectly) that a high rating has adverse rather than positive effects - while a green colour rating to suggest "positive" outcomes could also be confusing given that green means low level effects when assessing adverse effects indicators. Accordingly, no colour rating is used for the few indicators that focus on positive effects and tables simply show the rating as high positive, medium positive or low positive.

- **Linkage/Overlap Effect Indicators -** Some environmental, social and economic criteria and indicators address overall magnitudes related to linkages or overlaps, where a high or red rating means a high level of linkage or overlap without directly addressing specific adverse or positive effects that may occur, e.g., footprint territorial area, footprints land area effect, linear development distances, flow changes, relative scale of impoundment/flooding, climate change risk affecting resource financial attributes.
- **No Linkage included as Low Rating** - For many resource options, there is no linkage with various environmental indicators (or the indicator is not applicable to the resource option). A low or green rating includes these situations (thereby highlighting no basis for special attention in the future with regard to this indicator when pursuing the resource option).

At this initial stage of the resource option review, effects on any indicator are often best characterized as "potential" given the need to rely on existing information without project specific baseline or assessment studies to verify existing conditions, as well as expected effects. For most resource options evaluated here, current information is at a preliminary level of assessment.

In assessing potential adverse or positive effects, the evaluation assumes adoption of well understood mitigation measures or best management practices to manage potential effects; however, to provide a common evaluation approach for all options, customized mitigation developed for a specific resource option is not considered (even for the few options where more detailed studies and assessments have been carried out, e.g., Stewart-Keno City Transmission, Mayo Lake and Southern Lakes hydro storage enhancement projects).

Accordingly, a high or red rating related to potential adverse effects on an environmental or social indicator does not in any way signify that the resource option is infeasible. Such a rating only shows that these effects will need to be addressed and managed/mitigated in order for the project to proceed.

In summary, the ratings for the evaluation of each indicator were classified in terms of high, medium, and low as follows (see also Figure B 7-1):

- **High (Red when non-positive - no colour when positive effect)** means the resource option has a high expected effects linkage to the indicator (depending on the indicator, the likely effects may be adverse, positive or simply signify linkage and/or overlap without much additional guidance);
- **Medium (Yellow when non-positive - no colour when positive effect)** means the resource option has potential expected linkage to the indicator that falls between high and low ratings; and

- **Low (Green when non-positive - no colour when positive effect)** means the resource option likely has minimal, if any, expected effects linkage to the indicator (again, depending on the indicator, any potential minimal effects may be adverse, positive or simply signify no linkage/overlap with the indicator, i.e., no effects pathway).

Figure B 7-1: Rating Criteria Considerations

High	Classification of high means the resource option has a high expected effects linkage to the indicator (depending on the indicator, the likely effects may be adverse, positive or simply signify linkage/overlap without much additional guidance). Red signifies a high rating for all non-positive effect indicators. A red (high) rating related to potential adverse effects does not signify that the resource option is infeasible - such a rating only shows that these effects are high and will need to be addressed and managed/mitigated in order for the project to proceed. No colour is used to signify a high rating related to potential positive effects. A high positive rating indicates that such effects for the resource option are high relative to the effects on the indicator from other options; associated with such a rating is a likely requirement to address specific benefit management or enhancement measures.
Medium	Classification of medium means the resource option has potential expected linkage to the indicator that falls between low and high ratings. Yellow signifies a medium rating for all non-positive effect indicators. A yellow (medium) rating related to potential adverse effects indicates a likely need to proceed with caution and/or special attention to the management of certain potential adverse effects (without any determination today that a high expected effects linkage exists). No colour is used to signify a medium rating related to potential positive effects. In many evaluations of adverse effects a medium rating indicates a lack of information needed for a red (high) or green (low) rating.
Low	Classification of low means the resource option has minimal, if any, expected effects linkage to the indicator (again, depending on the indicator, any potential minimal effects may be adverse, positive or simply signify no linkage/overlap with the indicator, i.e., no effects pathway). A green (low) rating related to potential adverse effects indicates that such effects are well understood and likely can be managed through best management practices or standard mitigation measures. No colour rating is used to signify a low rating related to potential positive effects. A low positive rating indicates that such effects for the resource option are low relative to the effects on other options and unlikely to require special benefit management or enhancement measures. A green (low) rating may also signify no linkage between the resource option and the indicator.

ATTACHMENT 1:
RFP 2016-010 Draft IRP
Resource Options Evaluation Matrix

Attachment 1: RFP 2016-010 Draft IRP Resource Options Evaluation Matrix

ID	Criteria1	Description	Objective	Indicator	Metric ID	Metric	Rating Scheme	Data Sources
Environmental Criteria								
En1	**Species and Habitats**	The greater the number of valued species that inhabit a given area the greater the species richness implying greater heterogeneity of habitat - i.e., faunal species biodiversity. Species protection and recovery/restoration. Habitats of acknowledged high ecological value (e.g., calving grounds, winter range, wetlands, spawning grounds, protected areas). Habitat conservation considerations. Influence on water quality and quantity.	Options that have the lowest negative effect on biodiversity are preferred. Options that have minimal or no effects to such areas are preferred. No significant change beyond range of natural variability and ability of ecosystem to be sustainable.	Effects Radius/Influence Relative to Fish and Wildlife Key Areas	En1-1	Key habitat areal extent affected by option (km^2)		
				Effects Radius/Influence Relative to SARA Listed Species	En1-2	Type and number of SARA-relevant species in project area (type and n)		
				Effects Radius/Influence Relative to Protected Areas	En1-3	Proximity of Project to Protected Areas (km)		
				Effects to Water Quality	En1-4	Physical or chemical changes to water quality relative to baseline (various dependent on key analyses, e.g., temp, dissolved metals, pH, total gas pressure, total suspended solids)		
				Effects to Water Quantity	En1-5	Changes to water quantity relative to baseline (m^3, m^3/s) during all times of the year		
En2	**Land/Resource Use Intensity and Naturalness**	Landscape patterns are linked to biodiversity and other ecological values of the landscapes. Measures of anthropogenic footprint and intensity as well as biodiversity and other measures of naturalness and ecosystem robustness to be used here. Stream crossings captured may include those with known fish resources or anadromous fish resources (i.e., salmon), or all substantive watercourses regardless of fish (TBD).	Projects that have smaller project footprints or otherwise minimize negative effects to biodiversity and naturalness are preferable.	Project Footprint	En2-1	Areal Extent of Project Footprint (km^2)		
					En2-2	Visual Aesthetic Effects (Naturalness) Profiles (L/M/H)		
					En2-3	Length of Project, if linear development (km)		
				Access Requirements	En2-4	Length of Access Roads (km)		
					En2-5	No. of Stream Crossings (n)		
				Consumptive Water Use	En2-6	Water Use Intensity (m^3/day)		

ID	Criteria1	Description	Objective	Indicator	Metric ID	Metric	Rating Scheme	Data Sources
En3	**Pollution and Contamination**	Waste products and pollution created by resource option. Relative risk profile of resource for environmental releases and contamination.	Lower results are favoured.	Air Pollution	En3-1	Comparative Criteria Air Contaminant Production per unit energy produced (e.g., tonnes SOx, NOx, PM per kWh)		
				GHG Profile	En3-2	Life Cycle GHG Production in Yukon (tonnes/kWh)		
					En3-3	GHG ratio with fossil fuel alternative/default (tonnes renewable GHG/tonnes default Fossil GHG per kWh or vice versa)		
				Risk of Unintended Release of Pollutants	En3-4	Relative Likelihood/Probability of spill/release (L/M/H)		
					En3-5	Consequences of Spill/Release (L/M/H)		
En4	**Climate Change Adaptation / Resiliency**	Character of the option in the context of resiliency or adaptability to predicted long-term climate change and immediate severe weather effects. (Move permafrost indicator and metrics here; develop additional indicators and metrics).	Sites with higher resiliency to forecast CC effects preferred.	Susceptibility to Extreme Weather Events/Conditions	En4-1	Resilience to Extreme Heat/Drought (L/M/H)		
					En4-2	Resilience to Extreme Precipitation - flood/snow (L/M/H)		
					En4-3	Resilience to Extreme Wind Events (L/M/H)		
					En4-4	Resilience to Ice Related Processes/Events (L/M/H)		
				Conditions Susceptible to CC	En4-5	Extent of Permafrost in project footprint (L/M/H)		
Social Criteria								
S1	**Traditional Lifestyle**	Access to country foods, medicinal plants, other subsistence pursuits.	Projects that have lower magnitude effects preferred.	Land Availability/Access Effects	S1-1	Direct Loss of Land or Land Access for such pursuits (km2)		
				Land Quality Effects	S1-2	Indirect effects on land for such pursuits (+/- and L/M/H)		
				Land Tenure	S1-3	Number of cabins, camps, homesteads, etc. in study area that may be affected (n)		
				Diet	S1-4	Predicted effects to the ability/availability of country foods (+/- and L/M/H)		
					S1-5	Effects to the opportunity to harvest fish and meat (+/- and L/M/H)		

ID	Criteria1	Description	Objective	Indicator	Metric ID	Metric	Rating Scheme	Data Sources
S2	**Tourism & Recreation**	Qualitative assessment of effect on valued tourism, leisure, and/or recreational opportunities/resources (e.g., swimming, boating, sport fishing, playgrounds, youth/community centres, campgrounds, significant water recreation, trails, etc.) Professional judgment required to assess this criteria based on local knowledge. Includes big game outfitters.	Sites with less effect to tourism and recreational resources are preferred.	Existing Recreational Values	S2-1	Effect on nature and Scale of Recreational Values. (+/- and L/M/H)		
				New Recreational Opportunities	S2-2	Number/value of new opportunities that project-related access may provide for recreation (+/- and L/M/H)		
				Tourism Value	S2-3	Potential for improved Annual Value of tourism in Regional Study Area (+/- and L/M/H)		
S3	**Heritage Resources**	Project specific effects that can damage sacred or historic areas, artifacts, and loss of use of traditional place names.	Sites that do not effect known high value or significant heritage sites are preferred.	Heritage Resource Potential	S3-1	Density (number of discrete) known or potential archeological, palaeontological, ethnological, prehistoric, historic, or aesthetic resources (L/M/H)		
					S3-2	Importance/Cultural Value of heritage resources, including areas of land containing heritage resources. (L/M/H)		
S4	**Cultural and Community Well Being**	Effects of development/operation on public and worker safety, employment and educational (skills and training) opportunities, Shifts in patterns of work availability and employment can have effects on family/community contributions and/or support of community infrastructure/culture.	Projects that have positive effects on cultural and community wellbeing are preferred.	Employment	S4-1	No. of Direct/Indirect Jobs Created during construction and operations (n)		
				Public Safety	S4-2	Public safety risks posed by project - construction period (L/M/H)		
				Educational Opportunities	S4-3	Provides opportunities for advanced education of local people (L/M/H)		

ID	Criteria1	Description	Objective	Indicator	Metric ID	Metric	Rating Scheme	Data Sources
Economic Criteria								
Ec1	**Other Value Generation and Distribution**	Value of wages, taxes, and consumer spending locally and regionally. Economic leakage. Options that provide, or leverage, the greatest long-term or durable social benefits that contribute to the community sustainability vision. Payments to capital providers and governments.	Maximize circulation of wealth locally and regionally.	Economic Growth / Financial Value	Ec1-1	Gross Domestic Product (GDP)		
					Ec1-2	Genuine Progress Indicator (GPI)		
					Ec1-3	Change in total local/regional employment (no. of FT/PT jobs for construction and operation phases)		
				Economic Opportunity	Ec1-4	% of project employment opportunities that match the skills of the locally/regionally available workforce		
				Community Value	Ec1-5	Value of infrastructure contributions/improvements in communities required for, or inevitable with, project (L/M/H)		

APPENDIX C:
ENVIRONMENTAL EVALUATION TECHNICAL REPORT

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1.0 INTRODUCTION

Environmental criteria and indicators for evaluating the resource options, as finalized in Appendix B, are copied below in Table C 1-1.

The technical environmental evaluation of each resource option is addressed in Appendix C, with separate sections for each of the five main environmental criteria in Table C 1-1.

At the start of each section of Appendix C, the distinct issues, rating criteria and data sources for each criteria are summarized. In each case, environmental indicators address non-positive effects, e.g., adverse effects as well as non-linkage cases. Accordingly, as outlined in Section 7 of Appendix B, the ratings for the evaluation of each environmental indicator are classified in terms of high (red), medium (yellow), and low (green) as follows:

- **High (red)** means the resource option has a high expected non-positive effects linkage to the indicator (depending on the indicator, the likely effects may be adverse or simply signify linkage/overlap without much additional guidance);
- **Medium (yellow)** means the resource option has potential expected non-positive linkage to the indicator that falls between green and red ratings; and
- **Low (green)** means the resource option likely has minimal, if any, expected non-positive effects linkage to the indicator (again, depending on the indicator, any potential minimal effects may be adverse or simply signify no linkage / overlap with the indicator, i.e., no effects pathway).

"No linkage," which is shown as green, is separated out in the environmental evaluations to identify circumstances where there is no apparent or likely link between a resource project option (including new road and/or transmission access related to the resource project) and a given environmental indicator.

As each resource project option was reviewed, it was assumed that standard best management practices (BMPs) would be applied during the construction and operation stages to mitigate adverse effects. Where standard BMPs are expected to prevent any likely effect of concern on an indicator, a green or low effect rating is adopted.

Table C 1-1: Resource Option Evaluation Matrix - Environmental Criteria & Indicators

	ID	Criteria	Indicator	Metric ID	Metric
	Environmental Criteria				
Aquatic Environment	**En1**	**Fish and Fish Habitat**	Salmon & Habitat	En1-1	Presence or absence (Y/N) & Relative Impact (+/-)
			Species at Risk & Habitat	En1-2	Presence or absence (Y/N) & Relative Impact (+/-)
			Commercial, Recreational or Aboriginal Fishery Species & Habitat	En1-3	Presence or absence (Y/N) & Relative Impact (+/-)
	En2	**Water Quantity & Quality**	Consumptive Water Use	En2-1	Water Use Intensity (m3/day)
			Relative Scale of New Impoundment/ Flooding	En2-2	Presence or absence (Y/N) & Relative Scale (L/M/H)
			Flow changes	En2-3	Presence or absence (Y/N) & Relative Scale (Run of River; Storage; Pumped Storage)
Terrestrial Environment	**En3**	**Terrestrial Species & Habitat**	Species at Risk & Habitat	En3-1	Presence or absence (Y/N) & Relative Impact (+/-)
			Protected & Conservation Area	En3-2	Proximity to Protected & Conservation Areas (L/M/H)
			Wildlife Key Areas	En3-3	Proximity to WKAs (L/M/H)
			Caribou Ranges	En3-4	Proximity to Caribou Ranges (L/M/H)
	En4	**Terrestrial Footprint & Land Use**	Footprint Terrestrial Area including access & new flooding (Total km2)	En4-1	Area of Project Terrestrial Footprint (km2)
			Linear Development for roads, transmission (km)	En4-2	Total length of linear features (km)
			Permafrost	En4-3	Presence or absence (Y/N) & Relative Scale (L/M/H)
			Wetlands	En4-4	Presence or absence (Y/N) & Relative Scale (L/M/H)
Air	**En5**	**Air Quality**	GHG Emissions (in Yukon)	En5-1	Intensity (per kWh)
			Other Air Pollutants	En5-2	Intensity (per kWh)

2.0 FISH AND FISH HABITAT

2.1 RATING CRITERIA AND DATA SOURCES FOR EN-1: FISH & FISH HABITAT

The rating system outlined in Figure C 2-1 was adopted to guide evaluations of each resource project option for each of the fish and fish habitat indicators.

Figure C 2-1: Summary of Rating Criteria for Fish & Fish Habitat

Indicator	Low	Medium	High
Salmon & Habitat (En1-1)	No salmon present, or no linkage	Potential to interact with salmon rearing habitat	Potential change to salmon migration and/or spawning areas
Species at Risk & Habitat (En1-2)	No fish Species at Risk present, or no linkage	Species of Concern present and no basis for potential major concern.	Endangered species or Species of Concern present[1] and basis for potential major concern
Commercial, Recreational or Aboriginal Fisheries Species & Habitat (En1-3)	No commercial, recreational or Aboriginal fishery present, or no linkage	Commercial, recreational or Aboriginal fishery and no basis for potential major concern	Commercial, recreational or Aboriginal fishery present and basis for potential major concern

Note:

1. Evaluation assumes if a species on Schedule 1 or 2 of *Species at Risk Act* (SARA) are present and there is a basis for potential major concern due to potential effects of the project, this would be high effect to reflect potential levels of concern.

The fish and fish habitat indicators as defined in Table C 1-1 focus on the presence or absence of each indicator (Yes/No rating) and whether the effect is positive or negative. Unless otherwise explicitly noted, the evaluations of each resource option for these indicators have identified only negative effects. Notwithstanding the presence of an indicator species, a green or low rating is applied for access roads and transmission access or corridors for a resource option based on the assumption that BMPs are applied as required for permitting. The Figure C 2-1 rating system also provides a rationale to separate medium (yellow) ratings for each indicator from high (red) ratings, rather than treating the potential for adverse effects as red (high) in each instance. A red (high) rating indicates the need for additional mitigation to be designed that adequately addresses specific concerns if the resource project was to proceed to further review.

Fish habitat indicators have been evaluated based on available fish distribution data from the BC Ministry of Environment and Fisheries and Oceans Canada (DFO). As project-specific habitat assessments have not been undertaken, potential interactions are based on known species life-history functions.

In developing and applying the rating system, the ratings are based on available information regarding resource project option descriptions, as well as known types of environmental effects that the various

types of projects can have on the aquatic environment. Ratings also reflect the preliminary status of the project information available today.

- For **En1-1 (Salmon and Salmon Habitat)**, a project in a watershed with salmon will automatically generate a yellow (medium) rating, highlighting the need to proceed with some caution; however, a red (high) rating will apply if the project includes potential change to salmon migration and/or spawning areas. For example, if the project includes a dam across the river, the rating is elevated to red (high) due to the known effects dams have on salmon migration and access to spawning areas, even if specific spawning locations have not been identified at this time.
- For **En1-2 (Species at Risk and Habitat)**, a red (high) rating applies if endangered species or species of concern are present and there is a basis for potential major concern related to potential effects of the project that are likely to require additional mitigation to be designed that adequately addresses specific concerns if the resource project was to proceed to further review.
- For **En1-3 (Commercial, Recreational or Aboriginal Fisheries Species and Habitat)**, a red (high) rating applies if any of these species/habitat are present and there is a basis for potential major concern related to potential effects of the project that are likely to require additional mitigation to be designed that adequately addresses specific concerns if the resource project was to proceed to further review. In the case of hydro storage projects, for example, habitat changes resulting from flooding can result in an increase in methylmercury production that may affect commercial, recreational or Aboriginal (CRA) fisheries.

2.2 EVALUATIONS

2.2.1 Resource Options with No Material Concerns regarding Fish and Fish Habitat

The fish and fish habitat indicators are not applicable to many resource project options due to the following factors:

- No linkage circumstances where there is no apparent or likely link between a resource project option and a given environmental indicator (e.g., waters with no salmon, no species at risk, no fisheries and settings where a resource option does not have an apparent link or effect pathway with regard to any fish or fish habitat).
- The nature of some of the project types (e.g., there would be no fish habitat in streams for wind projects situated on mountain tops), where use of BMPs would control erosion and prevent negative effects to fish habitat in down gradient areas outside of the immediate project footprint. This same situation applies for resource options where it is recognized that BMPs will address any concerns regarding effects of fish and fish habitat (e.g., transmission projects that involve river or stream crossings) and are recognized not to raise material concerns regarding fish and fish habitat so long as appropriate BMPs are implemented.
- Location of infrastructure on previously disturbed or brownfield sites that are not affecting river environments. For example, resource project options such as solar PV, energy storage, and

various thermal options addressed in this evaluation that are located within urban areas (e.g., Whitehorse or Haines Junction), require no new disturbance and are expected to use standard BMPs to control erosion would also prevent negative effects to fish habitat in down gradient areas that are outside the immediate project footprint.

Table C 2-1 provides a summary of the resource project options with either no linkage (NL) or other green (low) rating (due to assumed BMPs being applied) for any of the fish and fish habitat indicators. Brief supporting information and analysis is provided below on these resource options:

1. **Fossil Fuel Thermal (Diesel or LNG), Non-fossil Fuel Thermal (Biomass, Waste-to-Energy, Biogas), Energy Storage Facility and Solar PV:** Each of these resource options is located in either Whitehorse or Haines Junction, and in most cases, on brownfield sites (e.g., Whitehorse Landfill, Takhini Substation),[1] with no anticipated direct effect pathway on any stream, river or other water body. For projects located in Whitehorse, it is noted that the Yukon River and tributaries in this area provide habitat for salmon and other fish species. However, as noted, none of these resource options would be expected to have any direct effects on the Yukon River. The application of standard BMPs during construction and operation of these resource options are assumed to minimize the risk of sediment or other elements from the project area entering any stream down gradient from the proposed resource option site areas.
2. **Wind Farms and Geothermal:** Each of these resource options involves no anticipated direct effect pathway on any stream, river or other water body. Application of standard BMPs during construction and operation are assumed to minimize the risk of sediment or other elements from the project area entering any stream down gradient from the proposed resource option site areas. Table C 2-1 shows no linkage (NL) for specific options where there is no salmon species, species at risk, or fisheries in the vicinity; in contrast, low is shown where the species or fisheries are in the vicinity (in some cases along access routes and/or transmission routes) and BMPs are required to prevent any effects on fish and fish habitat indicators.
3. **Refurbish Existing Hydro Generation:** Each of these resource options occurs within an existing facility and does not involve any changes to water flows or levels. Application of standard BMPs during construction and operation of these resource options are assumed to minimize the risk of sediment or other elements from the project area entering any stream down gradient from the proposed resource option site areas.
4. **Transmission Corridors:** commercial, recreational or Aboriginal fisheries species and habitat are present in the areas crossed by each transmission corridor option. Salmon and salmon habitat are also likely present for some transmission corridors, e.g. Whitehorse-related corridors and Stewart-Keno City Transmission; however, transmission projects crossing of rivers or streams are recognized not to raise material concerns regarding fish and fish habitat so long as BMPs are implemented as required for any permitting of such projects.

[1] The Haines Junction sites for biomass or solar resource options are within the town in already cleared or largely open areas. The biomass resource option will use beetle-kill wood and not require harvesting green trees.

Table C 2-1: Resource Project Options with No Linkage (NL) or Low Ratings for All Fish & Fish Habitat Indicators

Project / Options	Salmon & Habitat	Species at Risk & Habitat	Commercial, Recreational or Aboriginal Fisheries Species & Habitat
Fossil Fuel Thermal (Diesel or LNG)			
Whitehorse Landfill	Low	Low	Low
Takhini Substation	Low	Low	Low
Non-Fossil Thermal			
Biomass (Haines Junction)	NL	NL	NL
Waste-to-Energy (Whitehorse)	Low	Low	Low
Biogas (Whitehorse)	Low	Low	Low
Energy Storage Facility			
Takhini Substation	NL	NL	NL
Solar PV			
Whitehorse	NL	NL	NL
Haines Junction	NL	NL	Low
Wind Farms			
Cyprus Mine Hill	NL	NL	NL
Kluane Lake	NL	NL	Low
Miller's Ridge	Low	NL	Low
Mt. Sumanik	NL	NL	NL
Sugarloaf Mountain	NL	NL	Low
Tehcho (Ferry Hill)	Low	NL	Low
Thulsoo Mountain	NL	NL	Low
Geothermal			
McArthur	NL	NL	Low
Vista Mountain	Low	Low	Low
Refurbish Existing Hydro Generation			
Mayo A	NL	NL	Low
Aishihik re-runnering	NL	NL	Low
Transmission Corridors			
Aishihik-Destruction Bay	NL	NL	Low
Faro–Watson Lake	Low	Low	Low
Whitehorse–Atlin	Low	NL	Low
Whitehorse–Skagway	Low	NL	Low
Whitehorse–Teslin	Low	Low	Low
Stewart-Keno City	Low	Low	Low

2.2.2 Hydro Renewable Generation

Each of the hydro resource options that affect aquatic resources is evaluated separately in the following sections.

2.2.2.1 Pumped Storage

Pumped storage hydro generation resource options each require two reservoirs with water pumped from the lower reservoir to the upper reservoir during the summer season, and the upper reservoir then used for generation during the winter. Effects on fish and fish habitat indicators are reviewed in Table C 2-2 for each of the site options, taking into consideration available information on fish and fish habitat, as well as the changes in the water regime currently assumed for each project option. This evaluation does not attempt to assess any differences in effects on fish and fish habitat due to different scales of development for some of these options, e.g., storage at 50 GWh versus 100 GWh.

Table C 2-2: Summary of Assessment for Pumped Storage

Project / Option	Indicator	Ranking	Assessment
Atlin – Black Mountain	Salmon & Habitat	**No Linkage**	There are no salmon species known to occur within the project area.
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur or that are likely to occur in the project area are listed under *Species at Risk* Act (SARA).
	Commercial, Recreational or Aboriginal Species & Habitat	**Medium**	Fish species known to occur in Atlin Lake include: Arctic Grayling, Lake Trout Lake Whitefish, Northern Pike, Round Whitefish, Burbot, Least Cisco, Longnose Sucker, Lake Chub and Coarse (Large) Scale Sucker. Examining some of the adjacent lakes and streams, it is likely that species such as Slimy Sculpin and Burbot could also be present in the lake. There is no fisheries data available for the watershed 837-088400-28000-50000, in which the upper unnamed lake is located (Lake 00172ALL; BC MoE 2016 a, b). There is a commercial, recreational and Aboriginal fishery on Atlin Lake. There is a possibility of fish species being present in the upper reservoir lake that are of value to recreational and Aboriginal fisheries. ***The effect on these types of fisheries is considered to be Medium due to the remote location of the upper reservoir lake, uncertainty as to species in this upper reservoir lake and the minimal effects expected on Atlin Lake levels.***
Canyon – Ittlemit	Salmon & Habitat	**No Linkage**	There are no salmon species known to occur within the project area.
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.

Project / Option	Indicator	Ranking	Assessment
	Commercial, Recreational or Aboriginal Species & Habitat	**High**	Lake Trout are known to occur in Ittlemit Lake. Lake Whitefish, Lake Trout, Northern Pike, Longnose Sucker, and Slimy Sculpin have been documented in Canyon Lake. The presence of Lake Trout in Ittlemit Lake and the diverse fish community in Canyon Lake is an indication that recreational or Aboriginal fisheries could be present. The significant increase in Canyon Lake volume (based on the presence of a >30 m high dam), could result in adverse effects to fish populations (e.g. spawning/incubation success, habitat changes). ***Therefore, effects on this indicator were considered to be High.***
Lindeman – Fraser	Salmon & Habitat	**No Linkage**	There are no salmon species known to occur in the project area.
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.
	Commercial, Recreational or Aboriginal Species & Habitat	**High**	Lake Trout, Arctic Grayling, and Lake Whitefish are known to occur in Lindeman Lake. There was no fish information available for Fraser Lake. Based on the known fish species present, there is likely a recreational and Aboriginal fishery in Lindeman Lake. The size of the enlargements of the upper and lower reservoir lakes is unknown at this time. The increase in impoundment size could result in adverse effects to fish populations (e.g. spawning/incubation success, habitat changes). In addition, the dam at the lake outlet could affect fish movements and access to spawning habitat. ***Therefore, effects on this indicator were considered to be High.***
Racine – Moon	Salmon & Habitat	**No Linkage**	There are no salmon species known to occur in the project area.
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.
	Commercial, Recreational or Aboriginal Species & Habitat	**High**	Arctic Grayling, Burbot, Lake Trout and Round Whitefish are known to occur in Racine Lake. According to local guides, there are no fish present in Moon Lake. Based on the known fish species present, there is likely a recreational and Aboriginal fishery in Racine Lake. The construction of a dam on Racine Lake would control water levels and could obstruct movements between Racine and Tagish Lake. The preliminary dam location would also make the lake smaller resulting in a loss of habitat. Based on the available information it is not possible to assess the potential significance of the changes to Tagish Lake water levels and connection. Given the species diversity in Racine Lake, the loss of habitat and potential changes to water levels and migration, ***this has been assessed as High.***

Project / Option	Indicator	Ranking	Assessment
Racine – Mt. Brown	Salmon & Habitat	No Linkage	There are no salmon species known to occur in the project area.
	Species at Risk & Habitat	No Linkage	None of the fish species known to occur in the project area are listed under SARA.
	Commercial, Recreational or Aboriginal Species & Habitat	High	Arctic Grayling, Burbot, Lake Trout and Round Whitefish are known to occur in Racine Lake. According to local guides, there was no fish sampling information for the unnamed lake that will be used as the upper reservoir. Based on the known fish species present, there is likely a recreational and Aboriginal fishery in Racine Lake. The construction of a dam on Racine Lake would change water levels and could obstruct movements between Racine and Tagish Lake. The preliminary dam location would also make the lake smaller resulting in a loss of habitat. Based on the available information it is not possible to assess the potential significant of the changes to Tagish Lake water levels and connection. ***Given the species diversity in Racine Lake, the loss of habitat and potential changes to water levels and migration, this has been assessed as High.***
Squanga – Dalayee	Salmon & Habitat	No Linkage	There are no salmon species known to occur in the project area.
	Species at Risk & Habitat	High	The Squanga Whitefish are a genetically distinct form of Lake Whitefish. While the speciation of the Squanga Whitefish has not yet been clarified (i.e., are they a sub-species of Lake Whitefish or a separate species), they are currently listed as a Species of Concern under Schedule 3 of SARA. There is very little known about the life-history and habitat requirements of the Squanga Whitefish; however, it is a fall spawning species that can be affected by water level management. Impoundments and water level management on the two lakes have the potential to affect spawning/incubation success as well as habitat. ***As this project has the potential to change habitat in a substantial portion of the Squanga Whitefish known range, it has been ranked as High.***
	Commercial, Recreational or Aboriginal Species & Habitat	High	Arctic Grayling, Lake Trout and Burbot are known to occur in Dalayee Lake. Arctic Grayling, Lake Whitefish, Northern Pike and Slimy Sculpin occur in the stream between Dalayee and Squanga lakes. Northern Pike and Squanga Whitefish are known to occur in Squanga Lake and it is likely that the species found upstream of Squanga Lake would also be found in Squanga Lake. The impoundments on the two lakes could affect fish species important to recreational and Aboriginal fisheries, both in the lakes and the interconnecting stream reach. The increase in impoundment

Project / Option	Indicator	Ranking	Assessment
			size on Squanga Lake and water level management on both lakes could result in adverse effects to fish populations. The preliminary dam locations will also result in a loss of existing habitat (at and behind the dam) in both lakes. ***Therefore, this has been assessed as High.***
Moon Lake (Tutshi – Moon)	Salmon & Habitat	**No Linkage**	There are no salmon species known to occur in the project area.
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.
	Commercial, Recreational or Aboriginal Species & Habitat	**Medium**	Arctic Grayling, Burbot, Coarse Scale Sucker, Inconnu, Lake Trout, Longnose Sucker, Northern Pike, Round Whitefish and Slimy Sculpin are known to occur in Tutshi Lake. Arctic Grayling, Lake Trout, Round Whitefish and unidentified sucker species are known to occur downstream of the project area in Tagish Lake. The importance of the downstream flows between Tutshi and Tagish lakes to local fish populations is currently unknown; however, based on its size and geomorphological characteristics visible in the satellite images, it is likely an important migration corridor and would likely provide spawning habitat to stream spawning species such as Arctic Grayling and the various sucker species. Available analysis suggests that the project will have no material effect on water levels at Tutshi Lake, implying no material effect on downstream flows to Tagish Lake. ***Given the effects on fish appear to be restricted to the river where information on fish populations and flow changes is not available, this has been assessed as Medium.***
Faro – Vangorda Pit	Salmon & Habitat	**High**	There are no salmon species in the project area of the upper reservoir; however, the lower reservoir area will flood a large portion of Blind Creek, which is a known Chinook Salmon spawning stream. ***The flooding of Chinook spawning habitat results in this being ranked as High.***
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.
	Commercial, Recreational or Aboriginal Species & Habitat	**High**	A waterfall on Vangorda Creek approximately 4 km upstream of Pelly River prevents fish use of the upper section of this creek near the proposed project. However, the preliminary layout of the reservoir dimensions shows the lower reservoir affecting a portion of Blind Creek, which is a known Chinook Salmon spawning stream and likely has several other fish species. ***Therefore, this has been ranked as High.***

2.2.2.2 Small Hydro Projects

With the exception of the Wolf River option (which assumes a run-of-river development at 20 MW), the Small Hydro generation resource options in this evaluation each include a dam as required to provide storage for winter generation (with resultant effects on aquatic resources related to changed water flows, lake levels and impediments to fish movement). Effects on fish and fish habitat indicators are reviewed in Table C 2-3 for each of the site options, taking into consideration available information on fish and fish habitat, as well as the changes in the water regime currently assumed for each project option.

Table C 2-3: Summary of Assessment for Small Hydro Projects

Project / Option	Indicator	Ranking	Assessment
Drury Lake	Salmon & Habitat	**Medium**	Chinook Salmon are known to occur in Drury Creek downstream of Drury Lake and the dam. Therefore, dam operation could affect downstream flows; the extent of flow changes has not been modelled; ***therefore, this has been assessed as Medium.***
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.
	Commercial, Recreational or Aboriginal Species & Habitat	**High**	Arctic Grayling, Lake Trout and Northern Pike are known to occur in Drury Lake and Chinook Salmon have been documented in Drury Creek. Commercial, recreational and Aboriginal fisheries occur in the project area. In addition, increased lake levels and impoundment areas would flood terrestrial areas, which could have adverse effects on fish populations in the lake (e.g., spawning and incubation success and changes to habitat). Such changes could affect commercial, recreational and Aboriginal fisheries. ***Therefore, this has been assessed as High.***
Finlayson River	Salmon & Habitat	**No Linkage**	There are no salmon species known to occur in the project area.
	Species at Risk & Habitat	**Medium**	None of the fish species known to occur in the project area are listed under SARA. Bull Trout are known to occur in the project area. The Yukon population of this species are currently listed as "Data Deficient" (COSEWIC 2012). ***Due to uncertainties associated with this species, and the fact that it has been listed as a Species of Special Concern in other parts of its Canadian range, the Species at Risk & Habitat fish species indicator has been ranked as Medium.***

Project / Option	Indicator	Ranking	Assessment
	Commercial, Recreational or Aboriginal Species & Habitat	**High**	Arctic Grayling, Bull Trout, Lake Trout, Northern Pike, and unidentified species of whitefish are known to occur in Finlayson Lake. Increases in impoundment size could result in adverse effects to fish populations. Water level management could have an effect on critical life-stages (e.g., egg incubation) and habitat quality. Specifically, changes in lake levels could affect spawning habitat for fall spawning fish species (Lake Trout and whitefish). There are potential changes in downstream flows that potentially could affect fish habitat in the lower 6 km of the Finlayson River (upstream of the Frances Lake) due to diversion of water into the penstock. The importance of this river to local fish populations is currently unknown; however, based on its size and geomorphological characteristics visible in the satellite images, it is likely an important migration corridor and would likely provide spawning habitat to stream spawning species such as Arctic Grayling and Bull Trout. ***Changes to the lake and river habitats, combined with numerous species present results in High ranking***.
Altin – Pine Creek	Salmon & Habitat	**No Linkage**	There are no salmon species known to occur in the project area.
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.
	Commercial, Recreational or Aboriginal Species & Habitat	**Medium**	Arctic Grayling and Slimy Sculpin are known to occur in Surprise Lake. A barrier prevents other species from accessing the middle/upper portion of the watershed. The lower watershed (~2 km) can be accessed by the several fish species found in Atlin Lake; however, in terms of commercial, recreational or Aboriginal fish species, this area appears most suitable for Arctic Grayling. The Surprise Lake Arctic Grayling population has limited spawning habitat available and a fish way was included in the current power generating facility to provide unrestricted movements between the lake and Pine Creek (outflow tributary stream). Surprise Lake is already affected by an existing hydro development with a current licence allowing water levels up to 913.85 m. The proposed project would retain the current upper level of licensed operation but utilize increased storage by drawing down the lake to 911.35 m. The project has the potential to change water levels in Pine Creek and Surprise Lake and will have to be planned to mitigate effects on fish; however, ***given there appears to be only one species of concern that is generally resilient to change, this indicator has been ranked as Medium.***

Project / Option	Indicator	Ranking	Assessment
Tutshi – Windy Arm	Salmon & Habitat	**No Linkage**	There are no salmon species known to occur in the project area.
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.
	Commercial, Recreational or Aboriginal Species & Habitat	**High**	Arctic Grayling, Burbot, Inconnu, Lake Trout, Least Cisco, Longnose Sucker, Northern Pike, Round Whitefish and Slimy Sculpin are known to occur in the project area. Based on the fish species known to occur in the project area there would likely be recreational and Aboriginal fisheries. This project involves raising Tutshi Lake by 5 m, which will likely affect fish populations and habitat. There are also potential changes in downstream flows to the reach of river between Tutshi and Tagish lakes and upstream movements into Tutshi Lake due to the new dam and operation of the powerhouse. The importance of this river between Tutshi and Tagish lakes to the local fish populations is currently unknown; however, based on its size and geomorphological characteristics visible in the satellite images, it is likely an important migration corridor and would likely provide spawning habitat to stream spawning species such as Arctic Grayling and the various sucker species. ***Changes to the lake and river habitats, combined with numerous species present results in a High ranking.***
Wolf River	Salmon & Habitat	**Medium**	There are Chinook Salmon present in Wolf River and spawning has been documented as far upstream as the outlet of Wolf Lake. This project is run-of-river, which is limited to a short section of the lower Wolf River (~8 km) and should not impede fish passage. ***This has been ranked as Medium as the area affected is small and the extent of flow modifications has not been modelled.***
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.
	Commercial, Recreational or Aboriginal Species & Habitat	**Medium**	Fish species known to occur in the Wolf River include Arctic Grayling, Burbot, Chinook Salmon, Inconnu, Lake Trout, Least Cisco, Longnose sucker, Northern Pike, Round Whitefish, and Slimy Sculpin. The fish species present would contribute to commercial, recreational and Aboriginal fisheries. ***This has been ranked as Medium due as the area affected is small and the extent of flow modifications has not been modelled.***

Project / Option	Indicator	Ranking	Assessment
Anvil Creek	Salmon & Habitat	**Medium**	Blind Creek is a known Chinook salmon spawning stream. There is also likelihood that Anvil Creek is used by Chinook (especially juveniles). Flow reductions in Anvil Creek and modifications to flow rates in Blind Creek could affect Chinook salmon. The extent of flow changes has not been modelled; ***therefore, this has been assessed as Medium.***
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.
	Commercial, Recreational or Aboriginal Species & Habitat	**High**	Lake trout, northern pike, Arctic grayling and whitefish (unspecified species) have been documented in Anvil Creek near the outlet of Anvil Lake. Some cabins are present on the lake and recreational fishing does occur. Impoundment of the lake will result in flooding of terrestrial vegetation and this combined with fluctuating water levels could affect fish populations in the lake, especially fall spawning species such as lake trout; as such, ***this indicator has been ranked as High.***

2.2.2.3 Gladstone Diversion

The Gladstone Diversion resource option would divert water from the headwaters of Gladstone Creek into Isaac Creek, which flows into Sekulmun Lake and then Aishihik Lake. Lake trout spawning occurs in all four Gladstone Lakes, and Arctic Grayling spawning and rearing occur between the lakes and in Gladstone Creek. Lake Whitefish and other fish species occur in the Aishihik Lake area and there is an Aboriginal fishery in this area.

As reviewed in Section 4.3 of Appendix A, past work by Yukon Energy has indicated concerns from the Department of Fisheries and Oceans (DFO) as well as from local First Nations regarding interbasin pathogen transfer. YEC reported that the results of a full year of baseline studies provided no evidence to support a concern regarding interbasin pathogen transfer. Yukon Energy has continued to work with local First Nations to seek support for this project. A summary assessment for this project is provided in Table C 2-4.

Table C 2-4: Summary of Assessment for Gladstone Diversion

Project / Option	Indicator	Ranking	Assessment
Gladstone Diversion	Salmon & Habitat	**No Linkage**	No salmon or salmon habitat has been identified in this area.
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.

	Commercial, Recreational or Aboriginal Species & Habitat	**High**	Arctic Grayling is known to occur in the area and project development would result in loss of spawning and rearing habitat between the lakes and in Gladstone Creek. Lake Trout spawn in Gladstone Lakes and project development may affect spawning/incubation success.

2.2.2.4 Hydro Storage Enhancements

Two potential hydro storage enhancement options have been under detailed review and planning by Yukon Energy for several years. Each option would enhance existing storage for existing hydro generation without developing any new dams. The evaluations in Table C 2-5 do not take into account the specific mitigation and adaptive management measures developed to date as a result of detailed environmental assessment studies (for the Mayo Lake Enhanced Storage, Yukon Energy's Yukon Environmental and Socio-economic Assessment Board [YESAB] submission set out measures to address potential adverse effects based on studies and ongoing work with the local First Nation).

Table C 2-5: Summary of Assessment for Hydro Storage Enhancements

Project / Option	Indicator	Ranking	Assessment
Mayo Lake Enhanced Storage	Salmon & Habitat	**Low**	No salmon or salmon habitat has been identified in this area. Project may have positive downstream effects on salmon habitat.
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.
	Commercial, Recreational or Aboriginal Species & Habitat	**High**	Lake Trout and Lake Whitefish are known to occur in the area. As a result of the proposed reduction in the Mayo Lake licence lower supply level, Lake Trout and Lake Whitefish production may be lower.
Southern Lakes Enhanced Storage	Salmon & Habitat	**Medium**	Chinook salmon are present in the project area; however, flow changes are unlikely to have adverse effects.
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.
	Commercial, Recreational or Aboriginal Species & Habitat	**High**	Lake Trout are known to occur in the area. The project may have an adverse effect on incubation success and food sources.

2.2.2.5 Mayo Lake Outlet Channel Dredging

The Mayo Lake Outlet Channel Dredging Project would remove an old cofferdam, as well as sedimentation that has infilled in the Mayo Lake Outlet Channel over the past 63 years since the original Mayo hydro generation was developed and address measures to mitigate potential future sediment infill in this outlet channel. As such, this can be viewed as a system maintenance activity that would not be anticipated to have adverse effects on fish and fish habitat assuming that BMPs are adopted as required for all of the activities. As noted for the Mayo Lake Enhanced Storage Project, there are no salmon or endangered fish species in the Mayo Lake storage area or in the outlet channel area affected by the proposed dredging.

For the purpose of this evaluation, Table C 2-6 provides a summary assessment of the Mayo Lake Outlet Channel Dredging option. This assessment does not take into account any specific mitigation and adaptive management measures developed to date as a result of detailed environmental assessment studies.

Table C 2-6: Summary of Assessment for Mayo Lake Outlet Channel Dredging

Project / Option	Indicator	Ranking	Assessment
Mayo Lake Outlet Channel Dredging	Salmon & Habitat	**No Linkage**	No salmon or salmon habitat has been identified in this area. Project may have positive downstream effects on salmon habitat.
	Species at Risk & Habitat	**No Linkage**	None of the fish species known to occur in the project area are listed under SARA.
	Commercial, Recreational or Aboriginal Species & Habitat	**Low**	Assuming BMPs for this project are implemented, no effects of concern are expected on these fisheries.

3.0 WATER QUANTITY & QUALITY

3.1 RATING CRITERIA AND DATA SOURCES FOR EN-2: WATER QUANTITY & QUALITY

The rating system outlined in Figure C 3-1 was adopted to guide evaluation of each resource project option for each of the water quantity and quality indicators.

Figure C 3-1: Summary of Rating Criteria for Water Quantity & Quality

Indicator	Low	Medium	High
Consumptive Water Use (En2-1)	<10% of instantaneous flows is not returned to the natural environment, or no linkage	10% to 20% of instantaneous flows is not returned to the natural environment	>20% of instantaneous flows is not returned to the natural environment
Relative Scale of New Impoundment / Flooding (En2-2) [relevant to water quality]	No new impoundment; water levels will be held high for longer periods of time increasing potential for erosion/sediment mobilization, or no linkage	>0% and <10% of lake surface area will be affected due to new impoundment	>10% of lake surface area will be due to new impoundment, increasing potential for erosion/sediment mobilization and mercury issues
Flow Changes (En2-3)	<10% of instantaneous flows, or no linkage	10% to 20% of instantaneous flows	>20% of instantaneous flows

The water quantity and quality indicators as defined in Figure C 3-1 each require a relative scale for comparing the different resource options. Implicit with each indicator is also an initial assessment as to whether the project is likely to have any effect on the indicator. In assessing water quantity and quality indicators, overlaps may occur with fish and fish habitat indicators, e.g., criteria for assessing high effects from new flooding may take into consideration increased potential for erosion/sediment mobilization and mercury issues that affect fish and fish habitat. Water quantity and quality effects during construction that are assumed to be addressed by BMPs (e.g., sediment disturbance) are rated green (low).

The following are noted regarding the rating scheme used for the assessment:

- **Consumptive Water Use (En2-1):** Consumptive water use is considered to be relevant to projects that consume water directly from a river, stream or lake and do not return water to the source following use (e.g., a steam plant, if it took water directly from a river and then used the water, which was evaporated and released to the atmosphere). The temporary diversion of water (e.g., run-of-river, pump storage) are included in the changes in the Flow Changes indicator (En2-3). No attempt is made for this evaluation to assess loss of water use due to reservoir evaporation or potential changes to groundwater flow regimes related to any of the resource options.

The indicator adopted focuses on the approximate assessment of changes to instantaneous flows that is not returned to the natural environment. The 10% of instantaneous flows adopted in Figure C 3-1 as the upper range of effect for low or green rating has been used in BC in recent water licence applications to indicate a low rating; 20% of instantaneous flows has been uses as an unofficial BC Ministry of Forests, Lands and Natural Resource Operations (FLNRO) guideline for run-of-river projects to indicate a high level of regulatory concern that needs to be addressed.

- **Relative Scale of New Impoundment/Flooding (En2-2):** The rating for impoundment is based on changes to water levels and the increase in lake size to reflect potential increases in erosion/sediment mobilization and methylmercury production.
    - Low rating applies if no new impoundment or increase in lake size, and includes options where existing impoundments will be used to hold water levels high for longer periods of time than is currently allowed.
    - An increase in lake surface area of less than 10% due to impoundment is rated as yellow or medium.
    - An increase in lake surface area of more than 10% due to impoundment is rated as red or high to reflect increasing potential for adverse effects related to potential increases in erosion/sediment mobilization and methylmercury production.
- **Flow Changes (En2-3):** Guidelines for small hydro and water diversions used by regulators in BC have been referenced to provide a range of rating values to develop the evaluation criteria for water quantity and flows. Unlike the En2-1 indicator, En2-3 addresses simple changes in review flows without any consumptive use of the water that removes it from the natural environment. The guidelines provide the following thresholds which have been used to evaluate effects on flows:
    - Less than 10% change in instantaneous flows has been used as a regulatory threshold for recent water licences in BC (i.e., project likely not to have a significant effect on the aquatic environment);
    - More than 20% change in instantaneous flows has been used as an unofficial FLNRO guideline for run-of-river projects to indicate a high level of regulatory concern that needs to be addressed; and
    - Projects with over 10% and less than 20% change in instantaneous flows are rated yellow (medium) to indicate the need to address potential regulatory concerns.

Some of the pumped storage projects and small hydro projects could affect lake levels in downstream reservoir lakes, as well as in the outflow streams/rivers of the downstream reservoir lakes. Detailed modelling of downstream changes for most of the hydro projects has not yet been done. In these situations, where there could be a change in flows, but the scale is unknown, the ranking has defaulted to yellow (medium). That ranking would need to be reassessed in the future, when flow modelling information becomes available. In the case of small hydro projects, a red (high) indicator has been used where relevant based on anticipated flow change effects on fish and fish habitat.

3.2 EVALUATIONS

3.2.1 Resource Options with No Material Concerns re: Water Quantity and Quality

Indicators related to the scale of new impoundments and flow changes are most applicable to the pump-storage and small hydro options, as well as upgrades or changes to existing hydroelectric facilities (i.e., Southern Lakes, Mayo Lake, and Gladstone).

A number of projects included in the resource review do not require the impoundment or diversion of water and also do not require consumptive uses of water. For these projects there is clearly no linkage to the water quantity and quality criteria or indicators.

In summary, based on currently available information, all of the resource project options shown in Table C 2-1 (for fish and fish habitat indicators) are assessed in this study to not require the impoundment or diversion of water or any consumptive uses of water. For example, none of the thermal generation projects is indicated to assume consumptive use of water from local rivers or water bodies. The Mayo Outlet Channel Dredging Project is also included in this assessment as not likely to have any effect of concern on water quantity or quality, assuming implementation of BMPs. The BMPs are assumed to address water quality impacts from sediment disturbance during construction and are therefore not specifically addressed in the water quantity and quality indicators.

3.2.2 Hydro Renewable Generation

Each of the hydro resource options that affects aquatic resources related to water quantity and quality is evaluated separately in the following sections. In many cases, flow changes have not yet been modelled and therefore a yellow or medium rating is provided (this may well change to red for many hydro options when there is further information).

3.2.2.1 Pumped Storage

Consistent summary information on each of the Pumped Storage projects is not available to summarize existing lake areas, new lake areas, area flooded and other related information. Each project involves two lake areas (upper reservoir and lower reservoir), with impoundment and flooding effects primarily being on the upper reservoir

Table C 3-1 provides the assessment on water quantity and quality of each Pumped Storage hydro generation option examined in this review. This evaluation does not attempt to assess any differences in effects on water quantity and quality due to different scales of development for some of these options, e.g., storage at 50 GWh versus 100 GWh.

Table C 3-1: Summary of Assessment for Pumped Storage

Project / Option	Indicator	Ranking	Assessment
Atlin – Black Mountain	Consumptive Water Use	**No Linkage**	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment/ Flooding	**High**	The project consists of an unnamed upper lake/reservoir (BC Waterbody Identifier 00172ALL) south of Black Mountain and a lower reservoir (Atlin Lake). The project will involve the construction of dams (26 to 42 m) at each end of the unnamed lake to enlarge storage capacity of the unnamed lake. Water will be directed via an intake structure on the west end of the lake to a powerhouse on the shore of Atlin Lake. This will change the flows from the unnamed lake, from heading east to west. There will be some flooding associated with the dam development on the upper reservoir lake; the amount could double the size of the reservoir. Available satellite imagery shows that the lake is surrounded by alpine meadow and wetland habitat. These areas are high in organic material. Microbial degradation of flood organic materials could increase the rate of mercury methylation in the upper reservoir lake meaning that the pump and storage could be a vector for transporting methylmercury to Atlin Lake. ***Therefore, this risk is considered to be High.***
	Flow changes	**Medium**	The project will see flows directed from Stream 837-088400-28000-50000 and direct them to the west into Atlin Lake. The potential effects of such a flow diversion on Stream 837-088400-28000-50000 could not be assessed with the available information; ***therefore flow changes have been ranked as Medium. However, this ranking could be changed with further hydrological studies.***
Canyon – Ittlemit	Consumptive Water Use	**No Linkage**	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment/ Flooding	**High**	The project will use Ittlemit Lake as the upper reservoir and Canyon Lake as the lower reservoir. An expansion of the existing Canyon Lake dam and a saddle dam would cause a significant increase in the surface area of Canyon Lake. A 16 m high dam would be required on the outlet of Ittlemit Lake. The proposed project would increase Canyon Lake surface area by almost 50% and increase Ittlemit Lake by 12%. The significant increase in Canyon Lake volume (based on the presence of a >30 m high dam), could result in an increase in erosion/sediment mobilization and methylmercury production. ***Therefore, effects related to the relative scale of new impoundment/flooding were considered to be High.***
	Flow changes	**Medium**	Changes to downstream flows have not been modelled; ***therefore, this was ranked as Medium.***

Project / Option	Indicator	Ranking	Assessment
Lindeman – Fraser	Consumptive Water Use	**No Linkage**	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment/ Flooding	**High**	This project will use Fraser Lake as the upper reservoir and Lindeman Lake as the lower reservoir. It will include a 16 km penstock to bring water from Fraser Lake to Lindeman Lake. The proposed project would increase Fraser Lake surface area by 80% and increase Lindeman Lake by 36%. ***Therefore, effects related to the relative scale of new impoundment/flooding are considered to be High.***
	Flow changes	**Medium**	Changes to downstream flows have not been modelled; ***therefore, this was ranked as Medium.***
Racine – Moon	Consumptive Water Use	**No Linkage**	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment/ Flooding	**High**	The project would use Moon Lake as the upper reservoir and Racine Lake as the lower reservoir. A 16 m to 21 m high dam would be constructed on Moon Lake and a control structure on Racine Lake. The construction of a dam on Racine Lake would control water levels and could obstruct movements between Racine and Tagish Lake. The proposed project would increase Moon Lake surface area by 60%, but would not change the surface area of Racine Lake. Such changes on Moon Lake could increase in erosion/sediment mobilization and methylmercury production. ***Therefore, effects related to the relative scale of new impoundment/ flooding are considered to be High.***
	Flow changes	**Medium**	Changes to downstream flows have not been modelled; ***therefore, this was ranked as Medium.***
Racine – Mt. Brown	Consumptive Water Use	**No Linkage**	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment/ Flooding	**High**	The project would involve the impoundment of an unnamed lake near Mt. Brown by the construction of a 29 to 43 m high dam. A dam would be constructed on the outlet of Racine Lake to control water levels. The project would increase the surface areas of the Mt. Brown lake by 500%; ***therefore, effects related to the relative scale of new impoundment/flooding are considered to be High.***
	Flow changes	**Medium**	Changes to downstream flows have not been modelled; ***therefore, this was ranked as Medium.***

Project / Option	Indicator	Ranking	Assessment
Squanga – Dalayee	Consumptive Water Use	**No Linkage**	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment/ Flooding	**High**	The facility is located between Johnson's Crossing and Jake's Corner. Dalayee Lake would be the upper reservoir and Squanga Lake would serve as the lower reservoir. The proposed project would not increase the surface area of Dalayee Lake, but would increase the surface area of Squanga Lake by about 12%. ***Therefore, effects related to the relative scale of new impoundment/flooding are considered to be High.***
	Flow changes	**Medium**	Changes to downstream flows have not been modelled; ***therefore, this was ranked as Medium.***
Moon Lake (Tutshi – Moon)	Consumptive Water Use	**No Linkage**	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment/ Flooding	**High**	This option would use Moon Lake as the Upper Reservoir. The penstock would divert water to Tutshi Lake. Project operations are not expected to have a material effect on water levels of Tutshi Lake, and inflows and outflows from Tutshi Lake will remain uncontrolled during project operations. The proposed project would increase the surface area of Moon Lake by 100%, but would not increase the surface area of Tutshi Lake. ***Therefore effects related to the relative scale of new impoundment / flooding are considered to be High.***
	Flow changes	**Medium**	Changes to downstream flows have not been modelled; ***therefore, this was ranked as Medium.***
Faro – Vangorda Pit	Consumptive Water Use	**No Linkage**	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment/ Flooding	**High**	The project will involve the creation of new water bodies for the upper and lower reservoirs. The lower reservoir would be in the Blind Creek Valley and be 439 ha in size. The upper reservoir will be a new waterbody 520 ha in size. ***Therefore, effects related to the relative scale of new impoundment / flooding are considered to be High.***
	Flow changes	**Medium**	Changes to downstream flows have not been modelled; ***therefore, this was ranked as Medium.***

3.2.2.2 Small Hydro Projects

Table C 3-2 below summarizes some of the information available for the four small hydro projects where new impoundments are required (see also the general comments provided at outset of Section 2.2.2.2 with regard to these resource projects - Wolf River is run of river project, and the Atlin-Pine Creek project enhances power generation from storage facilities already in place).

Table C 3-2: Summary of Information Regarding Relative Scale of New Impoundment/Flooding

	Natural Lake Area (km^2)	New Lake Area (km^2)	Area Flooded (km^2)	Lake Level Increase (m)	Percentage increase of Existing Lake Surface Area	Est. Storage (000 m^3)
Drury Lake	26	27.9	1.9	5	7%	134,750
Finlayson (includes Finlayson and Wolverine lakes)	28.2	33.6	5.4	5	19%	154,500
Tutshi – Windy Arm (Tutshi Lake only)	51.9	55	3.1	5	6%	267,125
Anvil Creek	5.3	5.9	0.6	5	11%	27,875

Effects on water quantity and quality indicators are reviewed in Table C 3-3 for each of the site options, taking into consideration available information on the changes in the water regime currently assumed for each project option.

Table C 3-3: Summary of Assessment for Small Hydro

Project / Option	Indicator	Ranking	Assessment
Drury Lake	Consumptive Water Use	No Linkage	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment /Flooding	Medium	The project will include an impoundment on Drury Lake, which would increase lake levels by 5 m and the lake surface area by 1.9 km^2. An increase in lake levels and impoundment areas would flood terrestrial areas and could change rate of methylmercury production. ***There is a small increase in impoundment size (7%), therefore, this has been ranked as Medium.***
	Flow changes	Medium	There will be a diversion of flows from Drury Creek. The reduction in flows from Drury Lake outlet stream by diversion into the penstock could potentially affect fish movement between Drury Lake and Little Salmon Lake (downstream of Drury Lake) and access to habitat in the stream reach between the two lakes. Changes to downstream flows have not been modelled; ***therefore, this was ranked as Medium.***
Finlayson River	Consumptive Water Use	No Linkage	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment /Flooding	High	The project would store water in Finlayson and Wolverine lakes and include a 5 m dam on each lake, which would result in an increase in surface area of 3 km^2 for Finlayson Lake and 2.4 km^2 for Wolverine Lake. Increases in impoundment size could result in increased production of methylmercury. There will be a 22% increase in Wolverine Lake and a 13% increase in Finlayson Lake. ***Therefore, this has been ranked as High.***
	Flow changes	Medium	There are potential changes in downstream flows in the lower 6 km of the Finlayson River (upstream of Frances Lake) due to the diversion of water into the penstock. Changes to downstream flows have not been modelled; ***therefore, this was ranked as Medium.***
Atlin/Pine Creek	Consumptive Water Use	No Linkage	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment	Low	The project would include an increase to power generation facilities already in place. This will include increasing the water level range on Surprise Lake from 913.85 m to 911.35 m (vs the existing operating range from 913.1 to 912.1). The existing permits allow maximum

Project / Option	Indicator	Ranking	Assessment
	/ Flooding		water levels up to 913.85 m, so no change to the permit is required. As such the project would likely just result in a higher frequency of water levels at or near the permitted full supply level; ***therefore, this has been ranked as Low.***
	Flow changes	**Medium**	There are potential changes to downstream flows in Pine Creek and changes to access because of changes in operating levels. The existing facility already modifies flows; however, incremental changes to downstream flows have not been modelled; Therefore, ***flow changes has been ranked as Medium.***
Tutshi – Windy Arm	Consumptive Water Use	**No Linkage**	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment / Flooding	**Medium**	The project would increase the water level in Tutshi Lake by 5 m and increase the surface area by 3.1 km^2 by constructing a dam across the outlet of the lake. Increases in impoundment size could result in increased production of methylmercury. There is a small increase in lake surface area (6%). ***This has been ranked as Medium.***
	Flow changes	**Medium**	There are potential changes in downstream flows to the reach of river between Tutshi and Tagish lakes and upstream movements into Tutshi Lake, due to the new dam and operation of the powerhouse. Changes to downstream flows have not been modelled; ***therefore, this was ranked as Medium.***
Wolf River	Consumptive Water Use	**No Linkage**	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment / Flooding	**No Linkage**	The project is a run-of-river development and therefore there is not anticipated to be any new impoundment/flooding.
	Flow changes	**Medium**	Wolf River is a run-of-the-river facility and does not involve impounding of water. Water intake will be constructed and water diverted through the powerhouse located approximately 8 km downstream. Due to the diversion of water, an 8 km section of river will experience changes in flows. Changes to downstream flows have not been modelled; ***therefore, this was ranked as Medium.***
Anvil Creek	Consumptive Water Use	**No Linkage**	The Project is not anticipated to have consumptive water use.

Project / Option	Indicator	Ranking	Assessment
	Relative Scale of New Impoundment /Flooding	High	The project will include an impoundment on Anvil Lake, which would increase lake levels by 5 m and the lake surface area by 0.6 km^2. An increase in lake levels and impoundment areas would flood terrestrial areas and could change rate of methylmercury production. There is a moderate increase in impoundment size (11%), ***therefore, this has been ranked as High.***
	Flow changes	Medium	There will be diversion of flow from Anvil Lake to a powerhouse located near the mouth of the stream that will result in a reduction of flow in Anvil Creek and some changes in flow rates in Blind Creek. The extent of changes to downstream flows habitat not been modelled; ***therefore, this was ranked as Medium.***

3.2.2.3 Gladstone Diversion

The Gladstone Diversion project will require flooding of area adjacent to several small lakes, creating one larger lake. The project will also result in changes in flow in Gladstone Creek of >20% and increases in flows in Isaac Creek, leading to Sekulmun Lake. Table C 3-4 provides a summary assessment of this project effects on water quantity and quality.

Table C 3-4: Summary of Assessment for Gladstone Diversion

Project / Option	Indicator	Ranking	Assessment
Gladstone Diversion	Consumptive Water Use	No Linkage	The Project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment / Flooding	High	The project requires flooding the area adjacent to several small lakes to create one larger lake. ***Therefore, this was ranked as High.***
	Flow changes	High	The project will result in changes in flow in Gladstone Creek >20% and increases in flows in Isaac Creek, leading to Sekulmun Lake. ***Therefore, this was ranked as High.***

3.2.2.4 Hydro Storage Enhancements

The Hydro Storage Enhancements projects involve changes to the use of existing storage (impoundments) without creating any new impoundment or expansion of lake surface area. Table C 3-5 outlines the expected effects of these resource options on water quantity and quality.

Table C 3-5: Summary of Assessments for Hydro Storage Enhancements

Project / Option	Indicator	Ranking	Assessment
Southern Lakes Enhanced Storage	Consumptive Water use	No Linkage	The project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment /Flooding	Low	The project includes an increase to the high supply limit where lake levels can be controlled; however, this is designed to keep water levels high in late summer and fall rather than impound/flood any land. Higher water levels for a longer period of time will increase the potential for erosion/sediment mobilization. ***Therefore, this project has been ranked as Low.***
	Flow changes	High	Changes to downstream flows are predicted to be over 20% higher in the late winter than historical flows. Reductions of flows occur during the late summer but are expected to be < 10 % lower than historical. ***Given the higher changes in late winter, diversion of flows has been ranked as High.***
Mayo Lake Enhanced Storage	Consumptive Water use	No Linkage	The project is not anticipated to have consumptive water use.
	Relative Scale of New Impoundment / Flooding	Low	The project would actually decrease the average water level in Mayo Lake and, as such, erosion from high water events should be reduced. ***Therefore, this has been ranked as Low.***
	Flow changes	High	Changes to downstream flows are predicted on average to be over 20% higher in late winter/spring than flows without the enhancement (effects will vary for different years). Reductions of flows that occur during the summer are expected to be over 10% and perhaps slightly over 20% (depending on load conditions). ***Therefore, this has been assessed as High.***

4.0 TERRESTRIAL SPECIES & HABITAT

4.1 RATING CRITERIA AND DATA SOURCES FOR EN-3: TERRESTRIAL SPECIES AND HABITAT

The rating system outlined in Figure C 4-1 was adopted to guide evaluation for each resource project option for each of the terrestrial species and habitat indicators.

Figure C 4-1: Summary of Assessment Rating Criteria for Terrestrial Species & Habitat

Indicator	No Linkage-Low	Low	Medium	High
Species at Risk & Habitat (SAR) (En3-1)	No SAR within Zone of Influence (ZoI)	Potential indirect effects; SAR occurrences within sensory disturbance ZOI	Potential direct effects; magnitude estimated to affect < a quarter of local population/habitat, effects on regional populations very limited, if any	Potential direct effects; magnitude estimated to affect > a quarter of local population/habitat, effects on regional populations may be measurable
Protected & Conservation Areas (PCA) (En3-2)	No PCA within 2 km of project	New access within 2 km of PCA, but no potential effect expected on PCA	Potential indirect effect due to proximity	Potential direct material effect within PCA
Wildlife Key Areas (WKA) (En3-3)	No WKAs within species-specific sensory disturbance ZoI	Potential indirect effects; WKAs within sensory disturbance ZOI of relevant species	Potential direct effects; magnitude estimated to affect < a quarter of WKA	Potential direct effects; magnitude estimated to affect > a quarter of WKA
Caribou Ranges (En3-4)	No caribou range within ZoI	Potential indirect effects; caribou range within sensory disturbance ZOI	Potential direct effects; magnitude limited to small proportion (< approximately 5%) of range	Potential direct effects; magnitude > approximately 5% of range

The terrestrial species and habitat indicators as defined in Table C 1-1 focus on the presence or proximity of the indicator relative to the resource project option's terrestrial footprint. Unless otherwise explicitly noted, the evaluations of each resource option for these indicators address only adverse effects. Assessments for each indicator consider the terrestrial zone of influence (ZOI)[2] for a project's footprint (e.g., noise effects can extend beyond the physical footprint), as well as the extent to which project effects are likely to affect the indicator (e.g., how much of the species habitat or WKA area would be affected). Figure C 4-1 provides separate rating criteria for No Linkage to address the degree of proximity to the indicator beyond which no linkage is assumed. As reviewed below, ratings for specific resource

[2] Zone of influence is the extent surrounding the footprint of an anthropogenic activity within which wildlife and/or habitat are affected by the activity.

options modify the criteria in Figure C 4-1 to reflect relevant factors, e.g., flexibility with transmission elements to avoid material effects (reduces ratings), caribou ranges that are very small or that are declining (increases ratings).

This subset of potential indicators for Terrestrial Species and Habitat were selected based on:

- Conservation concern (species at risk);
- Potential land use constraints (protected and conservation areas);
- High value wildlife habitat areas (wildlife key areas); and
- Regional and territorial emphasis on caribou management.

This selection of indicators is meant to provide a strategic assessment of key values of terrestrial species to identify potential showstopper issues and to facilitate a high-level comparison of relative values among projects. Assessment of additional indicators will be required for projects that advance from this strategic assessment to feasibility studies and environmental assessment stages.

Assignments of green (no linkage or low), yellow (medium) and red (high) ratings were driven by the type of project effects (i.e., mechanism of effect on the indicator) and the potential degree of overlap between the project and indicator. A list of potential effects associated with each project type on Terrestrial Species and Habitat is listed in Table C 4-1.

Table C 4-1: Summary of Potential Effects on Terrestrial Species

Project Type	Potential Effects on Terrestrial Species
Facilities (Storage, generating stations)	• Direct and indirect habitat effects of facility (generally small footprints).
Wood Biomass	• Direct and indirect habitat effects of biomass collection activities (potentially large footprints). • See also Access Roads.
Small hydro, pumped storage, enhanced storage	• Direct and indirect habitat effects of dams and associated infrastructure. • Effects to shoreline-associated birds. • Effects to littoral, shoreline and riparian vegetation and habitat.
Solar PV	• Direct and indirect habitat effects of site clearing and solar panel arrays.
Wind Farms	• Direct and indirect habitat effects of site clearing and turbines. • Collision risk to birds and bats.
Transmission Lines	• Direct and indirect habitat effects of right-of-way clearing. • Collision risk to birds. • Increased human access (disturbance and mortality effects by humans). • Facilitated predation. • Invasive plants.
Access Roads	• Direct and indirect habitat effects of roads. • Increased human access (disturbance and mortality effects by humans). • Facilitated predation. • Invasive plants.

Medium (yellow) and/or red (high) ratings were applied to situations where the project has the potential to have a direct effect on the indicator, as well as situations where data limitations prevent a clear green (low) or red (high) rating.

The list of specific criteria used to guide ratings for each indicator are described in Figure C 4-1, and reviewed below.

- For **Species at Risk** and **Wildlife Key Areas,** the primary measure used to assess magnitude of effects was proportion of local habitat potentially affected.
    - For most species this was assessed qualitatively with respect to visual estimates of broad habitat types and conceptual stage project maps. For example, for Olive-sided Flycatcher potential habitat was considered as conifer leading forest visible in satellite imagery.
    - For most projects more detailed species-specific habitat data are not available.
    - For situations where direct effects could result from a project, an approximate level of a quarter of total potential habitat was used as a threshold to define yellow (Medium) (< a quarter of total habitat) and red (High) (> a quarter of total habitat) risk ratings. That threshold was assessed qualitatively based on conceptual project design maps and written project descriptions.
    - Caribou are noted where relevant within WKA', but (to avoid doubling counting with the separate "caribou ranges" indicator) are not a key factor in determining ratings for the overall Wildlife Key Areas ratings indicator.
- For **Protected and Conservation Areas,** any projects with potential direct material effects within Protected and Conservation Areas were rated red (High). Projects with potential measureable indirect effects on Protected and Conservation Areas due to proximity were rated yellow (Medium). Projects with new access within 2 km of Protected and Conservation Areas were rated green (Low) if no indirect effects are expected, based on the potential negative effects of new human access.
- For **caribou ranges,** ratings focussed on amount of range affected, however, location of the project within the range, habitat type (e.g. calving vs general range), and population status of the herd were also considered. This indicator focuses specifically on caribou WKAs.

Ratings were modified from the general criteria outlined in Figure C 4-1 by a one class upgrade or downgrade for specific situations.

- One situation was for assumed design flexibility and mitigations. For example, where a transmission line was proposed in proximity to a rare plant occurrence, the risk rating was downgraded from red (high) to yellow (medium) to account for flexibility in pole locations to avoid occurrences of the plant.
- Another situation was consideration of the population status (size and trend) of caribou ranges. Ratings were increased by one category for caribou ranges that are very small or that are declining.
- Another situation for caribou was where proposed roads or transmission lines followed existing rights-of-way. In those circumstances, incremental effects of the new linear features were assumed to be minimal and the potential effects were rated green (low).

Assessment of Species at Risk (SAR) considered all species listed under Schedule 1 of the federal Species at Risk Act and all species listed as vulnerable (S3), imperiled (S2), or critically imperiled (S1) within

Yukon by the Yukon Conservation Data Centre (CDC). This included birds, mammals, amphibians, insects, and plants. The primary sources of information used to evaluate potential SAR occurrences near projects in this assessment were CDC species occurrence data and Wildlife Key Areas mapping. This information was supplemented with range and habitat association information from guidebooks (e.g. Birds of the Yukon), regional studies, and knowledge of local biologists. However, information about the ranges, distribution, and habitat associations of many SAR species across the project area is incomplete. Due to the large number of SAR species, incomplete knowledge of distribution and habitat associations of many SAR species, limited base habitat information available, and limited time associated with the strategic nature of this assessment, results of the assessment of Species at Risk & Habitat indicator should not be considered comprehensive. More detailed desktop reviews and field studies could find SAR occurrences not located as part of this assessment.

In the following evaluations for the resource project options, a summary of the key factors guiding the rating assignment is provided, including note of any modifying criteria. Where relevant, site specific differences among projects and indicators are noted.

Maps and data of Wildlife Key Areas and Protected and Conservation Areas were obtained from Geomatics Yukon (ftp://ftp.geomaticsyukon.ca/GeoYukon/Biological/Wildlife_Key_Areas_250k/ and ftp://ftp.geomaticsyukon.ca/GeoYukon/Base/Wetlands_50k/).

Caribou range maps were obtained from Troy Hegel (Biologist, Yukon Environment) and population estimates and trend were obtained from the Yukon State of the Environment Report (2014) (http://www.env.gov.yk.ca/publications-maps/stateenvironment.php).

4.2 EVALUATIONS

4.2.1 Resource Options with No Material Concerns re: Terrestrial Species & Habitat

The following resource project options have green (low or no linkage) ratings for each of the terrestrial species and habitat indicators:

- **Fossil Fuel Thermal Generation: Diesel and LNG**, each in Whitehorse ([landfill or Takhini substation locations]):
    - No linkage for En3-2, Wildlife Key Areas (En3-3) and Caribou Ranges (En3-4);
    - Green (low) for En3-1 (Species at Risk and Habitat) - No occurrences of SAR are known in vicinity of these sites. Species that may occur based on habitat and range are Olive-sided Flycatcher (both sites) and Short-eared Owl (Takhini substation); and
    - It is noted that other terrestrial species are valued in the Whitehorse landfill site area. McIntyre Creek and adjacent marsh and upland habitat is a known wildlife corridor (EDI 2011) that is located 1 km south of the project. Ridges along McIntyre Creek are used by raptors for migration and staging. The area, including the landfill, is used by a wintering population of Bald Eagles.

- **Non-fossil fuel thermal generation: Biogas and Waste to Energy**, each at Whitehorse locations (Biogas at Whitehorse landfill; Waste-to-energy site not known but in Whitehorse in area where other commercial/government/institutional activity to utilize waste heat):
    - No linkage for Protected and Conservation Areas (En3-2), Wildlife Key Areas (En3-3) and Caribou Ranges (En3-4);
    - Green (low) for En3-1 (Species at Risk and Habitat): No occurrences of SAR are known in vicinity of Whitehorse landfill or are expected at any likely Waste-to-Energy site in Whitehorse. Species that may occur based on habitat and range at the biogas site (Whitehorse landfill) are Olive-sided Flycatcher. No likely issue of concern for any site likely to be selected for Waste-to-energy option; and
    - It is noted that other terrestrial species are valued in the Whitehorse landfill site area (biogas site). McIntyre Creek and adjacent marsh and upland habitat is a known wildlife corridor (EDI 2011) that is located 1 km south of the project. Ridges along McIntyre Creek are used by raptors for migration and staging. The area, including the landfill, is used by a wintering population of Bald Eagles.
- **Energy Storage Facility** at Whitehorse (Takhini substation):
    - No linkage for Protected and Conservation Areas (En3-2) and Caribou Ranges (En3-4); and
    - Green (low) for En3-1 (Species at Risk and Habitat) and En3-3 (Wildlife Key Areas) The project footprint is anticipated to be within late winter moose habitat, but there is low risk based on small project footprint.
- **Solar PV** at Whitehorse (old mine quarry) and Haines Junction:
    - No linkage for Caribou Ranges (En3-4) at both sites and for Protected and Conservation Areas (En3-2) and Wildlife Key Areas (En3-3) at Whitehorse site;
    - Green (low) for En3-1 (Species at Risk and Habitat) at both sites as no occurrences of species of concern are known in the vicinity of each site (at Whitehorse site, species that may occur based on habitat and range are Common Nighthawk, which nests on exposed soil and sparsely vegetated sites);
    - Green (low) for En3-2 (Protected and Conservation Area) at Haines Junction due to possible visual effect concerns with proximity (700 m) to Kluane National Park; and
    - Green (low) for En3-3 (Wildlife Key Areas) at Haines Junction site, which is within late winter moose range WKA. Potential effects assumed to be negligible due to small footprint and location.
- **Mayo Lake Outlet Channel Dredging:**
    - No linkage for Protected and Conservation Areas (En3-2), Wildlife Key Areas (En3-3) and Caribou Ranges (En3-4); and
    - Green (low) for En3-1 (Species at Risk and Habitat). No occurrences of species of concern have been recorded within 500 m of the proposed project. Wildlife species that may occur based on habitat and range are Olive-sided Flycatcher, Barn Swallow, Bank

Swallow, and Common Nighthawk. Overall, project effects on Species at Risk and Habitat are expected to be low and mostly mitigatable via site-level BMPs.

- **Refurbishment / Maintenance: Aishihik Rerunnering, and Mayo A Refurbishment**
    - No linkage to any of the indicators, assuming BMPs and that all material work is located within each facility.

4.2.2 Non-Hydro Renewable Generation

4.2.2.1 Non-Fossil Thermal Generation - Wood Biomass

The Wood Biomass resource option assumes a 0.5 MW generating facility located in Haines Junction (near school and other existing activities for use of waste heat) and 3,000 oven dry tonnes (ODT)/year of wood biomass from local beetle kill areas (unspecified location, but assuming no change in existing harvesting areas).

For the biomass generating facility in Haines Junction, the ratings for terrestrial species and habitat indicators are all green (low or no linkage):

- No linkage for Caribou Ranges (En3-4): and
- Green (low) for Species at Risk and Habitat (En3-1), Protected and Conservation Areas (En3-2) and Wildlife Key Areas (En3-3):
    - No occurrences of SAR are known in the vicinity. Species that may occur based on habitat and range are Olive-sided Flycatcher.
    - For En3-2 (Protected and Conservation Areas), there are possible visual and air quality concerns associated with proximity of the project (700 m) to Kluane National Park.
    - For En3-3 (Wildlife Key Areas), the site is within late winter moose range WKA. Potential effects are assumed to be negligible due to small footprint and location.

Under the current instance of a 0.5 MW facility, the biomass supply is assumed primarily to be residues from existing forest harvesting and sawmill activities. If biomass supply results in incremental timber harvesting operations, that could have effects on biodiversity and individual focal species. However, a variety of coarse- and fine-filter, ecosystem-based, management strategies are available to mitigate timber harvesting effects.

Table C 4-2 presents the assessment of the harvesting operations on terrestrial species and habitat indicators.

Table C 4-2: Summary of Assessment for Wood Biomass (Timber Harvesting)

Project / Option	Indicator	Ranking	Assessment
Wood Biomass (Timber Harvesting Operations)	Species at Risk & Habitat	Low	Although harvest areas have not been spatially identified, associations of SAR with target forests are generally low. Species that may occur based on habitat and range are: Olive-sided Flycatcher, which are known to use beetle damaged forests. Potential effects to Olive-sided Flycatcher may be mitigated via stand and landscape level forest harvesting strategies.
	Protected & Conservation Areas	Low	Timber harvesting can be spatially managed to avoid PCA.
	Wildlife Key Areas	Medium	Beetle damaged stands in southwest Yukon occur within numerous WKAs, notably moose winter range. Timber harvesting and road construction could have several types of effects including habitat effects, disturbance and mortality by humans, and facilitated predation.
	Caribou Ranges	Low	Beetle damaged stands in southwest Yukon are largely outside caribou ranges. However, if harvesting does occur in caribou range, habitat effects of logging and disturbance and mortality by humans, and facilitated predation by natural predators could be High.

4.2.2.2 Wind Farms

Wind farms typically have three types of infrastructure that can affect terrestrial species and habitat: wind turbines and associated facilities, access roads, and transmission lines. The following are potential project effects associated with wind farms that were frequently noted during project evaluations. A summary of potential project-specific effects of wind farms are listed in Table C 4-3.

- Direct habitat effects associated with vegetation clearing and construction of roads, turbines, facilities, and transmission lines.
- Indirect effects that result in species avoiding project infrastructure as a result of sensory disturbance.
- Increased disturbance and mortality by humans, and facilitated predation by natural predators, associated with new linear features (roads and transmission lines).

Potential focal species vary by location but often include resident and migrating raptors (Golden Eagle, Peregrine Falcon, Short-eared Owl), migrating waterfowl, rare plants in grassland steppe habitats, and ungulate winter ranges. Although not highlighted for specific sites, other valued terrestrial species may be affected by turbines, new access and new transmission lines at most sites, e.g., alpine raptors and migrating birds passing through the area.

Table C 4-3: Summary of Assessment for Wind Farms

Project / Option	Indicator	Ranking	Assessment
Cyprus Mine Hill (central site, 10 turbines, access road and transmission line; also dependent on Faro-Watson Lake Transmission Line)	Species at Risk & Habitat	**Medium**	No occurrences of species of concern are known in vicinity. Alpine areas offer potential habitat for Short-eared Owl; turbines and transmission lines could reduce habitat effectiveness and present collision risk. Talus slopes offer potential habitat for Collared Pika; project could affect habitat.
	Protected & Conservation Areas	**No Linkage**	
	Wildlife Key Areas	**Low**	Project occurs within early winter moose range WKA. Project would create new linear feature access onto Mount Aho that could result in increased disturbance and mortality by humans and facilitated predation by natural predators along the road and transmission line.
	Caribou Ranges	**Medium**	Project is in southwestern edge of Tay Caribou herd range. Project would create new linear feature access onto Mount Aho that could result in increased disturbance and mortality by humans and facilitated predation by natural predators. Turbines would have a small direct habitat effect and larger indirect effect via sensory disturbance.
Kluane Lake (central site, 10 turbines, access road and transmission line; also dependent on associated Transmission Lines)	Species at Risk & Habitat	**Medium**	Grizzly Bear are assumed to occur based on WKA designation (see below). Other species that may occur based on habitat and range are Olive-sided Flycatcher, Bank Swallow.
	Protected & Conservation Areas	**Medium**	Associated transmission line runs close to Kluane National Park and Kluane Wildlife Sanctuary and, under some options, might run through these protected areas. Rating may be reduced to Low depending on how project integrates with existing infrastructure.
	Wildlife Key Areas	**High**	Grizzly bear – spring, summer, fall range; project could have direct and indirect habitat effects; linear feature development could elevate risk of disturbance and mortality by humans. Moose late winter range; project could have direct and indirect habitat effects; linear feature development could affect risk of disturbance and mortality by humans, and result in facilitated predation risk.
	Caribou Ranges	**No Linkage**	
Miller's Ridge (central site, 10 turbines, access road and transmission	Species at Risk & Habitat	**Medium**	No occurrences of species of concern are known in vicinity, but risks of potential direct effects are noted. Grassland steppe ecosystems offer potential habitat for rare plants; BMP siting location mitigations to minimize effects to local plant occurrences are assumed to reduce rating to Low for such effects. Alpine areas offer suitable habitat for Short-eared Owl; turbines and transmission lines could reduce habitat effectiveness and present collision risk. Talus slopes may offer habitat for Collared Pika.

Project / Option	Indicator	Ranking	Assessment
line; also dependent on associated Transmission Lines)	Protected & Conservation Areas	**No Linkage**	
	Wildlife Key Areas	**Medium**	The eastern section of transmission line intersects WKAs for Golden and Bald Eagles. Transmission line could reduce habitat effectiveness and be a collision risk. Turbines on ridge could also reduce habitat effectiveness for foraging and be a collision risk. Effects on Bald Eagle expected to be low to none.
	Caribou Ranges	**Medium**	Project is in southeastern edge of Klaza Caribou herd range. Project would create new linear feature access onto Miller's Ridge that could result in increased disturbance and mortality by humans and facilitated predation by natural predators along the road and transmission line. Turbines would have a small direct habitat effect and larger indirect effect via sensory disturbance.
Mt. Sumanik (central site, 10 turbines, access road and transmission line)	Species at Risk & Habitat	**Medium**	Collared Pika are known to occur in vicinity; project could affect habitat. Alpine areas offer suitable habitat for Short-eared Owl; turbines and transmission lines could reduce habitat effectiveness and present collision risk.
	Protected & Conservation Areas	**No Linkage**	
	Wildlife Key Areas	**High**	Alpine raptor – summer reproduction WKA; turbines and transmission lines could reduce habitat effectiveness and present collision risk.
	Caribou Ranges	**No Linkage**	
Sugarloaf Mountain (central site, 10 turbines, access road and transmission line; also dependent on associated Transmission Lines)	Species at Risk & Habitat	**Medium**	No occurrences of species of concern are known in vicinity. Alpine areas offer potential habitat for Short-eared Owl; turbines and transmission lines could reduce habitat effectiveness and present collision risk. Talus slopes offer potential habitat for Collared Pika; project could affect habitat.
	Protected & Conservation Areas	**No Linkage**	
	Wildlife Key Areas	**High**	Alpine raptor – summer reproduction WKA; turbines and transmission lines could reduce habitat effectiveness and present collision risk. Woodland Caribou – fall rut and winter range WKAs; project could have direct and indirect habitat effects and linear feature development could elevate risk of disturbance and mortality by humans, and facilitated predation by natural predators (however, note that roads and trails already exist in area).

Project / Option	Indicator	Ranking	Assessment
			Mountain Goat – year-round WKA; project could displace goats from cliffs north of installations (however habitat is marginal).
	Caribou Ranges	**Medium**	Project is within Carcross Caribou herd range. Project would create new linear feature access onto Montana Mountain that could result in increased disturbance and mortality by humans, and facilitated predation by natural predators (however, note that roads and trails already exist in area). Turbines could have a small direct habitat effect and larger indirect effect via sensory disturbance.
Tehcho (Ferry Hill) (central site, 10 turbines, access road and transmission line; also dependent on associated Transmission Lines)	Species at Risk & Habitat	**Low**	No occurrences of species of concern are known in vicinity. Species that may occur based on habitat and range are: Olive-sided Flycatcher.
	Protected & Conservation Areas	**Low**	Devil's Elbow Habitat Protection Area is located 1.5 km to SE.
	Wildlife Key Areas	**Medium**	Black Bear – spring range; project could have direct and indirect habitat effects (however infrastructure avoids most high value habitat)
	Caribou Ranges	**No Linkage**	
Thulsoo Mountain (central site, 10 turbines, access road and transmission line; also dependent on associated transmission lines)	Species at Risk & Habitat	**Medium**	No occurrences of species of concern are known in vicinity. Alpine areas offer suitable habitat for Short-eared Owl; turbines and transmission lines could reduce habitat effectiveness and present collision risk. Talus slopes may offer habitat for Collared Pika.
	Protected & Conservation Areas	**No Linkage**	
	Wildlife Key Areas	**Medium**	Bison – year-round core range; linear feature development could elevate risk of disturbance and mortality by humans, and facilitated predation by natural predators. Thin horn Sheep – winter range; turbines could have indirect habitat effects; linear feature development could elevate risk of disturbance and mortality by humans.
	Caribou Ranges	**No Linkage**	

4.2.2.3 Geothermal

The two proposed geothermal projects have three types of infrastructure that can affect Terrestrial Species and Habitat: the geothermal facilities, access roads, and transmission lines. Most potential effects were associated with the access roads and transmission lines. The following are potential project effects

associated with the geothermal projects that were noted during project evaluations. A summary of potential project-specific effects are listed in the Table C 4-4.

- Direct habitat effects associated with vegetation clearing and construction of facilities, roads, and transmission lines.
- Indirect effects that result in species avoiding project infrastructure as a result of sensory disturbance.
- Increased risk of disturbance and mortality by humans, and facilitated predation by natural predators associated with new linear features (roads and transmission lines).

Table C 4-4: Summary of Assessment for Geothermal

Project / Option	Indicator	Ranking	Assessment
McArthur Springs (facility plus 43 km access road and transmission line)	Species at Risk & Habitat	Low	No occurrences of species of concern are known in vicinity. Species that may occur based on habitat and range are: Olive-sided Flycatcher.
	Protected & Conservation Areas	High	Facility and approximately 13 km of road and transmission line occur within Ddhaw Ghro Habitat Protection Area.
	Wildlife Key Areas	Medium	Woodland Caribou - winter range; project would create 43 km of new linear feature access that could result in increased disturbance and mortality by humans and facilitated predation by natural predators.
	Caribou Ranges	Medium	Project is within Ethel Lake Caribou herd range. Project would create 43 km of new linear feature access that could result in increased disturbance and mortality by humans and facilitated predation by natural predators.
Vista Mountain	Species at Risk & Habitat	Low	No occurrences of species of concern are known in vicinity. Species that may occur based on habitat and range are: Olive-sided Flycatcher.
	Protected & Conservation Areas	No Linkage	
	Wildlife Key Areas	No Linkage	
	Caribou Ranges	No Linkage	

4.2.3 Hydro Renewable Generation

Hydro renewable projects, including pumped storage, small hydro, enhanced storage and the Gladstone Diversion, typically have four types of infrastructure that can affect terrestrial species and habitat: dams and associated facilities, reservoirs that flood terrestrial habitat and affect shoreline dynamics, access roads, and transmission lines. The following are potential project effects associated with hydro renewable projects that were frequently noted during project evaluations. A summary of potential project-specific effects are listed in the following tables.

- Direct habitat effects associated with reservoirs flooding terrestrial habitats and wetlands, and affecting shoreline dynamics.
- Increased risk of disturbance and mortality by humans, and facilitated predation by natural predators, associated with new linear features (roads and transmission lines).

Potential focal species vary by location but often include resident and migrating water birds, rare plants, and moose winter ranges.

4.2.3.1 Pumped Storage

The range of pumped storage site options are reviewed below in Table C 4-5.

Table C 4-5: Summary of Assessment for Pumped Storage

Project / Option	Indicator	Ranking	Assessment
Atlin – Black Mountain (reservoir, penstock, transmission line; also dependent on associated transmission line)	Species at Risk & Habitat	**Medium**	No Data (BC). Wildlife species that may occur based on habitat and range are: Olive-sided Flycatcher, Horned Grebe, Red-necked Phalarope, Rusty Blackbird, Short-eared Owl, and Western Toad. Reservoir development could directly affect habitat of latter four species.
	Protected & Conservation Areas	**No Linkage**	
	Wildlife Key Areas	**Medium**	Thin horn Sheep – Ungulate Winter Range (BC); project construction could displace sheep and have indirect habitat effects. *
	Caribou Ranges	**Medium**	Project is within Atlin and Carcross Caribou herd ranges. Project would have relatively small direct and indirect habitat effects (further study could possibly downgrade rating to Low based on small extent of footprint).
	*New access roads are not specified; if required, new roads could result in increased disturbance and mortality by humans to thin horn Sheep and, depending on location, could increase rating to high.		
Canyon –	Species at	**Medium**	No occurrences of species of concern are known in vicinity. Wildlife

Project / Option	Indicator	Ranking	Assessment
Ittlemit (reservoir, penstock, transmission line; also dependent on associated transmission line)	Risk & Habitat		species that may occur based on habitat and range are: Olive-sided Flycatcher, Bank Swallow, Horned Grebe, Red-necked Phalarope, Rusty Blackbird, and Short-eared Owl. Reservoir development could directly affect habitat of latter 5 species.
	Protected & Conservation Areas	**No Linkage**	
	Wildlife Key Areas	**Medium**	Bison – year-round core range; elevated water levels could affect foraging habitat.* Thin horn Sheep – spring lambing; project not likely to have any significant effects. * Golden Eagle – summer breeding; elevated water levels could affect prey habitat. Bald Eagle – summer breeding; elevated water levels could affect riparian nesting habitat and prey (fish). Mule Deer – year-round range; project not likely to have any significant effects.
	Caribou Ranges	**No Linkage**	
	*New access roads are not specified; if required, new roads could result in increased disturbance and mortality by humans to Bison and thin horn Sheep and, depending on location, could increase rating to high.		
Lindeman – Fraser (reservoir, penstock, transmission line; also dependent on associated transmission line)	Species at Risk & Habitat	**Medium**	No occurrences of species of concern are known in vicinity. Wildlife species that may occur based on habitat and range are: Olive-sided Flycatcher, Bank Swallow, Horned Grebe, Red-necked Phalarope, Rusty Blackbird, Short-eared Owl, Common Nighthawk, and Western Toad. Reservoir development could directly affect habitat of latter 6 species.
	Protected & Conservation Areas	**High**	Within Chilkoot Trail National Historic Site.
	Wildlife Key Areas	**Medium**	Carcross Caribou – fall rutting habitat. Project would create 5 km of new linear feature access that could result in increased disturbance and mortality by humans and facilitated predation by natural predators.
	Caribou Ranges	**Medium**	Project is within Carcross Caribou herd range. Project would create 5 km of new linear feature access that could result in increased disturbance and mortality by humans, and facilitated predation by natural predators.

Project / Option	Indicator	Ranking	Assessment
Racine – Moon (reservoir, penstock, transmission line; also dependent on associated transmission line)	Species at Risk & Habitat	**Medium**	No data (BC). Wildlife species that may occur based on habitat and range are: Olive-sided Flycatcher, Bank Swallow, Horned Grebe, Red-necked Phalarope, Rusty Blackbird, Short-eared Owl, Common Nighthawk, and Western Toad. Reservoir development could directly affect habitat of latter six species.
	Protected & Conservation Areas	**No Linkage**	
	Wildlife Key Areas	**Medium**	Carcross Caribou – fall rutting habitat and winter range. Project would create 21 km of new linear feature access that could result in increased disturbance and mortality by humans and facilitated predation by natural predators. Mountain Goat – year-round range; project construction could have disturbance effects. * Thin horn Sheep – Ungulate Winter Range (proposed, BC); project construction could have disturbance effects. *
	Caribou Ranges	**Medium**	Project is within Carcross Caribou herd range. Project would create 21 km of new linear feature access that could result in increased disturbance and mortality by humans, and facilitated predation by natural predators.
	*New access roads are not specified; if required, new roads could result in increased disturbance and mortality by humans to Mountain Goats and Thin horn Sheep and, depending on location, could increase rating to high.		
Racine – Mt. Brown (reservoir, penstock, transmission line; also dependent on associated transmission line)	Species at Risk & Habitat	**Medium**	No data (BC). Wildlife species that may occur based on habitat and range are: Banks Swallow, Horned Grebe, Red-necked Phalarope, Rusty Blackbird, Short-eared Owl, Common Nighthawk, and Western Toad. Reservoir development could directly affect habitat of all species.
	Protected & Conservation Areas	**No Linkage**	
	Wildlife Key Areas	**Medium**	Carcross Caribou – fall rutting habitat and winter range. Project would create 24 km of new linear feature access that could result in increased disturbance and mortality by humans, and facilitated predation by natural predators. Mountain Goat – year-round range; project construction could have disturbance effects. * Thin horn Sheep – Ungulate Winter Range (proposed, BC); project construction could have disturbance effects. *
	Caribou Ranges	**Medium**	Project is within Carcross Caribou herd range. Project would create 24 km of new linear feature access that could result in increased disturbance and mortality by humans, and facilitated predation by natural predators

Project / Option	Indicator	Ranking	Assessment
	*New access roads are not specified; if required, new roads could result in increased disturbance and mortality by humans to Mountain Goats and thin horn Sheep and, depending on location, could increase rating to high.		
Squanga – Dalayee (reservoir, penstock, transmission line)	Species at Risk & Habitat	**Medium**	No occurrences of terrestrial species of concern are known in vicinity. Terrestrial wildlife species that may occur based on habitat and range are: Olive-sided Flycatcher, Bank Swallow, Horned Grebe, Red-necked Phalarope, and Rusty Blackbird. Reservoir development could directly affect habitat of latter four species.
	Protected & Conservation Areas	**Medium**	Elevated water level in Dalayee Lake would affect Agay Mene Natural Environment Park. Rating downgraded from high due to limited effect on edge of Park.
	Wildlife Key Areas	**High**	Carcross Caribou - fall rutting habitat and winter range. Project would create 8 km of new linear features (penstock) that could result in increased disturbance and mortality by humans, and facilitated predation by natural predators. Waterfowl – summer breeding and fall staging; changes in water levels could affect breeding and staging habitat. Bald Eagle – summer breeding; changes in water levels could affect riparian nesting habitat and prey (fish). High (red) rating reflects direct mechanism of potential effects and extent of effects on WKAs for three species.
	Caribou Ranges	**Medium**	Project is within Carcross Caribou herd fall rutting habitat and winter range. Project would create 8 km of new linear features (penstock) that could result in increased disturbance and mortality by humans, and facilitated predation by natural predators.
Tutshi – Moon	Species at Risk & Habitat	**Medium**	No data (BC). Species that may occur based on habitat and range are: Horned Grebe, Red-necked Phalarope, Rusty Blackbird, Short-eared Owl, Common Nighthawk, and Western Toad. Reservoir development could directly affect habitat of latter six species.
	Protected & Conservation Areas	**No Linkage**	
	Wildlife Key Areas	**Medium**	Carcross Caribou - fall rutting habitat and winter range. Project would create linear features that could result in increased disturbance and mortality by humans, and facilitated predation by natural predators. Mountain Goat – year-round range; project construction could have disturbance effects; new roads could result in increased disturbance and mortality by humans. Thin horn Sheep – Ungulate Winter Range (proposed, BC); project construction could have disturbance effects; new roads could result in increased disturbance and mortality by humans.
	Caribou	**Medium**	Project is within Carcross Caribou herd fall rutting habitat and winter

Project / Option	Indicator	Ranking	Assessment
	Ranges		range. Project would create linear features that could result in increased disturbance and mortality by humans and facilitated predation by natural predators.
Faro – Vangorda Pit	Species at Risk & Habitat	Low	No occurrences of terrestrial species of concern are known within project ZOI. An occurrence of Mount Sheldon Ragwort is recorded 6 km north of the reservoir and Canada Darner has been recorded 2 km east. Other species that may occur based on habitat and range are: Olive-sided Flycatcher. Grass steppe areas in the vicinity are candidates for rare plant species.
	Protected & Conservation Areas	No Linkage	
	Wildlife Key Areas	Medium	Thin horn Sheep – movement corridor; project could directly affect movement corridor.
	Caribou Ranges	Medium	Project is in southwestern edge of Tay Caribou herd range. Project would have limited direct habitat effects.

4.2.3.2 Small Hydro

The range of small hydro site options are reviewed below in Table C 4-6.

Table C 4-6: Summary of Assessment for Small Hydro

Project / Option	Indicator	Ranking	Assessment
Drury Lake	Species at Risk & Habitat	Medium	No occurrences of species of concern are known in vicinity. Wildlife species that may occur based on habitat and range are: Olive-sided Flycatcher, Short-eared Owl, Horned Grebe, Red-necked Phalarope, and Rusty Blackbird. Reservoir development could directly affect habitat of latter three species.
	Protected & Conservation Areas	No Linkage	
	Wildlife Key Areas	No Linkage	
	Caribou Ranges	Low	Southeast edge of Tatchun Caribou Herd range; project is expected to have minimal incremental effects to existing development.
Finlayson River	Species at Risk & Habitat	Medium	Rusty Blackbird and Barn Swallow have been documented in area. Other species that may occur based on habitat and range are: Olive-sided Flycatcher, Short-eared Owl, Horned Grebe, and Red-necked Phalarope. Changes in water levels in reservoir lakes and Finlayson River could directly affect habitat of latter two species and Rusty Blackbird.

Project / Option	Indicator	Ranking	Assessment
	Protected & Conservation Areas	No Linkage	
	Wildlife Key Areas	Medium	Finlayson Caribou – fall rutting habitat and winter range. Project would create new linear feature access that could result in increased disturbance and mortality by humans and facilitated predation by natural predators. Moose – late winter range; project could directly affect habitat by flooding habitat; new linear feature access could result in increased disturbance and mortality by humans and facilitated predation by natural predators. Thin horn Sheep – winter, rutting and lambing range; new roads could result in increased disturbance and mortality by humans.
	Caribou Ranges	Medium	Within Finlayson Caribou Herd range; project would create new linear feature access could result in increased disturbance and mortality by humans and facilitated predation by natural predators.
Atlin/Pine Creek	Species at Risk & Habitat	Medium	No occurrences of species of concern are known in vicinity. Wildlife species that may occur based on habitat and range are: Olive-sided Flycatcher, Bank Swallow, Barn Swallow, Horned Grebe, Red-necked Phalarope, Rusty Blackbird, and Short-eared Owl. Reservoir development could directly affect habitat of latter six species.
	Protected & Conservation Areas	No Linkage	
	Wildlife Key Areas	No Linkage	
	Caribou Ranges	Low	Within Atlin Caribou Herd range; based on existing development in area, project would have minimal incremental effects to existing development.
Tutshi – Windy Arm	Species at Risk & Habitat	Medium	No data (BC). Species that may occur based on habitat and range are: Horned Grebe, Red-necked Phalarope, Rusty Blackbird, Short-eared Owl, Common Nighthawk, and Western Toad. Reservoir development could directly affect habitat of all six species.
	Protected & Conservation Areas	No Linkage	
	Wildlife Key Areas	Medium	Carcross Caribou - fall rutting habitat and winter range. Project would create new linear feature access that could result in increased disturbance and mortality by humans, and facilitated predation by natural predators. Mountain Goat – year-round range; project construction could have disturbance effects; new roads could result in increased disturbance

Project / Option	Indicator	Ranking	Assessment
			and mortality by humans. Thin horn Sheep – Ungulate Winter Range (proposed, BC); project construction could have disturbance effects; new roads could result in increased disturbance and mortality by humans.
	Caribou Ranges	**Medium**	Project is within Carcross Caribou herd fall rutting habitat and winter range. Project would create linear features that could result in increased disturbance and mortality by humans, and facilitated predation by natural predators.
Wolf River	Species at Risk & Habitat	**Medium**	Northern Mudwort occurrence within Nisutlin National Wildlife Area (NWA). Other species that may occur based on habitat and range are: Horned Grebe, Red-necked Phalarope, Rusty Blackbird, Short-eared Owl, Common Nighthawk, and Western Toad. Transmission line may present collision risk to birds in area.
	Protected & Conservation Areas	**Medium**	Access road and transmission line run along edge of Nisutlin River Delta NWA; road access may increase disturbance and mortality by humans to wildlife in NWA; transmission line may present collision risk to water birds in NWA.
	Wildlife Key Areas	**Medium**	Moose – late winter range; new linear features could result in increased disturbance and mortality by humans, and facilitated predation by natural predators. Muskrat – year-round all functions; changes to water flows could affect species (low risk). Bald Eagle – summer breeding; transmission lines could present collision risk. Waterfowl – summer breeding; transmission lines could present collision risk. Swan – summer breeding; transmission lines could present collision risk.
	Caribou Ranges	**Low**	On edge of Wold Lake Caribou Herd range; new linear features could result in increased disturbance and mortality by humans, and facilitated predation by natural predators; effects likely to be low due to limited overlap with range.
Anvil Creek	Species at Risk & Habitat	**Medium**	One species of conservation concern has been documented in the area, Canada Darner, a dragonfly. Other wildlife species that may occur based on habitat and range are: Olive-sided Flycatcher, Short-eared Owl, Horned Grebe, Red-necked Phalarope, Rusty Blackbird. Changes in water levels in Anvil Lake and the outlet stream could directly affect habitat of latter 3 species and Canada Darner.
	Protected & Conservation Areas	**No Linkage**	
	Wildlife Key Areas	**Low**	The transmission line intersects a Thin horn Sheep movement corridor across Blind Creek; project could result in incremental disturbance and mortality by humans along the transmission line.

Project / Option	Indicator	Ranking	Assessment
	Caribou Ranges	**Medium**	Project is in southwestern edge of Tay Caribou herd range. Project would have limited direct habitat effects and create 19 km of new linear features that could result in increased disturbance and mortality by humans, and facilitated predation by natural predators.

4.2.3.3 Gladstone Diversion

The Gladstone Diversion involves dams to raise water levels in or to divert flows into the Aishihik Lake existing hydro generation. Table C 4-7 summarizes the assessment of terrestrial species and habitat effects.

Table C 4-7: Summary of Assessment for Gladstone Diversion

Project / Option	Indicator	Ranking	Assessment
Gladstone Diversion	Species at Risk & Habitat	High	Three occurrences of species of concern have been recorded within 500 m of the proposed project: Dawson Wallflower, Rock Wormwood, and Pale Comandra. Other wildlife species that may occur based on habitat and range are: Olive-sided Flycatcher, Peregrine Falcon, Short-eared Owl, Common Nighthawk, Horned Grebe, Red-necked Phalarope, Rusty Blackbird, Sharp-tailed Grouse, Grizzly Bear, and Collared Pika. Reservoir development could flood two occurrences of rare plants and affect habitat for Horned Grebe, Red-necked Phalarope, Rusty Blackbird, Short-eared Owl, and Common Nighthawk.
	Protected & Conservation Areas	No Linkage	
	Wildlife Key Areas	High	The project overlaps with 16 Wildlife Key Areas: • Woodland Caribou – fall rutting and winter range (6). • Moose – late winter range (1). • Thin horn Sheep – winter range (2). • Bison – annual core range (1). • Ungulate miner lick (2). • Golden Eagle, Gyrfalcon, Peregrine Falcon – summer breeding (5). Potential project effects include: • New linear features could result in increased disturbance and mortality by humans, and facilitated predation by natural predators, on ungulates. • Disturbance effects on nesting raptors. • Disturbance and indirect habitat effects on thin horn Sheep. o Effects may be partially mitigated by route selection. • Disturbance and habitat effects on ungulate mineral licks. o Effects may be partially mitigated by infrastructure siting locations.
	Caribou Ranges	Medium	The project occurs within the Aishihik Caribou Herd range. New linear features could result in increased disturbance and mortality by humans, and facilitated predation by natural predators.

4.2.3.4 Hydro Storage Enhancements

Hydro storage enhancement projects will utilize existing road and transmission corridors and generally not involve new structures or any increase in flooded areas. Therefore, project effects are primarily related to changes in water levels during different seasons or years. Table C 4-8 provides a summary of the assessment of effects on terrestrial species and habitat for the two hydro storage enhancement projects.

Table C 4-8: Summary of Assessment for Hydro Storage Enhancements

Project / Option	Indicator	Ranking	Assessment
Mayo Lake Enhanced Storage	Species at Risk & Habitat	Medium	No occurrences of species of concern are known in vicinity. Wildlife species that may occur based on habitat and range with habitat that could be affected by changes in water levels include Common Nighthawk, Horned Grebe, Red-necked Phalarope, and Rusty Blackbird.
	Protected & Conservation Areas	No Linkage	
	Wildlife Key Areas	Low	Bald Eagle – summer breeding; changes in water levels could affect riparian nesting habitat and foraging habitat in lake.
	Caribou Ranges	No Linkage	
Southern Lakes Enhanced Storage	Species at Risk & Habitat	High	Twelve occurrences of species of concern have been recorded within 500 m of the proposed project: Barn Swallow, Buff-breasted Sandpiper, Collared Pika, Columbia Spotted Frog, Dune Tachnid Fly, Muskeg Emerald, Baikal Sedge, Water Awlwort, Water Pygmyweed, and Slim-leaved Goosefoot. Other wildlife species that may occur based on habitat and range are: Olive-sided Flycatcher, Peregrine Falcon, Bank Swallow, Short-eared Owl, Common Nighthawk, Horned Grebe, Red-necked Phalarope, Rusty Blackbird, and Western Toad. Changes in water levels could affect habitat and/or forage for most of the known and potential species of concern.
	Protected & Conservation Areas	High	The project overlaps the Lewes Marsh and Tagish Narrows Habitat Protection Areas (HPAs). Changes in water levels associated with the project could affect wetland habitats within the HPAs.
	Wildlife Key Areas	High	The project overlaps with 72 Wildlife Key Areas: • Woodland Caribou: fall rutting and winter range (25). • Moose: late winter range (1). • Thin horn Sheep: winter range and spring lambing (3). • Mountain Goat: annual range (20). • Muskrat: annual habitat (2). • Bald Eagle: summer nesting (4). • Golden Eagle, Gyrfalcon, alpine Raptor: summer breeding (8). • Waterfowl, Swan, Duck – spring and fall staging, summer

Project / Option	Indicator	Ranking	Assessment
			breeding (12, 8 noted as national / international significance). Potential project effects include: • Changes in water level that could affect. o Staging and breeding habitat for water birds; o Habitat and overwintering conditions for muskrats; and o Riparian nesting habitat and prey (fish) for Bald Eagle and Osprey. • Effects to riparian and wetland vegetation in moose winter range. • Changes in distribution and abundance of water birds as prey for raptors. • Minimal project effects expected on caribou, sheep, goats.
	Caribou Ranges	**Low**	The project overlaps with the Carcross Caribou Herd range and, peripherally, with the Idex Caribou Herd range. The project would have minimal incremental effects to existing development.

4.2.4 Transmission Corridors

Due to the long, linear nature of transmission corridors these projects tend to have the highest degree of overlap with terrestrial species and habitat indicators. However, the mechanism and magnitude of effects on terrestrial species and habitats is relatively low in most circumstances, in part due to best management practices (including routing to avoid specific concerns) and in part due to the nature of the disturbance caused by a transmission line.

The primary factors associated with transmission line development on terrestrial species and habitat are removal of tree and shrub cover within the right-of-way and installation of power poles and transmission lines. A small area of site disturbance (clearing down to mineral soil) is also associated with power pole installation and construction access. The long (10s to 100s of km), narrow (<100 m) shape of transmission line corridors has specific effects associated with terrestrial species. For most mid- to large-wildlife species, at the individual territory or home range level, the right-of-way represents a narrow break in natural vegetation that most species will simply travel across. Prey species, especially smaller species, may be reluctant to cross the right-of-way, similar to how they avoid natural areas that lack cover. At larger scales, the transmission corridors may function as new access corridors. This includes human access, which could result in increased disturbance and direct mortality by humans on certain wildlife (notably ungulates). Transmission corridors may also be used by wolves for enhanced travel and hunting resulting in facilitated predation. Transmission corridors may also facilitate the spread of invasive species.

Often, potential site-specific effects of transmission line development on terrestrial species, such as effects on ungulates using a mineral lick or a rare plant occurrence, can be avoided by route selection, power pole location, and site-level BMPs. Where new transmission lines are located along existing highway or utility rights-of-way the incremental effects of the new lines are much reduced compared to completely new lines.

The following are potential project effects associated with transmission corridors that were frequently noted during project evaluations. A summary of potential project-specific effects are listed in the Table C 4-9.

- Transmission corridors may result in new human access that could result in disturbance and mortality (i.e., hunting) to certain wildlife species. This effect is most likely to occur where the transmission corridors occur in proximity to high use wildlife areas, such as ungulate winter ranges or escape terrain for mountain goats and tinhorn sheep. Information sources that identified potential areas where this effect is more likely to occur include WKAs and caribou ranges.
- Transmission corridors may provide travel corridors that elevate natural predation by wolves by allowing them to hunt more effectively under certain circumstances.[3] Information sources that identified potential areas where this effect is more likely to occur include WKAs and caribou ranges.
- Transmission corridors may directly affect high value terrestrial species habitat or provide new access that could result in disturbance effects to wildlife concentration areas. Information sources that identified where this effect is more likely to occur include Parks and Conservation Areas, species occurrence locations from the Conservation Data Centre, and wildlife key areas.
- Power lines can be a source of avian mortality as a result of collisions and electrocution. This effect is elevated where birds with large wing spans congregate. Information sources that identified where this effect is more likely to occur include Parks and Conservation Areas and WKAs.

[3] This situation is often referred to as facilitated predation.

Table C 4-9: Summary of Assessment for Transmission Corridors

Project / Option	Indicator	Ranking	Assessment
Aishihik – Destruction Bay	Species at Risk & Habitat	Low	Fourteen occurrences of species of concern have been recorded within 500 m of the proposed project. These include Rusty Blackbird, Yukon Grasshopper, Yukon Draba, Narrow-leaved Moonwort, Rock Wormwood, Yukon Aster, Pale Comandra, Many-headed Sedge, and Winterfat. Other wildlife species that may occur based on habitat and range are: Olive-sided Flycatcher, Peregrine Falcon, Short-eared Owl, Common Nighthawk, and Sharp-tailed Grouse. Overall, project effects on Species at Risk are expected to be low and mostly mitigatable via route selection and site-level BMPs.
	Protected & Conservation Areas	High	A portion of the project is assumed to run through Kluane National Park and Kluane Wildlife Sanctuary. Options are noted for a route to avoid the park.
	Wildlife Key Areas	Medium	The project overlaps with 43 Wildlife Key Areas: • Grizzly Bear – spring, summer and fall range (7). • Moose – late winter range (7). • Mountain Goat – annual range (2); project is on edge of WKA, no escape terrain is affected. • Mule Deer – annual range (2). • Thin horn Sheep – winter range (3). • Swan – fall staging (2). • Bald Eagle, Osprey – summer breeding (1). • Peregrine Falcon – summer breeding (1). • Sharp tailed Grouse – year-round habitat (6). Potential project effects include: • Transmission line right-of-way (ROW) may provide suitable forage for grizzly bears that could result in elevated risk of human interactions and vehicle collisions. • New linear features could result in increased disturbance and mortality by humans, and facilitated predation by natural predators, on ungulates. o Effects can be partially mitigated by overlapping route with existing highway and utility ROW. • Collision risk for nesting and migrating raptors and swans. o Effects can be partially mitigated by route selection and visual deterrents • Indirect habitat effects on Sharp-tailed Grouse. o Effects may be partially mitigated by route selection.
	Caribou Ranges	Low	The project has very limited overlap with the Kluane Caribou Herd range. Potential project would have minimal incremental effects to existing development.

Project / Option	Indicator	Ranking	Assessment
Faro – Watson Lake	Species at Risk & Habitat	Low	Twenty one occurrences of species of concern have been recorded within 500 m of the proposed project. These include Rusty Blackbird, Barn Swallow, Woodchuck, Raups's Willow, Yukon Goldenweed, Shadow Darner, Siberian Polypod Additional species that may occur based on habitat and range are: Olive-sided Flycatcher, Peregrine Falcon, Short-eared Owl, Common Nighthawk, and Western Toad (southern extent only). Overall, project effects on SAR are expected to be low and mostly mitigatable via route selection and site-level BMPs.
	Protected & Conservation Areas	No Linkage	
	Wildlife Key Areas	Medium	The project overlaps with 23 WKAs: • Moose – late winter range and mineral licks. • Thin horn Sheep – winter range, mineral licks, migration corridor. • Caribou – fall rutting, winter range, and mineral licks. • Bald Eagle, Osprey, Golden Eagle, Peregrine Falcon – summer breeding. Potential project effects include: • Linear features that could result in increased disturbance and mortality by humans and facilitated predation by natural predators on ungulates. o Effects can be partially mitigated by overlapping route with existing highway ROW. • Habitat and disturbance effects at mineral licks. o Effects can be largely mitigated by route selection. • Collision risk for nesting raptors. o Effects can be partially mitigated by route selection and visual deterrents.
	Caribou Ranges	High	The project overlaps with five Caribou Herd ranges: Tay, Pelly (limited overlap), Finlayson, Horseranch and Little Rancheria. Development of the transmission line would create a new linear feature that could result in increased disturbance and mortality by humans, and facilitated predation by natural predators. The High rating is based on the large linear extent of the project. Potential effects could potentially be reduced to Medium or Low if the project as finally planned followed the nearby highway ROW to a greater extent (the footprint as provided is offset from the highway ROW for most of its length).
Whitehorse – Atlin	Species at Risk & Habitat	Low	Four occurrences of species of concern have been recorded within 500 m of the proposed project. These include Common Nighthawk, Barn Swallow, Dune Tachnid Fly, and Dryland Sedge. Other wildlife species that may occur based on habitat and range are: Olive-sided Flycatcher, Rusty Blackbird, Short-eared Owl, and Western Toad. Overall, project effects on Species at Risk are expected to be low and mostly mitigatable via route selection and site-level BMPs.

Project / Option	Indicator	Ranking	Assessment
	Protected & Conservation Areas	**Medium**	The project runs just inside Agay Mene Natural Environment Park and outside Lewes Marsh Habitat Protection Area, along existing highway ROW. New transmission lines may pose a collision risk to concentrations of birds at Lewes Marsh.
	Wildlife Key Areas	**Medium**	The project overlaps with 37 Wildlife Key Areas: • Moose – late winter range (3). • Woodland Caribou – fall rutting and winter range (16). • Mountain Goat – year-round (2); project is on edge of WKA, no escape terrain is affected. • Muskrat – year-round (2). • Bald Eagle, Osprey, Riparian Raptor– summer breeding (3). • Golden Eagle – summer breeding (2). • Waterfowl, Swan– spring and fall staging, summer breeding (9, 4 noted as national/international significance). Potential project effects include: • New linear features could result in increased disturbance and mortality by humans, and facilitated predation by natural predators, on ungulates. o Effects expected to be minimal because route follows existing highway and utility ROW. • Collision risk for nesting and migrating raptors and waterfowl. o Effects can be partially mitigated by route selection and visual deterrents. • No effects expected for Muskrat.
	Caribou Ranges	**Low**	The project overlaps with three Caribou Herd ranges: Carcross, Atlin, and Laberge (peripheral). Most of the project utilizes existing highway and utility ROW, and would have minimal incremental effects to existing development. Small sections of new linear feature development could result in increased disturbance and mortality by humans and facilitated predation by natural predators.
Whitehorse – Skagway	Species at Risk & Habitat	**Low**	Eight occurrences of species of concern have been recorded within 500 m of the proposed project. These include Common Nighthawk, Collared Pika, Dune Tachnid Fly, Muskeg Emerald, Baikal Sedge, and Water Pygmyweed. Species that may occur based on habitat and range are: Olive-sided Flycatcher, Rusty Blackbird, Short-eared Owl, Common Nighthawk, and Western Toad. Overall, project effects on Species at Risk are expected to be low and mostly mitigatable via route selection and site-level BMPs.
	Protected & Conservation Areas	**No Linkage**	
	Wildlife Key Areas	**Medium**	The project overlaps with 30 Wildlife Key Areas: • Moose – late winter range (1). • Mountain Goat – annual range (4); project is on edge of WKAs, no escape terrain is affected.

Project / Option	Indicator	Ranking	Assessment
			• Thin horn Sheep – spring lambing (1). • Woodland Caribou – fall rutting and winter range (19). • Swan and waterfowl– spring staging (2). • Bald Eagle and Osprey– summer breeding (2). • Alpine Raptor – summer breeding (1). Potential project effects include: • New linear features could result in increased disturbance and mortality by humans and facilitated predation by natural predators on ungulates. o Effects can be substantially mitigated by overlapping route with existing highway and utility ROW. • Collision risk for nesting and migrating raptors and waterfowl. o Effects can be partially mitigated by route selection and visual deterrents.
	Caribou Ranges	**Low**	The project overlaps with one Caribou Herd range, the Carcross Caribou Herd. Most of the project utilizes existing highway and utility ROW, and would have minimal incremental effects to existing development. Small sections of new linear feature development could result in increased disturbance and mortality by humans, and facilitated predation by natural predators.
Whitehorse – Teslin	Species at Risk & Habitat	**Low**	Five occurrences of species of concern have been recorded within 500m of the proposed project. These include Common Nighthawk, Barn Swallow, and Elko Paintbrush. Additional wildlife species that may occur based on habitat and range are Olive-sided Flycatcher, Rusty Blackbird, and Short-eared Owl. Overall, project effects on SAR are expected to be low and mostly mitigatable via route selection and site-level BMPs.
	Protected & Conservation Areas	**Low**	The project runs just outside Agay Mene Natural Environment Park and Lewes Marsh Habitat Protection Area, along existing highway ROW. New transmission lines may pose a collision risk to concentrations of birds at Lewes Marsh.
	Wildlife Key Areas	**Medium**	The project overlaps with 42 Wildlife Key Areas: • Moose – late winter range (2). • Woodland Caribou – fall rutting and winter range (16). • Ungulate – mineral lick (1). • Muskrat – year-round (4). • Beaver – year-round (2). • Bald Eagle, Osprey, Riparian Raptor– summer breeding (5). • Golden Eagle – summer breeding (1). • Waterfowl, Swan– spring and fall staging, summer breeding (11, 4 noted as national/international significance). Potential project effects include: • New linear features could result in increased disturbance and mortality by humans and facilitated predation by natural predators on ungulates.

Project / Option	Indicator	Ranking	Assessment
			o Effects expected to be minimal because route follows existing highway and utility ROW. • Potential habitat and disturbance effects at mineral licks. o Effects expected to be largely mitigated by route selection. • Collision risk for nesting and migrating raptors and waterfowl. o Effects can be partially mitigated by route selection and visual deterrents. No effects expected for Muskrat and Beaver.
	Caribou Ranges	**Low**	The project overlaps with three Caribou Herd ranges: Carcross, Atlin (peripheral), and Laberge (peripheral). Most of the project utilizes existing highway and utility ROW, and would have minimal incremental effects to existing development. Small sections of new linear feature development could result in increased disturbance and mortality by humans, and facilitated predation by natural predators.
Stewart River – Keno	Species at Risk & Habitat	**Low**	Three occurrences of species of concern have been recorded within 500 m of the proposed project. These include Collared Pika, Slack Sedge, and Hudson Bay Sedge. Additional wildlife species that may occur based on habitat and range are: Olive-sided Flycatcher, Horned Grebe, Red-necked Phalarope, Rusty Blackbird, and Short-eared Owl. Overall, project effects on SAR are expected to be low and mostly mitigatable via route selection and site-level BMPs.
	Protected & Conservation Areas	**Low**	The project runs just outside Devil's Elbow Habitat Protection Area, along existing road ROW. New transmission lines may pose a collision risk to concentrations of birds using the HPA.
	Wildlife Key Areas	**Medium**	The project overlaps with 6 Wildlife Key Areas: • Black Bear – spring range (1). • Bald Eagle raptor– summer breeding (2). • Golden Eagle – summer breeding (1). • Waterfowl – summer breeding and moult (3). Potential project effects include: • New linear features could result in increased disturbance and mortality by humans to black bears. o Effects expected to be minimal because route follows existing highway and utility ROW. • Collision risk for nesting and migrating raptors and waterfowl. o Effects can be partially mitigated by route selection and visual deterrents.
	Caribou Ranges	**No Linkage**	

5.0 TERRESTRIAL FOOTPRINT & LAND USE

5.1 RATING CRITERIA AND DATA SOURCES FOR EN-4: TERRESTRIAL FOOTPRINT AND LAND USE

The rating system outlined in Figure C 5-1 was adopted to guide evaluations of each resource project option for each of the Terrestrial Footprint & Land Use indicators.

Figure C 5-1: Summary of Assessment Rating Criteria for Terrestrial Footprint & Land Use

Indicator	Low	Medium	High
Footprint Terrestrial Area including access & new flooding (Total km2) (En4-1)	< 0.5 km^2	0.5-1.0 km^2	> 1.0 km^2
Linear Development for roads, transmission (km) (En4-2)	< 10 km	10 – 100 km	> 100 km
Permafrost (En4-3)	< 2 km^2 affected by project, or no linkage to permafrost	>2 km^2 affected by project	Permafrost potential to be a material constraint to project
Wetlands (En4-4)	< 0.1 km^2 affected by project or no linkage to wetlands	0.1– 1.0 km^2 affected by project	> 1.0 km^2 affected by project or other potential for major concern

Indicators for Terrestrial Footprint and Land Use were selected to highlight the range of two terrestrial footprint indicators (Footprint Terrestrial Area and Linear Development distance) for the various project resource options, and to quantify the extent of potential project effects and overlap with two types of potentially sensitive environmental areas: Permafrost and Wetlands.

The following are noted regarding the rating scheme and thresholds used for the assessment:

- **Terrestrial Area Footprint (En4-1):** Estimates of terrestrial area footprints include all project components including facilities, access roads, transmission corridors, and, for hydro-related projects, new flooding (i.e., existing water areas were not included). Where the sizes of certain project components were not specified in the project description, industry standard right-of-way widths and buffer sizes were used (Table CA 2-1). For flooded areas, the estimated area from the project description was used. No new hydrological modelling was conducted to estimate the footprints associated with water level changes. Footprint areas were summed for all components within projects (e.g. area of facilities plus area of new roads plus area of transmission corridors).[4] These footprint assessments do not provide any information as to which valued terrestrial

[4] Estimated footprint areas for Terrestrial Area Footprint (En4-1) do not correspond to the areas estimated for Footprint Land Area Impact (S2-1), reflecting differences in assumptions and methods used to develop each estimate.

components may be affected by each project or resource option. The rating criteria were selected simply to help assign resource projects to clearly separate groups based on this indicator.

- **Linear Development for Roads and Transmission (En4-2):** Linear developments primarily consist of access roads and transmission corridors. Lengths of all linear developments were summed for all components within projects (e.g. length of roads plus length of transmission corridors). These linear footprint assessments do not provide any information as to which valued terrestrial components may be affected by each project or resource option. The rating criteria were selected simply to help assign resource projects to clearly separate groups based on this indicator.

- **Permafrost (En4-3):** Potential project effects associated with permafrost were estimated by assessing the extent of overlap between the Terrestrial Area Footprint and modelled permafrost occurrence. The permafrost model that was used was the Yukon Permafrost Probability Map (Bonnaventure et al. 2012). The permafrost area was calculated by weighting the Terrestrial Area Footprint (En4-1) by the modelled probability of permafrost occurring. This method may dilute the extent by which a specific permafrost effect area may be concentrated in a material portion of the project footprint area. The dominant permafrost class (isolated patches [<10%], sporadic discontinuous [10-50%], extensive discontinuous [50-90%], or continuous [>90%) was also noted for each project.

  This evaluation was from the perspective of potential environmental effects associated with permafrost degradation affected by the projects. Construction and engineering factors associated with project development and permafrost were not considered as part of this assessment. Also, the effects of permafrost change associated with climate change were not considered in this assessment due to the complexity and uncertainty of those patterns of permafrost change. However, planners should be aware that widespread changes to permafrost are occurring across the planning area. Those changes have effects from site-level to regional scales, and could have significant effects for each project, depending on the local distribution of permafrost.

  Notwithstanding the uncertainty associated with regional changes in permafrost, no red (high) ratings were applied, reflecting the lack of evidence that permafrost related issues would pose a material constraint to any project, in terms of potential environmental effects. A threshold of 200 ha (2 km^2) was selected to classify projects as green (low) or yellow (medium) ratings, based on the observed distribution of values across projects.

- **Wetlands (En4-4):** Potential project effects associated with wetlands were estimated primarily by assessing the extent of overlap between the Terrestrial Area Footprint and 1:50,000 scale wetland mapping available from Geomatics Yukon. Ratings also considered whether the project overlapped any wetland complexes that had been identified at the territory level (e.g., Yukon Environment 2008). A green rating is applied for projects with less than 10 ha (0.1 km^2) of estimated wetland area affected, and a yellow rating is applied for projects with estimated wetland area affected between 10 and 100 ha (between 0.1 and 1.0 km^2). No resource projects are rated red with affected wetland area in excess of 100 ha (1.0 km^2).

  Wetland area estimates appear to be most significant for hydro renewable projects. Waterbodies associated with hydro renewable projects may contain unmapped wetlands that would be affected by changes in water levels, including small wetlands, long thin wetlands, and wetlands

fringing ponds and lakes. This potential issue is not reflected in the current ratings, and more work would be needed to map such areas where appropriate should a hydro project go forward to more detailed review.

For indicators within the Terrestrial Footprint and Land Use criteria, ratings were based primarily on the aerial extent of the indicator measure. The break points used to differentiate between green (low), yellow (medium), and red (high) ratings were selected based on the range of extents that occurred across the proposed projects. In this context, ratings represent more of a relative comparison across projects, than references to specific benchmarks.

Footprint indicators for overall area and linear distances for access are applicable to all resource options other than those that involve no new land areas, e.g., hydro storage enhancements and existing hydro generation refurbishment or maintenance. Assessments were based on geospatial GIS files without adjustment for potential spatial configuration of components.

Table C 5-1 presents the resource project option information for two indicators (Footprint Terrestrial Area [En4-1] and Linear Development [En4-2]). These indicators provide an overview of the relative terrestrial footprint requirements of each resource option without addressing which valued terrestrial elements are being affected. Table C A2-2 in Attachment 2 provides each of the four indicator results for each resource option.

Table C 5-1: Terrestrial Footprint & Land Use: Footprint Terrestrial Area & Linear Development

Resource Option	Project/Site	Footprint Terrestrial Area (En4-1) (km^2)	Linear Development (roads, trans.) (En4-2) (km)
Fossil Thermal	Whitehorse Landfill	0.20	N/A
	Takhini Substation	0.20	0.31
Non-Fossil Thermal Generation	Biogas - Whitehorse	0.20	0.31
	Waste to Energy (Whitehorse)	0.20	N/A
	Wood Biomass (Haines Junction Facility, Timber Harvesting)	0.20 facility Unknown harvesting[1]	N/A
Energy Storage Facilities	Takhini Energy Storage	0.20	N/A
Solar PV	Haines Junction	0.25	N/A
	Whitehorse	0.50	N/A
Wind Farms	Cyprus Mine Hill	1.13	20.1
	Kluane Lake	1.00	11.2
	Miller's Ridge	2.23	41.0
	Mt. Sumanik	1.13	22.8
	Sugarloaf Mountain	1.21	13.9
	Tehcho (Ferry Hill)	1.18	14.0
	Thulsoo Mountain	2.28	64.3
Geothermal	McArthur Springs	2.61	87.0
	Vista Mountain	0.28	6.3
Hydro - Pumped Storage	Atlin-Black Mountain	2.43	4.7
	Canyon-Ittlemit	6.92	15.4
	Lindeman – Fraser	4.65	22.6
	Racine – Moon	5.66	31.0
	Racine – Mt. Brown	6.64	30.0
	Squanga – Dalayee	3.01	13.1
	Faro – Vangorda Pit	10.87	22.9
	Moon Lake (Tutshi – Moon)	4.99	8.5
Small Hydro	Drury Lake	2.33	15.5
	Finlayson River	19.36	33.2
	Atlin/Pine Creek	3.09	15.0
	Tutshi-Windy Arm	3.78	30.2
	Wolf River	3.25	60.4
	Anvil Creek	2.27	19.2
Other Hydro	Gladstone Diversion	3.61	54.5
	Hydro Storage Enhancements (Southern Lakes, Mayo Lake)	N/A	0
	Mayo Lake Outlet Channel Dredging	0.20	0

Resource Option	Project/Site	Footprint Terrestrial Area (En4-1) (km^2)	Linear Development (roads, trans.) (En4-2) (km)
	Refurbish/enhance existing hydro (Mayo A, Aishihik re-runnering)	N/A	0
Transmission Corridors	Aishihik – Destruction Bay	10.41	173.6
	Faro – Watson Lake	25.63	427.2
	Whitehorse – Atlin	10.33	171.7
	Whitehorse – Skagway	10.27	170.8
	Whitehorse – Teslin	10.48	174.4
	Stewart River – Keno	11.42	190.0

Notes:
1. Area associated with timber harvesting unknown but expected to be thousands of hectares.
2. Footprints associated with hydro renewable projects are driven by reservoirs; estimates of those extents are preliminary.

5.2 EVALUATIONS

The following terrestrial evaluations regarding concerns focuses mainly on the Terrestrial Footprint and Land Use indicators related to permafrost and wetlands (as these indicators address potential specific effect concerns).

5.2.1 Resource Options with No Material Concerns regarding Terrestrial Footprint and Land Use

The following resource project options are rated green (low or not applicable) for each of the terrestrial footprint and land use indicators:

- **Fossil Thermal: Diesel and LNG** (Whitehorse Landfill and Takhini Substation location options);
- **Non-fossil Thermal: Biogas, Waste-to-Energy, Wood Biomass** (Whitehorse and Haines Junction location options);
- **Energy Storage Facilities** (Takhini Substation);
- **Solar PV** (Haines Junction site);
- **Geothermal** (Vista Mountain);
- **Hydro Storage Enhancements** (Mayo Lake);
- **Mayo Lake Outlet Channel Dredging;** and
- **Existing Hydro Refurbishments / Maintenance** (Mayo A, Aishihik Re-runnering).

If the basic footprint indicators Footprint Terrestrial Area (En4-1) and Linear Development (En4-2) as provided in Table C 5-1 are excluded, the following additional resource options are rated green (low or not applicable) for each of the two remaining footprint and land use indicators (Permafrost [En4-3] and Wetlands [En4-4]):

- **Solar PV** (Whitehorse quarry site);
- **Wind Farms** (all site options);
- **Geothermal** (McArthur Springs);
- **Pumped Storage** (Atlin-Black Mountain, Lindeman-Fraser);
- **Small Hydro** (Drury Lake,[5] Atlin-Pine Creek [Surprise Lake], Tutshi-Windy Arm, Anvil Creek); and
- **Transmission Corridors** (Whitehorse-Atlin, Whitehorse-Skagway, Whitehorse-Teslin).

[5] See Appendix E, Table E 3-1, which rated Drury Creek red with regard to extent of permafrost in the project footprint, based on geotechnical risks and presence of permafrost noted in previous KGS reports on this small hydro site.

5.2.2 Hydro Renewable Generation

5.2.2.1 Pumped Storage

As reviewed in Attachment 2, Table C A 2-2, the following pumped storage projects have yellow ratings:

- Canyon-Ittlemit: rated yellow for Permafrost (En4-3) with an expected area of 3.89 km^2;
- Racine-Moon: rated yellow for Wetlands (En4-4) with an expected area of 0.96 km^2;
- Racine-Mt. Brown: rated yellow for Permafrost (En4-3) with an expected area of 3.07 km^2;
- Squanga-Dalayee: rated yellow for Wetlands (En4-4) with an expected area of 0.12 km^2;
- Faro-Vangorda Pit: rated yellow for Permafrost (En4-3) with an expected area of 7.18 km^2 and rated yellow for Wetlands (En4-4) with an expected area of 0.40 km^2; and
- Moon Lake (Tutshi-Moon): rated yellow for Wetlands (En4-4) with an expected area of 0.94 km^2.

5.2.2.2 Small Hydro

As reviewed in Attachment 2, Table C A 2-2, the following small hydro projects have yellow ratings:

- Finlayson River: rated yellow for Permafrost (En4-3) with an expected area of 16.15 km^2; and
- Wolf River: rated yellow for Wetlands (En4-4) with an expected area of 0.19 km^2.

5.2.2.3 Hydro Storage Enhancements – Southern Lakes

As reviewed in Attachment 2, Table C A 2-2, Southern Lakes Storage Enhancement has a red rating for Wetlands (En4-4), based on the quality rather than the quantity of wetlands potentially affected by changes in water levels at different seasons, including wetlands at M'Clintock Bay, Lewes Marsh and Nares Lake.

5.2.2.4 Other Hydro - Gladstone Diversion

As reviewed in Attachment 2, Table C A 2-2, Gladstone Diversion has a yellow rating for Permafrost (En4-3) with an expected area of 2.57 km^2.

5.2.3 Transmission Corridors

As reviewed in Attachment 2, Table C A 2-2, the following transmission corridor projects have yellow ratings for Permafrost (En4-3):

- Aishihik-Destruction Bay (Burwash): rated yellow for Permafrost (En4-3) with an expected area of 3.83 km^2; this expected or average estimate may well understate the significance of permafrost challenges for a material segment of this corridor (see Appendix E, Table E 3-1, which highlights permafrost as a material challenge for segments of this corridor based on the Midgard report's estimate of 14,789 ha of extensive discontinuous as well as 6078 ha of sporadic discontinuous permafrost in the 500 m corridor examined for that study).

- Faro-Watson Lake: rated yellow for Permafrost (En4-3) with an expected area of 14.94 km^2.
- Stewart-Keno City: rated yellow for Permafrost (En4-3) with an expected area of 7.89 km^2; planning for this specific corridor has advance to complete YESAB assessment for a preferred route that improves the existing line's location through these challenging areas.

6.0 AIR QUALITY

6.1 RATING CRITERIA AND DATA SOURCES FOR EN-5: AIR QUALITY

The rating system outlined in Figure C 6-1 was adopted to guide evaluations of each resource project option for each of the Air Quality indicators.

Figure C 6-1: Summary of Assessment Rating Criteria for Air Quality

Indicator	Low	Medium	High
GHG Emissions En5-1	Total GHG <50 kg CO_2e.MWh [20 & 100 year GWP]	Total GHG >50 and <500 kg CO_2e.MWh [20 & 100 year GWP]	Total GHG >500 kg CO_2e.MWh [20 & 100 year GWP]
Other Air Emissions En5-2	Non-thermal option, or no linkage	Thermal generation	N/A

Indicators for Air Quality as defined in Table C 6-1 focus on the intensity of emissions per unit of energy generated or transmitted, e.g., kg of emissions per kWh or per MWh. The ratings and evaluation are based on information as provided by Yukon Energy's studies, as reviewed below:

- **Information Sources**: The scope for the resource studies carried out for Yukon Energy, as referenced in Appendix A, did not address air emission intensity for any of the options. The only Yukon Energy study on Air Emissions is provided by ArticCan Energy Services (ACES), "Lifecycle Assessment for Energy Resource Options in Yukon Territory – Final Report", September 6, 2016 (the "ACES Report"). A summary of the results of the ACES Report is provided in Table C 6-1.
- **Non-GHG Air Emissions**: All non-thermal resource options assessed in this study will have no air emission effects as an integral element of operation, and therefore are rated green for Other Air Emissions (En5-2). In contrast, thermal generation resource options (e.g., fossil fuel thermal generation [diesel or LNG] or non-fossil fuel generation [municipal solid waste, biomass, biogas]) will each have air emissions. It is assumed for these thermal generation options (as well as for any other option where air emissions may occur during construction or operation) that all air emissions will be required to comply with regulations such that no material adverse effects are expected, i.e., no red ratings are applicable. In the absence of detailed assessments of potential non-GHG air emissions for each thermal generation option, each thermal generation resource option is rated yellow under non-GHG emissions (Other Air Emissions [En5-2]).
- **GHG Emissions** – The ACES Report as summarized in Table C 6-1 addresses, per MW.h equivalent of useful net energy delivered (including heat as well as electricity) over a technology option life, total GHG emissions (kg CO_2e [carbon dioxide equivalent]) from all sources (including greenhouse gas [GHG] emissions related to construction of facilities, operation in Yukon, and operation activities required outside of Yukon, but excluding "downstream" emissions from plant decommissioning and related activities). GHG emissions are estimated using the Global Warming

Potential (GWP) for both the 20 year and 100 year time horizons, using GWP factors taken from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (ARS).[6]

The ACES Report notes that the most widely accepted time scale for reporting GWP values is 100 years, which adequately represents most GHGs due to their significantly long lifetime and was used under the Kyoto Protocol. The shorter 20 year GWP value is included in the ACES Report to examine global warming potential effects over shorter timeframes in order to address the immediate effects of short-lived methane on global temperatures.[7]

The ACES Report reports GWP values with and without biogenic CO_2 emissions. Biogenic CO_2 emissions in biogas and biomass pathways originate from biogas combustion and biomass gasification life cycle stages, and without these biogenic CO_2 emissions the overall CO_2 emissions for these options fall significantly. Material CO_2 emission reduction estimates also occur for hydro options when biogenic CO_2 emissions are excluded.[8]

Table C 6-1 shows the following GHG emissions estimates for each technology, with and without biogenic CO2 emissions and for both 100 year and 20 year GWP values:

- Fixed GHG intensity (kg CO_2e/MWh) is calculated based on the total plant fixed emissions[9] divided by the total energy delivered by the plant over its expected life. Table C 6-1 shows this estimate calculated per the assumptions provided and as reported in the ACES Report. Reductions in actual energy delivered over the plant life result in an increase in GHG intensity for "fixed emissions", i.e., these emissions are locked prior to plant operation. Variances can occur in fixed emissions within a technology or resource option depending on the source of materials, the specific technology method selected, etc.[10]
- Variable GHG emissions (kg CO_2e/MWh) as shown in Table C 6-1 are as reported in the ACES Report, and reflect GHG emissions for plant operation (including production and transportation to the plant of any fuel source used). Variable emissions per year typically vary annually depending on actual plant operation; however, for some technologies (e.g., hydro plants) the variable emissions relate to land inundated and may therefore not be affected as directly by actual hydro generation (and may decline over time as land inundation impacts on GHG emissions decline).
- Variable emissions per MWh will also vary depending on operation practices and on total energy delivered per MWh of power generation, i.e., if heat is also delivered the GHG intensity per unit of delivered energy will decline.

[6] For more information and full discussion on the issues, see: ArticCan Energy Services (ACES), "Lifecycle Assessment for Energy Resource Options in Yukon Territory – Final Report", September 6, 2016 (the "ACES Report").
[7] Ibid. for full discussion of 100 Year and 20 Year GWP.
[8] Ibid. for full discussion of issues related to inclusion and exclusion of biogenic CO2 emissions. Burning of biomass, or flooding of organic areas, releases CO2 emissions that can be recaptured by planting and growing new vegetation - issues arise related to the time scales of these two activities.
[9] Fixed plant emissions as estimated in the ACES Report (kg CO2e per plant) reflect GHG emissions for plant construction or manufacture, transmission line construction, materials acquisition and transportation, site preparation, and resource extraction (diesel and LNG). These GHG emissions occur from activities conducted prior to operation of the generation or transmission resource option.
[10] The ACES Report notes, by way of example, significant fixed GHG emission variances for different wind and storage battery technologies.

The ACES Report provides estimated GHG intensity for a specific scope design for different resource options examined (see Table C 6-1). The ACES report does not address the enhanced hydro storage resource options, the Mayo Lake Outlet Channel Dredging option, or options to refurbish existing hydro generation at Mayo and Aishihik.

Ratings in Figure C 6-1 for resource option GHG emissions (En5-1) are based on a simple scale to highlight the extent by which the Yukon Energy resource options differ for this indicator.

- **Including biogenic CO_2 emissions:** When assessed on a relative basis as per Table C 6-1 with biogenic CO_2 emissions, the resource options typically fall into either green (low) rating at <50 kg CO_2e/MWh lifecycle emissions, or red (high) rating at >500 kg CO_2e/MWh lifecycle emissions, regardless as to whether evaluated on the 20 year or 100 year GWP. None of the technology options evaluated in Table C 6-1 with biogenic VO_2 emissions fall into the yellow [medium] rating for GHG emissions.
- **Excluding biogenic CO_2 emissions:** When assessed on a relative basis as per Table C 6-1 without biogenic CO_2 emissions, the only changes that occur are reductions in GHG emissions for the following resource options (ratings are the same for both 20 year and 100 year GWP):
    - Waste-to-energy and Biogas resource options - ratings for these options change from red to yellow.
    - Biomass - ratings for this option change from red to green.
    - Pumped Storage, Small Hydro and Other Hydro (Gladstone Diversion) - ratings for these options remain unchanged (green ratings).

The GHG ratings applicable to a technology option per Table C 6-1 are assumed to apply for all other Yukon Energy resource options of that same technology, e.g., the wind rating for Mt. Sumanik is assumed to apply for all other wind options, the small hydro rating for Drury Lake is assumed to apply for all other small hydro options.

The ACES Report identifies the following factors that can vary the GHG emission estimates from the Table C 6-1 intensities:

1. **Modify Heat Energy Assumed to be consumed:** Table C 6-1 highlights assumed heat energy for biomass and municipal solid waste (MSW) waste-to-energy resource options, i.e., heat energy assumed to be used is 2.4 times the assumed equivalent electricity generation for MSW options and 3.1 times for the biomass option. Reductions in assumed heat energy use for the biomass and MSW waste-to-energy options would result in a material increase in GHG emission intensity. Conversely, assuming similar heat energy use for diesel and LNG options would result in a material decrease in GHG emission intensity. In summary, potential use of heat waste energy from thermal generation is desirable, where feasible, regardless of the resource option – and it can be argued that these resource options should be assessed based on comparable assumptions as regards use of available heat energy.
2. **LNG Combustion Emissions:** The ACES Report notes that emission factors selected for the baseline scenario for LNG combustion (as shown in Table C 6-1) are in the upper range of emissions and are therefore conservative. The ACES Report notes that actual natural gas GHG

emissions would likely be lower based on actual operating conditions of each unit. The ACES Report notes that GHG combustion operation emissions assuming 2016/217 B.C. Best Practices Methodology for Qualifying Greenhouse Gas Emissions (Ministry of Environment, May 2016) would be only 46% of the baseline scenario operation emissions for 20 year GWP (reduction of 456.4 kg CO_2e/MWh to 390.49 kg CO_2e/MWh) and 68% of the baseline scenario operation emissions for 100 year GWP (reduction of 184.2 kg CO2e/MWh, to 390.08 kg CO2e/MWh). Such reductions as a single measure would still leave LNG rated red (high) based on Figure C 6-1 when non-operation emissions are included.

3. **Transmission Line Capacity Utilization:** Table C 6-1 indicates the very high level of electricity transmission capacity utilization assumed for estimates of GHG emissions intensity for transmission corridor options. The ACES Report notes that reduction of the assumed use to 40% of transmission capacity (230 kV) would more than double the estimated GHG intensity per MWh for this option. Even at much lower levels of use, kg CO_2e/MWh for transmission continue to be rated green or low based on Figure C 6-1.

Table C 6-1: Summary of GHG Emissions from Resource Options (20 and 100 Year GWP)

Technology	Annual Power Energy (net) GWh/yr.	Annual Heat Energy (net) GW.hth /yr.	Operating Years	GHG Emissions with Biogenic CO2						Excluding Biogenic CO2	
				20 Year GWP			100 Year GWP			20 Year GWP	100 Year GWP
				Fixed GHG (kg CO2e/MWh)	Variable GHG (kg CO_2e/MWh)	Total GHG (kg CO_2e/MWh)	Fixed GHG (kg CO_2e/MWh)	Variable GHG (kg CO_2e/MWh)	Total GHG (kg CO_2e/MWh)	Total GHG (kg CO_2e/MWh)	Total GHG (kg CO_2e/MWh)
Diesel, 5 MW	39.4	-	20.0	0.4	1058.5	**1058.9**	0.4	950.7	**951.1**	**1058.9**	**951.1**
LNG, 5 MW	39.4	-	20.0	0.7	1050.1	**1050.8**	0.6	727.0	**727.7**	**1050.8**	**727.7**
Waste to energy: MSW & Biomass	10.0	23.70	25.0	9.2	666.0	**675.2**	8.9	654.1	**663.0**	**319.3**	**307.1**
Waste to energy: MSW	10.0	23.70	25.0	9.2	699.8	**709.1**	8.9	687.9	**696.8**	**453.7**	**441.4**
Biogas	0.9	-	20.0	10.5	1151.2	**1161.7**	10.1	1005.8	**1015.9**	**259.6**	**113.8**
Biomass	2.6	8.06	20.0	3.2	769.3	**772.5**	3.1	768.9	**772.0**	**17.7**	**17.2**
Storage Battery: lithium ion	2.8	-	20.0	16.2	-	**16.2**	14.7	-	**14.7**	**16.2**	**14.7**
Solar: 5 MW	5.2	-	30.0	43.1	0.1	**43.2**	38.9	0.1	**39.0**	**43.2**	**39.0**
Wind: Mt. Sumanik, 6 MW	14.6	-	25.0	10.0	0.7	**10.7**	9.6	0.7	**10.3**	**10.7**	**10.3**
Geothermal: McArthur Springs, 5.5 MW	32.1	-	30.0	4.6	0.0	**4.6**	4.2	0.0	**4.2**	**4.6**	**4.2**
Pumped Storage: Moon Lake, 20.2 MW	54.0	-	65.0	4.6	18.8	**23.4**	4.6	10.6	**15.1**	**17.7**	**9.5**
Small Hydro: Drury Lake, 8.1 MW	31.7	-	65.0	3.3	17.3	**20.6**	3.2	9.8	**13.0**	**15.3**	**7.7**
Other Hydro: Gladstone Diversion	29.7	-	65.0	0.1	21.3	**21.4**	0.1	12.0	**12.1**	**15.0**	**5.6**
Transmission Corridor: Whitehorse-Skagway	3880.7	-	55.0	0.1	0.0	**0.2**	0.1	0.0	**0.2**	**0.2**	**0.2**

Source: ArticCan Energy Services (ACES), "Lifecycle Assessment for Energy Resource Options in Yukon Territory – Final Report", September 6, 2016. Tables in the report and appendices (with changes as provided by Yukon Energy).

6.2 EVALUATIONS

6.2.1 Resource Options with No Material Concerns re: Air Quality

All non-thermal generation resource options are assumed to have no material concerns (green rating) for non-GHG air emissions (En5-2).

The following non-thermal generation resource options are also rated green or low for GHG emissions based on the Figure C 6-1 criteria for En5-1 and the estimated GHG emissions intensity as estimated in Table C 6-1 with and without biogenic CO2 emissions for both 20 year and 100 year GWP:

- Storage Battery options examined in the current resource planning;
- All Solar PVs examined in the current resource planning;
- All Wind site options at 6 MW to 20 MW examined in the current resource planning;
- All Geothermal site options examined in the current resource planning;
- All Pumped Storage site options examined in the current resource planning;
- All Small Hydro site options examined in the current resource planning;
- All Other Hydro options examined in the current resource planning (including Gladstone Diversion, Hydro Storage Enhancements, Mayo Lake Outlet Channel Dredging, Refurbish/enhance existing hydro facilities); and
- All transmission corridor options examined in the current resource planning.

In the case of hydro generation options (e.g., pumped storage, small hydro, diversion project), the level of GHG emissions is reduced if biogenic CO_2 emissions are excluded rather than included. However, with or without CO_2 emissions, green (low) ratings continue to apply for each hydro resource option.

6.2.2 Thermal Generation Resource Options

The remaining resource options that are not rated green (low) are thermal generation resource options.

Each thermal generation resource option is rated yellow for Other Air Emissions (En5-2).

Each of the fossil fuel thermal generation options is rated red (high) for GHG Emissions (En5-1), based on the Figure C 6-1 criteria and the estimated GHG emissions intensity as estimated in Table C 6-1. The 100 year GWP total GHG [CO_2/MWh] are shown below for each option with no use of heat energy as assumed in Table C 6-1, i.e., material use of available heat energy will materially reduce total GHG intensity per MWh for each option:

- **Fossil Thermal**
    - Diesel generation (951.1 kg CO_2/MWh).
    - LNG generation (727.7 kg CO_2/MWh).

Each of the non-fossil thermal generation options is rated red or high for GHG emission (En5-1) when biogenic CO2 emissions are included, based on the Figure C 6-1 criteria and the estimated GHG emissions intensity as estimated in Table C 6-1. If biogenic CO2 emissions are excluded, ratings for these options are reduced to yellow (medium) (waste-to-energy and biogas) or green (low) (biomass). The 100 year GWP total GHG (CO_2/MWh) are shown below for each option, with and without biogenic CO_2 emissions, with full use of heat energy as assumed in Table C 6-1, i.e., materially lower levels of heat energy use will materially increase total GHG intensity per MWh:

- **Non-Fossil Thermal (Renewable Thermal Generation)**
    - Waste to-energy
        - Including biogenic CO_2 emissions: 663.0 kg CO_2/MWh for MSW & Biomass, 696.8 kg CO_2/MWh for only MSW.
        - Excluding biogenic CO_2 emissions: 307.1 kg CO_2/MWh for MSW and Biomass, 441.4 kg CO_2/MWh for only MSW.
    - Biogas
        - Including biogenic CO_2 emissions: 1,005.8 kg CO_2/MWh.
        - Excluding biogenic CO_2 emissions: 113.8 kg CO_2/MWh.
    - Biomass
        - Including biogenic CO_2 emissions: 772.0 kg CO_2/MWh.
        - Excluding biogenic CO_2 emissions: 17.2 kg CO_2/MWh.

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ATTACHMENT 1:

Fisheries Information

Table C A1-1: Summary of Common and Scientific Names of Fish Species that occur in the Yukon Energy Power Review Study Area

Common Name	Scientific Name	BC/Yukon Species Codes
Longnose Sucker	*Catostomus catostomus*	LSU
Largescale Sucker	*C. macrocheilus*	CSU
Lake Whitefish	*Coregonus clupeaformis*	LW
Least Cisco	*C. sardinella*	CS
Squanga Whitefish	*C. sp*[1]	SQ
Slimy Sculpin	*Cottus cognatus*	CCG
Lake Chub	*Couesius plumbeus*	LKC
Northern Pike	*Esox lucius*	NP
Arctic Lamprey	*Lethenteron camtschaticum*	AL
Burbot	*Lota lota*	BB
Round Whitefish	*Prosopium cylindraceum*	RW
Pygmy Whitefish	*P. coulteri*	PW
Bull Trout	*Salvelinus confluentus*	BT
Dolly Varden	*S. malma*	DV
Lake Trout	*S. namaycush*	LT
Inconnu	*Inconnu*	IN
Arctic Grayling	*Thymallus arcticus*	GR

[1]Not officially designated as a species or subspecies; however, they appear to be genetically distinct from sympatric populations of Lake Whitefish (Government of Canada 2016).

Table C A1-2: Summary of Fish Species Information

Project	Fish Species	Comments	Type of Fisheries*	References
Waste-to-energy generation		No major creek on access road or actual site.		
Wood biomass generation (Haines Junction)		No major creek on access road or actual site.		
Biogas generation		No site specifications.		
Fossil thermal generation – Takhini Substation		No major creek on access road or actual site.		
Solar - Whitehorse Quarry site (120 acres)		No major creek on access road or actual site.		
Solar - Haines Junction site north of dump (65 acres)		No major creek on access road or actual site.		
Geothermal - Vista Mountain		No major creek on site or near access road. The only water body close to site is a small pond to the south.		
Geothermal - McArthur Springs	N/A	The potential road would cross several creeks close to Summit Lake, Woodburn Lake and the head waters of Little Kalzas River area. No fish information is available for the area.		
Pumped storage - Tutshi-Moon (Midgard report)	BB, CCG, CS, GR, IN, LSU, LT, NP, RW.	All fish listed are from Tutshi Lake. No game fish in Moon Lake according to Gerd at Alpine Aviation.	Recreational and traditional fisheries.	Single Waterbody Query – BC Ministry of Environment.

Project	Fish Species	Comments	Type of Fisheries*	References
Pumped storage – Tutshi-Moon (KP report)	BB, CCG, CS, GR, IN, LSU, LT, NP, RW.	All fish listed are from Tutshi Lake. No game fish in Moon Lake according to Gerd at Alpine Aviation.	Recreational and traditional fisheries.	Single Waterbody Query – BC Ministry of Environment.
Pumped storage – Racine-Moon	BB, RW, GR, LT.	All fish listed are from Racine Lake. No game fish in Moon Lake according to Gerd at Alpine Aviation.	Recreational and traditional fisheries.	Single Waterbody Query – BC Ministry of Environment.
Pumped storage – Racine-Mt. Brown	BB, RW, GR, LT.	All fish listed are from Racine Lake.	Recreational and traditional fisheries.	Single Waterbody Query – BC Ministry of Environment.
Pumped storage – Lindeman-Fraser	LT, GR, LW.	All fish listed are from Lindeman Lake. More species are suspected to be found in Lindeman, no information was available for Fraser.	Recreational and traditional fisheries.	Environment Canada – Catalogue of Aquatic Resources of the Upper Yukon River Drainage (Whitehorse Area).
Pumped storage – Squanga-Dalayee	LT, GR, BB in Dalayee Lake (Taiga Journeys) LW, NP, CCG were also found in a creek between Dalayee Lake and Squanga Lake (FISS 2003) SQ, NP are also known to be in Squanga Lake.	Likely to find more species in Dalayee Lake, a change in water levels could affect lake trout and other species that might be living in the lake. Squanga Whitefish are genetically unique species of Lake Whitefish that have a restricted distribution in northern BC and southern Yukon. They are currently listed on SARA Schedule 3 as species of Special Concern.	Recreational and traditional fisheries.	FISS 2003 Taiga Journeys (pers. Comm.). Environment Yukon – Burbot Population Assessment Squanga Lake 2013 (Barker et al. 2014b).

Project	Fish Species	Comments	Type of Fisheries*	References
Pumped storage – Atlin-Black Mountain	GR, LT, LW, NP, RW, BB, CS, LSU, LKC, CSU.	All species listed are from Atlin Lake.	Commercial, recreational and traditional fisheries.	Single Waterbody Query – BC Ministry of Environment.
Pumped storage – Canyon-Ittlemit	LT (Ittlemit) LT, NP, RW, LW, BB LSU and CCG in Canyon Lake.	Lake trout living in Ittlemit lake could be affected.	Recreational and traditional fisheries.	EDI fish and fish habitat report for Champagne and Aishihik.
Pumped storage – Faro-Vangorda Pit (With storage)	GR, BB, CH (juveniles), LKC, LSU, CCG, RW (in lower 4 km of Vangorda only). RW, BB, CH in Blind Creek.	Blind Creek is a known Chinook spawning stream with returns that are counted annually at a weir.	Possible CH commercial fishery, Recreational and traditional fisheries.	EDI – Faro Mine Fish and Fish Habitat Literature Review (Vangorda). FISS Database (Blind Creek).
Small hydro – Drury Lake(With storage)	CH (in Creek), LT, GR, NP.	Juvenile CH may use the creek as natal habitat depending on the extent of spawning. LT, GR, NP are found in Drury Lake.	Possible CH commercial fishery. Recreational and traditional fisheries.	EDI - Little Salmon Carmacks First Nation Salmon Knowledge Study. Drury Lake Fishing Lodge.
Small hydro – Finlayson (With storage)	LT, GR, NP, WF, BT.	All the species listed other than BT are found in the lake, while BT is found in the river just below the lake.	Recreational and traditional fisheries.	Environment Yukon.
Small hydro – Atlin-Pine Creek (Surprise Lake) (With storage)	GR, CCG.	All the species listed are found in Surprise Lake or in the upper section of Pine Creek.	Recreational and traditional fisheries.	Biological Assessment of the Atlin Hydroelectric Project.
Small hydro – Tutshi-Windy Arm (With storage)	BB, CCG, GR, LT, NP, RW, IN, LSU, CS.	All the species listed are found in Tutshi Lake.	Recreational and traditional fisheries.	Single Waterbody Query – BC Ministry of Environment.
Small hydro – Wolf river (Run of river)	GR, LT, RW, CCG, BB, LW, NP, LSU, WSU, CH.	Chinook salmon have been identified spawning as far upstream as the outlet of Wolf Lake.	Possible CH commercial fishery. Recreational and traditional fisheries.	EDI – Compilation and mapping of fisheries information within the Teslin Tlingit Traditional Territory.

Project	Fish Species	Comments	Type of Fisheries*	References
Small Hydro – Anvil Creek	LT, NP, GR, WF	Documented near the outlet of Anvil Lake. Species are likely present in lake as well.	Recreational fishery is documented – some locals from Faros have cabins on lake. Species that are targeted by traditional fisheries are present	FISS Database (Blind Creek)
Southern Lakes Enhanced Project	LW, CS, RW, GR, LT, CH, NP, LSU, BB, CCG.	All fish listed are found in the southern lakes and would need to be considered for any water level changes.	Commercial, recreational and traditional fisheries	AECOM – Fish species presence in the Yukon River Drainage.
Mayo Lake Enhanced Project	GR, LW, NP, LT, BB, RW, CCG, LSU.	All fish listed were found in Mayo River and would need to be considered for any water level changes.	Recreational and traditional fisheries.	EDI – Mayo Lake Aquatic Baseline Studies 2009.
Mayo A possible changes	GR, LW, NP, LT, BB, RW, CCG, LSU, PW.	All fish listed were found in Mayo and would need to be considered for any water level changes.	Recreational and traditional fisheries	EDI – Mayo Lake Aquatic Baseline Studies 2009.
Transmission - Whitehorse-Atlin corridor	LW, CS, RW, GR, LT, CH, NP, LSU, BB, CCG.	Transmission line would follow existing road. It would cross the McClintock River which is salmon habitat.	Commercial, recreational and traditional fisheries.	EDI Ta'an Salmon Information Gathering/Workshop Summary Report. AECOM – Fish species presence in the Yukon River Drainage.
Transmission – Whitehorse – Skagway corridor	LW, CS, RW, GR, LT, CH, NP, LSU, BB, CCG (Yukon River).	Transmission line would follow existing road. So it will cross many streams, including the Yukon River in Carcross.	Commercial, recreational and traditional fisheries.	AECOM – Fish species presence in the Yukon River Drainage.

Project	Fish Species	Comments	Type of Fisheries*	References
Transmission – Whitehorse – Teslin corridor	LW, CS, RW, GR, LT, CH, NP, LSU, BB, CCG, IN, CM, DV, PW, LKC, SQ.	Transmission line would follow existing road. It would cross the McClintock River and Teslin River. The McLintock River has Chinook Salmon spawning habitat, while the Teslin river has both Chinook and Chum salmon spawning habitat.	Commercial, recreational and traditional fisheries.	AECOM – Fish species presence in the Yukon River Drainage. EDI Ta'an Salmon Information Gathering/Workshop Summary Report.
Transmission – Faro – Watson Lake corridor (More info needed from YE)	LW, CS, RW, GR, LT, CH, NP LSU, BB, CCG, BT, PW, LKC all likely to occur.	Transmission line would follow existing road. Crosses Pelly River and tributaries as well as many streams in the Liard River watershed.	Commercial, recreational and traditional fisheries.	DFO – FISS Yukon.
Transmission – Aishihik – Burwash Landing corridor	LW, RW, GR, LT, NP, LSU, CCG, BB, RB, DV.	Transmission line would follow existing road. Most fish found on the different crossings along this road are noted.	Commercial, recreational and traditional fisheries.	EDI – Overview fish and fish habitat for the Champagne and Aishihik Traditional Territory.
Wind farm – Cyprus Mine		The turbines would be located at high elevation, away from creeks or other water bodies. The access road passes close to a small creek flowing into Rose Creek, but no fish have been found in area.		DFO – FISS Yukon.
Wind farm - Kluane	LT, RW, CCG, GR, LW, NP, LSU, BB, IN.	All the turbines and access road would be very close to existing Alaska Highway and would not cross any streams.		Barker et al. 2014a.

Project	Fish Species	Comments	Type of Fisheries*	References
Wind farm – Miller's Ridge	In Nordenskiold River: CH, CM, LT, GR, RW, LW, LSU, NP, BB, AL, CCG.	Access road and turbines would not cross any streams. The transmission line would cross the Nordenskiold River South of Carmacks.	Possible commercial fisheries for CH and CM. Recreational and traditional fisheries.	Tsawnjik Chu Nordenskiold – Habitat Protection Area Management Plan.
Wind farm - Sugarloaf	In Yukon River: LW, CS, RW, GR, LT, CH, NP, LSU, BB, CCG.	Access road and turbines don't cross any major streams, but the proposed transmission likely would cross the Yukon River.	Commercial, recreational and traditional fisheries.	AECOM – Fish Species presence in Yukon River Drainage (Lindsey et al. 1981).
Wind farm - Sumanik		Access road follows a small creek which has been sampled downstream from the proposed road and no fish were found. (DFO) Turbines are not close to any streams.		DFO – FISS Yukon ID: 80093044.
Wind farm – Tehcho		Access road already established, turbines up high with no streams in proximity.		
Wind farm – Thulsoo		Access road does not cross any streams, all turbines have no streams in proximity.		

*Type of fisheries is inferred by the fish species present.

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ATTACHMENT 2:

Terrestrial Information

Table C A2-1: Summary of Disturbance Footprints Associated with Project Feature Types

Feature	Disturbance Footprint
Access Road	10 m each side of centreline (20 m ROW total footprint)
Canal	70 m (140 m total footprint)
Control Dam	10 m radius
Dam Crest	15 m radius
Forebay	15 m radius
Heat Transfer Line	15 m (30 m total footprint)
Intake	15 m radius
Interconnection Line	15 m (30 m total footprint)
Low Pressure Pipe	15 m (30 m total footprint)
Penstock	100 m ROW footprint
Powerhouse	15 m radius (circular footprint)
Saddle Dam	15 m radius
Transmission Line	30 m each side of centreline (100 m ROW footprint)
Weir	15 m radius
Wind Turbine	50 m radius

A summary of ratings for Terrestrial Footprint and Land Area indicators is provided below.

Table C A2-2: Terrestrial Footprint and Land Area Indicators by Resource Option

Resource Option / Project	Terrestrial Development (km^2)	Linear Development (roads, trans., km)	Permafrost (mean probability and weighted area km^2)	Wetlands (km^2)
Fossil Thermal				
Whitehorse Landfill	0.20	N/A	**Sporadic Discontinuous, Mean=0.20, Area=0.01**	**0**
Takhini Substation	0.20	0.31	**Sporadic Discontinuous, Mean=0.23, Area=0.02**	**0**
Non-Fossil Thermal Generation				
Biogas - Whitehorse	0.20	0.31	**Sporadic Discontinuous, Mean=0.20, Area=0.01**	**0**

Resource Option / Project	Terrestrial Development (km^2)	Linear Development (roads, trans., km)	Permafrost (mean probability and weighted area km^2)	Wetlands (km^2)
Waste to Energy (Whitehorse)	0.20	N/A	**Sporadic Discontinuous, Mean=0.20, Area=0.01**	**0**
Wood Biomass (Haines Junction Facility)	0.20	N/A	**Sporadic Discontinuous, Mean=0.19, Area=0.00**	**0**
Wood Biomass (Timber Harvesting)	Unknown[1]	N/A	N/A	N/A
Energy Storage Facilities				
Takhini Energy Storage	0.20	N/A	**Sporadic Discontinuous, Mean=0.23, Area=0.02**	**0**
Solar PV				
Haines Junction	0.25	N/A	**Sporadic Discontinuous, Mean=0.18, Area=0.04**	**0**
Whitehorse	0.50	N/A	**Sporadic Discontinuous, Mean=0.18, Area=0.09**	**0**
Wind Farms				
Cyprus Mine Hill	1.13	20.1	**Extensive Discontinuous, Mean=0.75, Area=0.85**	**0**
Kluane Lake	1.00	11.2	**Extensive Discontinuous, Mean=0.51, Area=0.51**	**0**
Miller's Ridge	2.23	41.0	**Extensive Discontinuous, Mean=0.66, Area=1.73**	**0**
Mt. Sumanik	1.13	22.8	**Extensive Discontinuous, Mean=0.78, Area=1.03**	**0**
Sugarloaf Mountain	1.21	13.9	**Sporadic Discontinuous, Mean=0.47, Area=0.57**	**0**

Resource Option / Project	Terrestrial Development (km^2)	Linear Development (roads, trans., km)	Permafrost (mean probability and weighted area km^2)	Wetlands (km^2)
Tehcho (Ferry Hill)	1.18	14.0	**Extensive Discontinuous, Mean=0.55, Area=0.65**	**0**
Thulsoo Mountain	2.28	64.3	**Continuous, Mean=0.78, Area=1.77**	**0**
Geothermal				
McArthur Springs	2.61	87.0	**Extensive Discontinuous, Mean=0.70, Area=1.71**	**0**
Vista Mountain	0.28	6.3	**Sporadic Discontinuous, Mean=0.22, Area=0.06**	**0**
Pumped Storage				
Atlin-Black Mountain	2.43	4.7	**Sporadic Discontinuous, Mean=0.25, Area=0.69**	**0**
Canyon-Ittlemit	6.92	15.4	**Extensive Discontinuous, Mean=0.52, Area=3.89**	**0.09**
Lindeman – Fraser	4.65	22.6	**Sporadic Discontinuous, Mean=0.08, Area=0.36**	**0.10**
Racine – Moon	5.66	31.0	**Sporadic Discontinuous, Mean=0.19, Area=1.08**	**0.96**
Racine – Mt. Brown	6.64	30.0	**Extensive Discontinuous, Mean=0.43, Area=3.07**	**0.09**
Squanga – Dalayee	3.01	13.1	**Sporadic Discontinuous, Mean=0.17, Area=0.51**	**0.12**
Faro – Vangorda Pit	10.87	22.9	**Extensive Discontinuous, Mean=0.66, Area=7.18**	**0.40**

Resource Option / Project	Terrestrial Development (km^2)	Linear Development (roads, trans., km)	Permafrost (mean probability and weighted area km^2)	Wetlands (km^2)
Tutshi – Moon	4.99	8.5	**Sporadic Discontinuous, Mean=0.13, Area=0.78**	**0.94**
Small Hydro				
Drury Lake	2.33	15.5	**Extensive Discontinuous, Mean=0.61, Area=0.29**	**0**
Finlayson River	19.36	33.2	**Extensive Discontinuous, Mean=0.68, Area=16.15**	**0.08**
Atlin-Pine Creek (Surprise Lake)	3.09	15.0	**Isolated Patches, Mean=0.06, Area=0.09**	**0**
Tutshi-Windy Arm	3.78	30.2	**Isolated Patches, Mean=0.07, Area=0.04**	**0.05**
Wolf River	3.25	60.4	**Sporadic Discontinuous, Mean=0.16, Area=0.51**	**0.19 Nitsutlin Delta**
Anvil Creek	2.27	19.2	**Extensive Discontinuous, Mean=0.64, Area=1.46**	**0**
Other Hydro				
Gladstone Diversion	3.61	54.5	**Extensive Discontinuous, Mean=0.71, Area=2.57**	**0**
Hydro Storage Enhancements				
Mayo Lake	N/A	0	**N/A**	**N/A**
Southern Lakes	N/A	0	**N/A**	**Size N/A M'Clintock Bay Lewes Marsh Nares Lake**
Mayo Lake Outlet Channel Dredging	0.20	0	**N/A**	**N/A**

Resource Option / Project	Terrestrial Development (km^2)	Linear Development (roads, trans., km)	Permafrost (mean probability and weighted area km^2)	Wetlands (km^2)
Transmission Lines				
Aishihik – Destruction Bay	10.41	173.6	**Sporadic Discontinuous, Mean=0.44, Area=3.83**	**0.02 Swede Johnson Wetland; Kloo and Sulpur Lakes**
Faro – Watson Lake	25.63	427.2	**Extensive Discontinuous, Mean=0.58, Area=14.94**	**0.40 Frances Lake**
Whitehorse – Atlin	10.33	171.7	**Isolated Patches, Mean=0.13, Area=1.13**	**0.07 M'Clintock Bay Lewes Marsh**
Whitehorse – Skagway	10.27	170.8	**Isolated Patches, Mean=0.12, Area=0.95**	**0.14 Nares Lake**
Whitehorse – Teslin	10.48	174.4	**Isolated Patches, Mean=0.13, Area=1.27**	**0.02 M'Clintock Bay Lewes Marsh; Teslin Lake Outlet**
Stewart – Keno City	11.42	190.0	**Extensive Discontinuous, Mean=0.69, Area=7.89**	**0.04 McQuesten and Devil's Elbow**

Notes:
1. Area associated with timber harvesting unknown but expected to be thousands of hectares.
2. Footprints associated with hydro renewable projects are driven by reservoirs; estimates of those extents are preliminary.

APPENDIX D:
SOCIAL EVALUATION TECHNICAL REPORT

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1.0 INTRODUCTION

Social criteria and indicators for evaluating resource options as finalized in Appendix B, are copied below in Table D 1-1.

The technical social evaluation of each resource option is addressed in Appendix D, with separate sections for each of the social criteria in Table D 1-1.

At the start of each section of Appendix D, the distinct issues, rating criteria and data sources for each criteria are summarized. As outlined in Section 7 of Appendix B, the ratings for the evaluation of each indicator are classified in terms of high, medium, and low as follows:

- **High (Red when non-positive - no colour when positive effect)** means the resource option has a high expected effects linkage to the indicator (depending on the indicator, the likely effects may be adverse, beneficial or simply signify linkage/overlap without much additional guidance);
- **Medium (Yellow when non-positive - no colour when positive effect)** means the resource option has potential expected linkage to the indicator that falls between low and high ratings; and
- **Low (Green when non-positive - no colour when positive effect)** means the resource option likely has minimal, if any, expected effects linkage to the indicator (again, depending on the indicator, any potential minimal effects may be adverse, beneficial or simply signify no linkage / overlap with the indicator, i.e., no effects pathway).

No linkage or Not Applicable, which is shown as green, is separated out in the social evaluations to identify circumstances where there is no apparent or likely link between a resource project option and a given social indicator.

As each resource project option was reviewed, it was assumed that standard best management practices (BMPs) would be applied during the construction and operation stages to mitigate adverse effects and enhance positive effects. Where standard BMPs are expected to prevent any likely effect of concern on an indicator, a green or low effect rating was adopted.

Table D 1-1: Resource Options Evaluation Matrix – Social Criteria & Indicators

ID	Criteria	Indicator	Metric ID	Metric
Social Criteria				
S1	**First Nation Lands**	Settlement Lands, Interim Protected Lands	S1-1	Overlap and/or access with these lands (Y/ Potential/N)
S2	**Traditional Lifestyle**	Footprint land area impact	S2-1	Total area (ha) of direct land loss
		Land area loss re Traditional Lifestyle	S2-2	Total area (ha) of Traditional Use land area loss
		Land Quality Effects on Traditional Lifestyle	S2-3	Indirect effects on land or access for such pursuits (+/- and L/M/H)
		Cabins, Camps & Structures	S2-4	Number of cabins, camps, homesteads, etc. in footprint (corridor for linear access) that may be affected (n)
		Country Foods	S2-5	Effects to the opportunity to harvest country foods (+/- and L/M/H)
S3	**Heritage Resources**	Heritage Resource Potential	S3-1	Density (number of discrete) known or potential archeological, palaeontological, ethnological, prehistoric, or historic resources (L/M/H)
			S3-2	Importance/Cultural Value of heritage resources, including areas of land containing heritage resources. (L/M/H)
S4	**Tourism, Recreation & Other Resources and Land Use**	Recreational Values	S4-1	Effect on nature and scale of existing and new Recreational Values. (+/- and L/M/H)
		Tourism Values	S4-2	Effect on nature and Scale of Tourism Values. (+/- and L/M/H)
		Aesthetics	S4-3	Effect on auditory or visual aesthetics. (+/- and L/M/H)
		Non-renewable Resources	S4-4	Effect on Non-Renewable Resources. (+/- and L/M/H)
		Other Renewable Resources	S4-5	Effect on other Renewable Resources. (+/- and L/M/H)
		Land Use & Renewable Resources Plans	S4-6	Consistent with Land Use& Renewable Resources Plans (Y/N, NA)
S5	**Cultural and Community Well Being**	Infrastructure & Services	S5-1	Effect on Infrastructure & Services (+/- and L/M/H)
		Public Safety, Worker Interaction, Human and Community Health	S5-2	Risks to Community Health & Safety - construction & operation (L/M/H)
		Community, First Nation & Personal Development	S5-3	Effects on local jobs, business, training & development (+/- and L/M/H)

2.0 FIRST NATION LANDS

2.1 RATING CRITERIA AND DATA SOURCES FOR S1: FIRST NATION LANDS

The rating system outlined in Figure D 2-1 below was adopted to guide evaluations of each resource project option for the First Nation Lands indicator.

Figure D 2-1: Summary of Rating Criteria for First Nation Lands

Indicator	Low	Medium	High
Settlement Lands, Interim Protected Lands (S1-1)	No overlap with Settlement Lands or Interim Protected Lands	Potential overlap with Settlement Lands or Interim Protected Lands	Expected overlap with Settlement Lands or Interim Protected Lands

The Settlement Lands and Interim Protected Lands indicator as defined in Table D 1-1 focuses on the presence or absence of an overlap (Yes/No rating), with the option of a potential effect (if there is uncertainty). "Overlap" in this context references the footprint required for the resource option lands, access rights-of-way (ROW) (road and transmission), any required buffer lands, and whether any of the footprint requires use of any settlement lands or interim protected lands in Yukon (or any known reserve blocks in British Columbia).

An initial question is whether a generation resource site footprint is expected to overlap (red), or might potentially overlap (yellow), with First Nation lands as defined. Separately, a related question is whether new road and/or transmission access required for a resource option is expected to overlap, or might potentially overlap, with First Nation lands as defined. In this case, it becomes relevant to assess if the overlap is expected/required (a red [high] rating) or merely a potential option within the 500m area assumed for selecting a final 60m ROW (a yellow [medium] rating).

The approach and assumptions used in evaluating potential effects on the First Nation Lands indicator are:

- In applying the rating system, available information was considered regarding resource project options description.
- The evaluations of each resource option for this indicator identify resource project option overlaps with Settlement or Interim Protected Lands that must be addressed (and reserve blocks for projects in BC). It is noted that such overlaps are not necessarily adverse and could have positive effects as well as adverse effects (i.e., in certain cases the affected First Nation may not be opposed to the development, recognizing that there may be the potential for positive effects due to projects being located on settlement land, such as benefits to the First Nation through project agreements).
- Existing information is not likely, without consultation with the First Nation, to provide any useful basis for assessing the extent that there may be material concerns in this regard that are not

likely to be mitigated. Accordingly, the assessment focuses only on the extent to which an overlap is expected versus may only potentially occur (without being a likely requirement).

- This indicator focuses only on First Nation lands where a project must obtain some form of permit for actual use. Consultation with First Nations with regard to project effects on traditional lands is a separate requirement that continues to apply in connection with almost all resource options.

2.2 EVALUATION

Table D 2-1 provides a summary of all resource options indicating for each option whether it has no overlap with Settlement or Interim Protected Lands (green [low] rating) or is expected to have an overlap with Settlement or Interim Protected Lands (red [high] rating). A yellow (medium) rating is provided for situations where there is uncertainty with the potential for the resource option to have an overlap that cannot be avoided with Settlement or Interim Protected Lands. This rating reflects the existence of First Nation lands within the area potentially affected by a project's footprint, including access roads and/or transmission where it is not clear in the available information that there are options for final routing and/or project location that may avoid overlap with such lands.[1]

Table D 2-1 indicates that the largest group of projects is rated green (low) because there is no overlap.

The next largest groups of project sites is rated yellow, highlighting the potential overlap with settlement lands or interim settlement lands without a separate report confirming that an overlap is in fact required for the resource option. The specific assessments of future projects will determine the exact issues to be addressed in each instance, potentially in the manner adopted for the Stewart-Keno City Transmission project (as noted in Table D 2-1).

The following 13 resource options are rated red (high) in Table D 2-1, and the components leading to this rating are noted below where feasible:

- Two wind farm projects (Kluane Lake and Sugarloaf Mountain) are rated red (high), based on information supported by the specific resource option report indicating that each option requires overlap with Settlement Lands for the generation site component.
- The three potential new transmission corridors rated red (high) have segments where First Nation Settlement Lands are adjacent to both sides of the proposed corridor located along an existing highway, e.g., this situation has been identified for multiple points along corridors from Whitehorse to Carcross and from Whitehorse to Jake's Corner or Teslin.
- Southern Lakes Enhanced Storage project is rated red to reflect affected water bodies adjacent to various Settlement Lands, where potential edge effects have been highlighted for the project.
- Gladstone Diversion is rated red to reflect the linear features' potential overlap with Settlement Lands.

[1] Existing information for a potential resource project option typically does not allow for a clear conclusion that flexibility exists to avoid First Nation lands. First Nation lands may create constraints for even transmission line routing that must be addressed, and that cannot be avoided by BMPs in the same way as many environmentally sensitive areas.

- Canyon-Ittlemit is rated red to note that potential overlaps with Settlement Land would occur in the context of existing issues with local First Nations with regard to current Aishihik generation.
- Anvil Creek small hydro is rated red to reflect that the transmission connection to the grid would overlap with Interim Protected Lands (without any apparent practical routing option to avoid this overlap).
- Four other hydro generation options are rated red to reflect potential segments of Settlement Lands that may affect routing options and discussions for new transmission connections needed to connect with the existing grid, plus specific potential Settlement Land overlaps that may affect the Vangorda Pit pumped storage development on currently undeveloped lands.

Table D 2-1: Resource Project Options Assessment for First Nation Lands Indicator

	ResourceOptions	No Overlap with Settlement or Interim Protected Lands	Potential Overlap with Settlement or Interim Protected Lands	Expected Overlap with Settlement or Interim Protected Lands
		Low	**Medium**	**High**
Fossil Fuel Thermal (Diesel or LNG)	Whitehorse Landfill	No Overlap		
	Takhini Substation		Yes	
Non-Fossil Thermal	Biomass (Haines Junction)	No Overlap		
	Waste-to-Energy (Whitehorse)	No Overlap Expected		
	Biogas (Whitehorse)	No Overlap		
Energy Storage Facility (Takhini)		No Overlap		
Solar PV	Whitehorse	No Overlap		
	Haines Junction	No Overlap		
Wind Farms	Cyprus Mine Hill	No Overlap		
	Kluane Lake			Yes[2]
	Millers Ridge		Yes	
	Mt. Sumanik	No Overlap		
	Sugarloaf Mountain			Yes[2]
	Tehcho (Ferry Hill)	No Overlap		
	Thulsoo Mountain	No Overlap		
Geothermal	McArthur		Yes	
	Vista Mountain		Yes	
Pumped Storage	Moon Lake (Tutshi-Moon)	No Overlap		
	Racine - Moon	No Overlap		
	Lindeman – Fraser	No Overlap		
	Racine – Mt. Brown		Yes	
	Atlin – Black Mountain		Yes	
	Squanga - Dalayee			Yes[2]
	Canyon - Ittlemit			Yes[2]
	Faro – Vangorda Pit			Yes[2]
Small Hydro	Drury Lake		Yes	
	Tutshi – Windy Arm	No Overlap		
	Wolf River			Yes[2]
	Finlayson River			Yes[2]
	Anvil Creek			Yes[2]
	Atlin/Pine Creek		Yes	
Other Hydro	Gladstone Diversion			Yes[2]
	Southern Lakes			Yes[2]
	Mayo Lake	No Overlap		
	Mayo Lake Dredging	No Overlap		
Refurbish Existing Hydro Generation	Mayo A	No Overlap		
	Aishihik re-runnering	No Overlap		
Transmission Corridors	Aishihik-Burwash		Yes	
	Faro – Watson Lake		Yes	
	Whitehorse – Atlin			Yes[2]
	Whitehorse – Skagway			Yes[2]
	Whitehorse – Teslin			Yes[2]
	Stewart - Keno City		Yes[1]	

Notes:

1. Reference to one parcel where the existing line has an existing right of way, and no objection to having a new line also use this area (options existed for routing if the First Nation settlement land use not acceptable).
2. See text for discussion of components and information that lead to each red rating.

3.0 TRADITIONAL LIFESTYLE

3.1 RATING CRITERIA AND DATA SOURCES FOR S2: TRADITIONAL LIFESTYLE

The rating system outlined in Figure D 3-1 was adopted to guide evaluations of each resource project option for each of the Traditional Lifestyle indicators.

Figure D 3-1: Summary of Rating Criteria for Traditional Lifestyle

Indicator	Low	Medium	High
Footprint Land Area Impact (S2-1)[1]	<10 ha of land area affected, or not applicable	Between 10 and 100 ha of land area affected	>100 ha of land area affected
Land Area Loss re: Traditional Lifestyle[2] (S2-2)	< 500 ha of potential traditional lifestyle land area loss, or not applicable	Between 500 and 2500 ha of potential traditional lifestyle land area loss	Over 2500 ha of traditional lifestyle land area loss
Land Quality Effects on Traditional Lifestyle (S2-3)	No known or only minor concerns, or not applicable	Known minor concerns that require further work	Known significant concerns that may be very difficult to mitigate[3]
Cabins, Camps, & Structures (S2-4)[4]	Less than 26 Cabins, Camps or other Structures within the right-of-way or buffer area[5], or not applicable	Between 26 and 50 Cabins, Camps or other Structures within the right-of-way or buffer area[5]	Over 50 Cabins, Camps or other Structures within the right-of-way or buffer area[5]
Country Foods (S2-5)	No known concerns or only minor concerns, or not applicable	Known minor concerns that require some further work	Known significant concerns that may be difficult to mitigate[6]

Notes:
1. This indicator is similar to, but not the same as, the environmental indicator En4-1. See text for discussion of the differences.
2. This indicator considers total area (ha) of access loss (i.e., amount of land lost to use and lost to access). The assessment assumes that roads to facilities are gated in order to restrict access to each facility.
3. Examples: adverse impacts on known sacred places, burial grounds, graves.
4. May include indirect impacts on quality of life.
5. For smaller projects, only consider footprint. For larger projects such as pumped storage or small hydro, a buffer of 100 m has been included. A low rating for the larger projects would apply where there are no known sites or low potential for sites within the 100 m buffer.
6. Examples: adverse impacts on known special species, habitat or land; known special spawning grounds or collection areas.

The Traditional Lifestyle indicators as defined in Table D 1-1 focus on the scale of impact (L/M/H), including total area or number of structures impacted, and (for Land Quality Effects on Traditional Lifestyle [S2-3] and Country Foods [S2-5]) whether the effect is positive or negative. Unless otherwise explicitly noted, the evaluations of each resource option for these indicators address only negative effects. Figure D 3-1 provides ratings for assessing relative magnitude of the effect(s) of a resource option on each indicator.

In applying the rating system, available information regarding resource project option descriptions was considered, as well as known types of effects that the various types of projects can have on the social environment.

Traditional Lifestyle indictors have been evaluated based on information available from:

- A combination of known heritage resources and Yukon Historic Sites Inventory (YHSI) resources; cabins, camps, and structures; and high value natural resources; and
- Known traditional lifestyle valued components for other project studies.

In addition, as outlined in Table D 3-1, other environmental and/or social criteria assessments were considered where relevant for each of the S2 indicators.

Table D 3-1: Other Criteria Considered in Evaluation of Traditional Lifestyle

S2 Criteria - Indicators	Other Criteria Considered
Footprint Land Area Impact	En4-1: Footprint Terrestrial Area, including Access and New Flooding
Land Area Loss re: Traditional Lifestyle	En1-3: Commercial, Recreational or Aboriginal Fishery Species and Habitat En3-2: Protected and Conservation Areas En3-3: Wildlife Key Areas En3-4: Caribou Ranges
Land Quality Effects on Traditional Lifestyle	En1-3: Commercial, Recreational or Aboriginal Fishery Species and Habitat En3-2: Protected and Conservation Areas En3-3: Wildlife Key Areas En3-4: Caribou Ranges
Cabins, Camps, & Structures	N/A
Country Foods	En1-3: Commercial, Recreational or Aboriginal Fishery Species and Habitat En3-2: Protected and Conservation Areas En3-3: Wildlife Key Areas En3-4: Caribou Ranges

The following are noted with regard to the assessment approach adopted for each indicator:

- **Footprint Land Area Impact (S2-1)** – Footprint Land Area Impact is a quantitative metric that considers only direct land loss. The total footprint or land area affected may not be permanently lost for the purposes of traditional lifestyle activities (assessed separately below). Accordingly, this indicator is used only as background information and is not directly adopted for the assessment of effects on the Land Quality Effects on Traditional Lifestyle indicator.[2] The rating criteria were selected simply to help assign resource project options to clearly separate groups based on the indicator.
- **Land Area Loss regarding Traditional Lifestyle** – This metric assesses the amount of the footprint or land area that is permanently lost or that can no longer be accessed for traditional lifestyle activities (e.g., an access road or site area that is gated or closed off).

[2] Estimated footprint areas for S2-1 do not correspond to the areas estimated for En4-1, reflecting differences in assumptions and methods used to develop each estimate.

- **For projects located within Whitehorse or Haines Junction** (i.e., fossil thermal, non-fossil thermal [biomass, biogas and waste-to-energy] and other renewable, including solar and storage battery), the total access lost is expected to equal the total area of direct land lost due to the project. This assumes that the areas for the project are gated and access to the site is controlled. However, for each of these sites there are less than 50 ha of total land area affected and consequently effects are expected to be low.
- **Wind projects or geothermal projects located outside of urban centres** – The total area of land loss for these projects ranges between 28 ha (Vista Mountain) and 261 ha (McArthur Springs). The assessment assumes that access roads and the project site are gated with restricted access. Adverse effects are expected, but are anticipated to be low.
- **Small hydro and pumped storage projects -** These projects have higher total area of land affected by the project when reservoir or surface area of affected lakes are considered. Consequently, while the total area of the project may be high, the effects on traditional lifestyle activities, including access to lakes or shoreline areas may not be as large or significant. The assessment considers only the incremental effect on land area due to the project and does not consider the existing surface area of the lake or reservoir.
- **Transmission projects -** The total area loss relating to traditional lifestyle activities will likely be much smaller. The project may create new access into previously inaccessible areas and could have both positive and negative effects on traditional activities.

- **Land Quality Effects on Traditional Lifestyle** – This indicator considers indirect effects on traditional areas or traditional lifestyle activities due to the loss of access or other concerns related to the project. This considers the effects related to footprint and land area effects, as well as land area loss related to traditional lifestyle.
- **Cabins, Camps and Structures** – This is a quantitative indicator that considers the number of dwellings (e.g., cabins, camps) that are either within a project ROW or within a 100m buffer of a project ROW for hydro and pumped storage projects.
- **Country Foods** – This considers the effects on the ability to harvest available country foods (including hunting, trapping, fishing and plant collection activities).

Table D 3-2 summarizes the assessment of the resource options with regard to the indicators for the Traditional Lifestyle criteria.

Table D 3-2: Traditional Lifestyle: All Indicators

Resource Options	Footprint Land Area Impact (S2-1) (ha)	Land Area Loss re: Traditional Lifestyle (S2-2) (ha)	Land Quality Effects on Traditional Lifestyle (S2-3) (L,M,H)	Cabins, Camps, & Structures (S2-4)	Country Foods (S2-5) (L,M,H)
Fossil Thermal (Diesel or LNG)					
Whitehorse Landfill	7	7	L	0	N/A
Takhini Substation	7	7	L	0	N/A
Non-Fossil Thermal					
Waste to Energy (Whitehorse)	1 or 2	1 or 2	L	0	N/A
Biogas (CHP) (Whitehorse Landfill)	1 or 2	1 or 2	L	0	N/A
Biomass (Haines Junction)	2	2	L	5	N/A
Other Non-Hydro Renewable					
Storage Battery (Takhini Substation)	1	1	L	0	N/A
Solar PV: Whitehorse Fixed Tilt: 10 MW	48	48	L	0	N/A
Solar PV: Haines Junction Fixed Tilt: 5 MW	23	23	L	0	N/A
Wind: Cyprus Mine Hill, 20 MW	114	114	L	1	N/A
Wind: Kluane Lake, 20 MW	100	100	L	0	N/A
Wind: Millers Ridge, 20 MW	213	213	L	0	N/A
Wind: Mt. Sumanik , 20 MW	132	132	L	0	N/A
Wind: Sugarloaf Mountain, 20 MW	121	121	L	8	N/A
Wind: Tehcho (Ferry Hill), 20 MW	118	118	L	3	N/A
Wind: Thulsoo Mountain, 20 MW	228	228	L	0	L
Geothermal: McArthur Springs	261	261	L	0	L
Geothermal: Vista Mountain	28	28	L	0	N/A
Hydro Generation					
Pumped Storage: Moon Lake (Tutshi-Moon)	5946	0-500	L	0	L
Pumped Storage: Racine - Moon	1814	0-500	L	1	L
Pumped Storage: Lindeman-Fraser	1006	0-500	L	12	L
Pumped Storage: Racine - Mt. Brown (15 MW)	1743	0-500	L	0	L
Pumped Storage: Racine - Mt. Brown (25 MW)	1743	0-500	L	3	L
Pumped Storage: Atlin - Black Mountain (15 MW)	51711	0-500	L	0	L
Pumped Storage: Atlin - Black Mountain (25 MW)	51711	0-500	L	0	L
Pumped Storage: Squanga - Dalayee	2438	0-500	L	0	M
Pumped Storage: Canyon - Ittlemit	2380	0-500	M	0	L
Pumped Storage: Vangorda Pit	1088	1088	L	1	L
Small Hydro: Drury Lake	2663	190	L	0	L
Small Hydro: Tutshi - Windy Arm	68	310	L	0	L
Small Hydro: Wolf River	325	0	L	6	L
Small Hydro: Finlayson River	15543	540	M	0	M
Small Hydro: Anvil Creek	227	0-500	L	2	L
Small Hydro: Atlin/Pine Creek	3553	0-500	L	7	L
Other Hydro: Gladstone Diversion	667	0-500	M	6	H
Other Hydro: Southern Lakes Storage	54527	0-500	M	~380	L
Other Hydro: Mayo Lake Storage	9665	0	L	0	L
Other Hydro: Mayo Dredging	N/A	N/A	N/A	0	L
Aishihik Re-runnering	N/A	N/A	N/A	0	N/A
Mayo A Refurbishment	NA	NA	NA	0	NA
Transmission Corridors					
Transmission: Whitehorse - Atlin (138 kV)		0-500	L		L
Transmission: Whitehorse - Skagway (230 kV)	1027	0-500	L	47	L
Transmission: Whitehorse - Teslin (138 kV)	1049	0-500	L	16	L
Transmission: Faro - Watson Lake (230 kV)	2563	0-500	L	21	L
Transmission: Aishihik - Destruction Bay (230 kV)	1042	0-500	L	9	L
Transmission: Stewart-Keno City (138 kV & substations)	1143	0-500	L	9	L

3.2 EVALUATION

3.2.1 Resource Options with No Material Concerns re: Traditional Lifestyle

The first indicator in Table D 3-2 (Footprint Land Area Impact [S2-1]) does not directly address effects on traditional lifestyle, and is therefore not considered in this assessment beyond providing background information. The following resource project options have a green (low) rating for each of the four remaining indicators assessed in Table D 3-2, indicating no material basis for concerns regarding the Traditional Lifestyle criteria:

- Fossil fuel thermal generation (diesel and LNG, each in Whitehorse);
- Non fossil thermal generation (biomass at Haines Junction, biogas and waste-to-energy in Whitehorse);
- Energy storage facility (batteries) at Takhini Substation;
- Solar PV at Whitehorse and Haines Junction;
- Wind farms at each of the 7 sites included in this evaluation;
- Geothermal generation at McArthur Springs and Vista Mountain (near Takhini Substation) – it is assumed that any sensitive areas may be avoided with moveable footprint access and transmission line;
- Pumped storage hydro generation options, except for Squanga-Delayee, Canyon-Ittlemit and Vangorda Pit;
- Small hydro options, except for Finlayson River;
- Other hydro options, except for Gladstone Diversion and Southern Lakes Storage Enhancement;
- Hydro refurbishment/maintenance (Mayo A and Aishihik); and
- Transmission corridors (each of the project options included in this evaluation, except for the Whitehorse-Skagway Transmission Corridor).

3.2.2 Hydro Generation

3.2.2.1 Pumped Storage

The following yellow (medium) ratings are assessed for three pumped storage project options:

- Squanga-Dalayee - a yellow (medium) rating for potential effects on Country Foods (S2-5) related to effects to game outfitting[3] and perceived high game habitat;

[3] Outfitting is also discussed in the evaluations for Land Use and Renewable Resource Plans and Tourism.

- Canyon-Ittlemit - a yellow (medium) rating for potential effects of Land Quality Effects on Traditional Lifestyle (S2-3) related to high food values and perceived high game habitat, and game outfitting concerns; and
- Vangorda Pit - a yellow (medium) rating for Land Area Loss regarding Traditional Lifestyle (S2-2) – although this area is adjacent to the disturbed ground of the Vangorda Pit area, this footprint is basically undisturbed and would affect a relatively large amount of land and stream basin.

3.2.2.2 Small Hydro

The Finlayson River option is rated yellow (medium) for Land Area Loss regarding Traditional Lifestyle (S2-2), Land Quality Effects on Traditional Lifestyle (S2-3), and potential effects on Country Foods (S2-5). This option would overlap with a moderate amount of land area (in the yellow/medium category), and has known significant values for wetlands, game and fisheries.

3.2.2.3 Other Hydro

Red (high) ratings are provided for the following indicators and projects (assessments are made prior to consideration of potential mitigation that may be developed for each project):

- Gladstone Diversion - a red (high) rating for potential effects on Country Foods (S2-5). A significant concern here is based on the federal fisheries concerns of potential risk of disease (due to potential interbasin pathogen transfer) and perceived high values of indirect effects similar to previous concerns at the Aishihik Generating Station, such as changes in water levels and related possible effects.
- Southern Lakes Enhanced Storage - a red (high) rating for potential effects on Cabins, Camps and Structures (S2-4). The cabins, camps and structures values are the highest of all the resource options and reflect a high level of private and First Nations concerns, possible effects to graves and perceived concerns of ground water effects and erosion.

The same two resource options also have a yellow (medium) rating for potential effects on Land Quality Effects on Traditional Lifestyle (S2-3).

3.2.2.4 Transmission Corridors

The Whitehorse-Skagway transmission corridor resource option has yellow (medium) rating for potential effects on Cabins, Camps and Structures (S2-4). It is likely that the project routing would be selected to address any such potential effects.

4.0 HERITAGE RESOURCES

4.1 RATING CRITERIA AND DATA SOURCES FOR S3: HERITAGE RESOURCES

The rating system outlined in Figure D 4-1 was adopted to guide evaluations of each resource project option for each of the Heritage indicators.

Figure D 4-1: Summary of Rating Criteria for Heritage Resources

Indicator	Low	Medium	High
Density of Heritage Resources (S3-1)	Few known or expected heritage sites[1] (approximately <2) within or near project right-of-way or buffer area[2]	Small number of known heritage sites within or near ROW or buffer (approximately>2 and <25); high potential for archeological sites	High number of heritage sites within or near ROW or buffer (approximately >25)
Importance/ Cultural Value of Heritage Resources (S3-2)	No known sites of cultural value (or only minor concerns) within or near project right-of-way or buffer area[2]	Presence of known minor sites with concerns that require further work	Presence of known sites or potential sites with known significant concerns[3]

Notes:
1. Heritage site or heritage resources includes YHSI sites, paleontological sites, and archeological sites or other sites of cultural value.
2. For smaller projects, the evaluation only considers footprint. For larger projects, such as pumped storage or small hydro, a buffer of 100 m has been included. A low rating for the larger projects would apply where there are no known heritage sites or low potential for heritage sites within the 100m buffer. Transmission projects are rated low if route selection is likely to avoid any effects on heritage sites.
3. Examples: known significant sites and resources, sacred places, burial grounds, graves. This indicator does not include parks, as parks are included in the environmental indicator Protected and Conservation Areas (En3-2).

The Heritage Resources indicators as defined in Table D 1-1 focus on the scale of effect (L/M/H), including total area or number of heritage resources (and important heritage resources) affected. Unless otherwise explicitly noted, the evaluations of each resource option for these indicators address only negative effects. Figure D 4-1 provides ratings for assessing relative magnitude of effect of a resource activity on each indicator. “Heritage resources” include known archeological sites, known YHSI sites, known paleontological sites, known areas of archeological potential and areas of ethnographical potential.

In applying the rating system, available information was considered regarding resource project option descriptions, as well as known types of effects that the various types of projects can have on the social environment.

Heritage Resources indicators have been evaluated based on information available from:

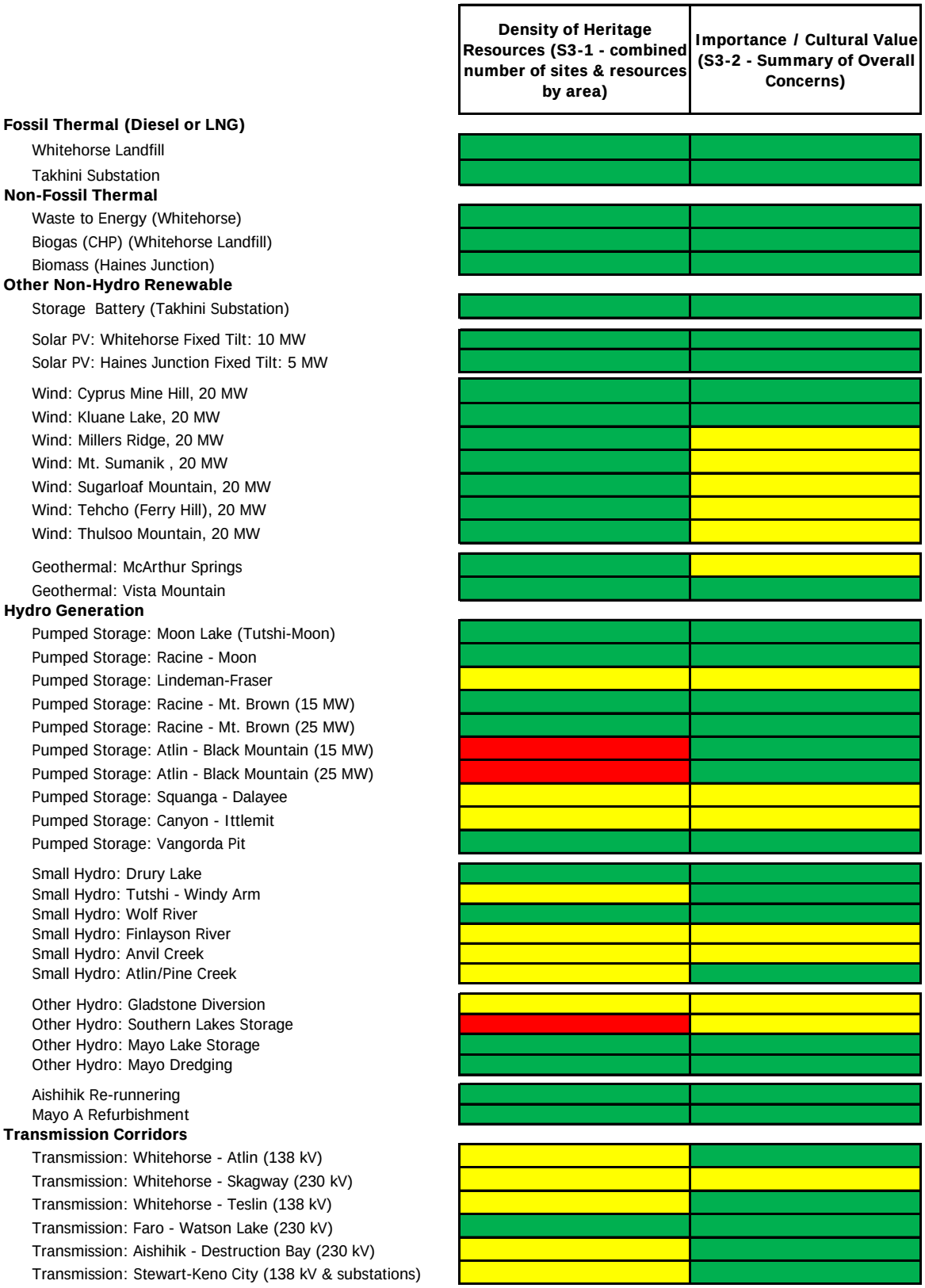
- Previously recorded archeological, paleontological and historic sites in Yukon and British Columbia and YHSI records.

The approach and assumptions used in evaluating potential effects on Heritage Resources indicators are:

- Looked for overlap between resource project option sites and the following:
    - Known archeological sites;
    - Known YHSI sites;
    - Known paleontological sites;
    - Known areas of archeological potential; and
    - Areas of ethnographical potential.
- Combined number of sites and resources by total hectares (ha).
- Considered whether there were sites of specific cultural value or importance.

Table D 4-1 summarizes the assessment of the resource options with regard to the indicators for the Heritage Resource criteria. Resource options rated yellow or red for any indicator are highlighted with the colour rating. The considerations in each evaluation are reviewed in Section 4.2 below.

Table D 4-1: Heritage Resource: All Indicators



4.2 EVALUATION

4.2.1 Resource Options with No Material Concerns re: Heritage Resources

The following resource project options have a green (low) rating for each of the heritage resources indicators reviewed in Table D 4-1, indicating no material basis for concerns regarding the Heritage Resources criteria:

- Fossil fuel thermal generation (diesel and LNG, each in Whitehorse);
- Non fossil thermal generation (biomass in Haines Junction, biogas and waste-to-energy in Whitehorse);
- Energy storage facility (batteries) at Takhini Substation;
- Solar PV in Whitehorse and Haines Junction;
- Wind farms at Cyprus Mine Hill and Kluane Lake;
- Geothermal generation at Vista Mountain (near Takhini Substation);
- Pumped storage hydro generation options at Moon Lake (Tutshi-Moon), Racine-Moon, Racine-Mt. Brown, and Vangorda Pit;
- Small hydro options at Drury Lake and Wolf River;
- Other hydro options – Mayo Lake Storage Enhancement and Mayo Dredging;
- Hydro refurbishment/maintenance (Mayo A and Aishihik); and
- Transmission corridors – Faro-Watson Lake.

4.2.2 Non-Hydro Renewables

4.2.2.1 Wind Farms

All of the wind farm options are rated green (low) for Density of Heritage Resources (S3-1). Although there are no heritage sites known today in these footprints, the following five wind farm options are rated yellow (medium) for Importance/Cultural Value of Heritage Resources (S3-2) due to the predicted high potential areas that the footprints overlap:

- Miller's Ridge;
- Mt. Sumanik;
- Sugarloaf Mountain;
- Tehcho (Ferry Hill); and
- Thulsoo Mountain.

4.2.2.2 Geothermal – McArthur Springs

McArthur Springs geothermal is rated green (low) for Density of Heritage Resources (S3-1) and rated yellow (medium) for Importance/Cultural Value of Heritage Resources (S3-2). A medium rating is based on expected level of sites and resources.

4.2.3 Hydro Generation

4.2.3.1 Pumped Storage

The following three pumped storage sites are rated yellow (medium) for Density of Heritage Resources (S3-1) and for Importance/Cultural Value of Heritage Resources (S3-2):

- Lindeman-Fraser – Chilkoot Trail National Historic Site and related resources and areas of potential;
- Squanga-Dalayee - structures close to footprint on Dalayee Lake and structures near footprint on Squaqnga Lake, significant heritage potential; and
- Canyon-Ittlemit - reference to previous Champagne and Aishihik First Nations (CAFN) concerns regarding Aishihik Generating Station.

The Atlin-Black Mountain pumped storage site is rated red (high) for Density of Heritage Resources (S3-1) and green (low) for Importance/Cultural Value of Heritage Resources (S3-2).

4.2.3.2 Small Hydro

The Finlayson River and Anvil Creek small hydro sites are each rated yellow (medium) for Density of Heritage Resources (S3-1) and for Importance/Cultural Value of Heritage Resources (S3-2) due to significant heritage and paleontological potential. The Anvil Creek site ratings reflect high archaeological potential along Anvil Lake shore, along Anvil and Blind Creek, and Pelly River valley.

The Tutshi-Windy Arm and Atlin-Pine Creek small hydro sites are each rated yellow (medium) for Density of Heritage Resources (S3-1) and green (low) for Importance/Cultural Value of Heritage Resources (S3-2).

4.2.3.3 Other Hydro - Gladstone Diversion and Southern Lakes Storage Enhancement

Gladstone Diversion is rated yellow (medium) for Density of Heritage Resources (S3-1) and for Importance/Cultural Value of Heritage Resources (S3-2) due to moderate amount of sites and CAFN concerns.

Southern Lakes Storage Enhancement is rated red (high) for Density of Heritage Resources (S3-1) and for Importance/Cultural Value of Heritage Resources (S3-2), due to high number of sites and Carcross/Tagish First Nation (CTFN) concerns.

4.2.3.4 Transmission Corridors – Other Than Faro-Watson Lake

Each of the transmission corridors other than Faro-Watson Lake is rated yellow (medium) for Density of Heritage Resources (S3-1), reflecting the potential for a notable number of heritage resource sites along such corridors.

The Whitehorse-Skagway Transmission Corridor is also rated yellow (medium) for Importance/Cultural Value of Heritage Resources (S3-2), reflecting the Chilkoot Trail National Historic Park of Canada and Klondike Gold Rush National Historic Site (USA) and related resources, as well as BC and Alaska Historic Site concerns.

5.0 TOURISM, RECREATION AND OTHER RESOURCES AND LAND USE

5.1 RATING CRITERIA AND DATA SOURCES FOR S4: TOURISM, RECREATION, AND OTHER RESOURCES AND LAND USE

The rating system outlined in Figure D 5-1 was adopted to guide evaluations of each resource project option for each of the tourism, recreation, and other resources and land use indicators.

Figure D 5-1: Summary of Rating Criteria for Tourism, Recreation, and Other Resources and Land Use

Indicator	Low	Medium	High
Recreational Values (S4-1)	No nearby/ affected recreational sites, or not applicable[1]	Project visible or audible – do not expect major change in recreational activities	Project overlaps with site(s)/ may necessitate a major change in recreational activities
Tourism Values (S4-2)	No nearby/ affected tourism opportunities, or not applicable[1]	Project overlaps with site – do not expect major change in activities	Project overlaps with site(s)/ may necessitate a major change in tourist activities
Aesthetics (S4-3)	Project not visible/audible from known valued viewpoints/ communities, or not applicable	Project visible or audible from known valued viewpoints/ communities - not expect major aesthetic value change	Project location may disrupt/ disturb valued viewpoint/ community-noted aesthetic value of area
Non-renewable Resources (S4-4)	No overlap with claims and current extraction activities, or not applicable[1]	Project overlaps with known claims - not expect major change in ability to undertake activity	Project overlaps and may affect ability to undertake resource extraction activity
Other Renewable Resources (S4-5)	No overlap with known renewable resource activities, or not applicable	Project overlaps with known renewable resource activity - not expect major change in the activity	Project overlaps and may affect the ability to undertake renewable resource activity
Land Use and Renewable Resource Plans (S4-6)	Project does not overlap with such plans, or not applicable	Project overlaps with such plans – not in conflict nor a cause a major change in activity	Project is located in zone with conflicting usage designation

Note:

1. Projects may also have a positive effect on recreational values, tourism values, and non-renewable resources (e.g., access enabled by transmission lines or access roads). These indicators do not include parks per se, as parks are included in the environmental indicator Protected and Conservation Areas (En3-2). Activities in and tourism associated with parks are discussed in evaluations where relevant.

The Tourism, Recreation, and Other Resources and Land Use indicators as defined in Table D 1-1 focus generally on whether the effect of the resource option on the indicator is positive or negative, and the relative magnitude of the effect (L/M/H). Unless otherwise explicitly noted, the evaluations of each resource option for these indicators have identified only negative effects. Figure D 5-1 provides ratings for assessing relative magnitude of effect from a resource option on each indicator, including provision

for a possible yellow (medium) magnitude effect that differs from red (high) magnitude (even for S4-6, where the indicator assumes a Yes/No or Not Applicable rating). Overall, the social evaluations tend to treat "not applicable" in the same manner as the environmental evaluations treat "no linkage."

Tourism, Recreation, and Other Resources and Land Use indicators have been evaluated based on information available from:

- **Yukon Environment:** Community-based Work Plans (for Renewable Resource Council), wildlife management plans, trapping concessions, campground locations, forestry plans;
- **Department of Tourism and Culture:** tourism information;
- **Community Websites:** Official Community Plans, Zoning by-laws, tourism and recreation information, infrastructure and services;
- **Yukon Department of Energy, Mines and Resources:** Claims information;
- **Geomatics Yukon:** Spatial data; and
- **DataBC:** Spatial data.

Summary baseline information for population centres near resource options are included in Attachment 1. Information includes population counts, applicable land use plans, infrastructure and services.

In addition to outside sources, results from other evaluations were considered. Table D 5-1 presents the other environmental, social, and economic criteria inform the evaluations in this section.

Table D 5-1: Other Criteria Considered in Evaluation of Tourism, Recreation, and Other Resource and Land Use

S4 Criteria - Indicators	Other Criteria Considered
Recreational Values (S4-1)	En1-3: Commercial, Recreational or Aboriginal Fishery Species and Habitat En3-2: Protected and Conservation Areas En3-3 Wildlife Key Areas En3-4 Caribou Ranges
Tourism Values (S4-2)	En1-3: Commercial, Recreational or Aboriginal Fishery Species and Habitat En3-2: Protected and Conservation Areas En3-3 Wildlife Key Areas En3-4 Caribou Ranges
Aesthetics (S4-3)	N/A
Non-renewable Resources (S4-4)	N/A
Other Renewable Resources (S4-5)	N/A
Land Use and Renewable Resource Plans (S4-6)	En1-3: Commercial, Recreational or Aboriginal Fishery Species and Habitat En3-2: Protected and Conservation Areas En3-3 Wildlife Key Areas En3-4 Caribou Ranges

The approach and assumptions used in evaluating potential effects on Tourism, Recreation, and Other Resources and Land Use indicators are:

- Looked for geographic overlap between resource project option sites and known recreational sites, tourist sites, mineral and oil and gas claims, designated areas in planning and resource management documents.
- Direct spatial overlap would result in at least a medium ranking because it is assumed that it could potentially result in some change in activity or desirability of engaging in the activity at that site. A red rating results if there is a potential for major change in the indicator.
- There is not necessarily a linkage related to aesthetics solely because a site is a greenfield site. The site must be visible and infrastructure must have an effect on a landscape that someone values (e.g., be visible from a viewpoint popular for wildlife viewing).
- In light of the remote location of most of the projects, the focus for recreation and tourism is on outdoor activities (e.g., hiking, fishing, camping) and it assumed that individuals engaging in these activities value undisturbed landscapes.

Limitations to the evaluation include:

- Recreational and tourism values are personal and subjective. Changes to a recreational or tourist experience because of project development may adversely affect the experience for one individual but not have an effect on another individual's experience. For evaluating changes in recreational and tourism experiences, the evaluation focuses primarily on physical proximity as assessable with desktop research, i.e., no interviews or field work was feasible.
- All projects fall within an area overseen by a Renewable Resource Council (RRC). The status of community-based fish and wildlife work plans were at different stages at the time of these evaluations and some RRCs do not complete multi-year work plans. The evaluations for Land use and Renewable Resource Plans (S4-6), therefore, incorporate plans where they are known. It is assumed that the appropriate RRC will be engaged should a given project be advanced.

5.2 EVALUATION

5.2.1 Resource Options with No Material Concerns re: Tourism, Recreation and Other Resources and Land Use

Table D 5-2 provides a summary of the resource project options with green (low) ratings for each of the tourism, recreation and other resources and land use indicators. Brief supporting information and analysis is provided in the table on the application of the Tourism, Recreation, and Other Resources and Land Use indicators to these resource options.[4]

[4] Detailed review of mapping or local plan information has not been done for these resource options. If and when a resource option is subject to more detailed feasibility and planning review, it is possible that specific issues may arise that will need to be addressed in order to proceed.

Table D 5-2: Resource Project Options with Green Ratings for All Tourism, Recreation and Other Resources & Land Use Indicators

Resource Project Options	Comments re: All Indicators being Green
Fossil Fuel Thermal (Diesel or LNG)	
Whitehorse Landfill	Brownfield site with current industrial use; zoned for public utilities.
Takhini Substation	Adjacent to brownfield site (substation). No apparent conflicts; however, planning issues must be addressed.[1]
Non-Fossil Thermal	
Waste-to-Energy (Whitehorse)	Assumed brownfield site without any conflicts.
Biogas (Whitehorse)	Brownfield site; zoned for public utilities.
Energy Storage Facility	
Takhini Substation	Adjacent to brownfield site (substation). No apparent conflicts; however, planning issues must be addressed.[1]
Solar PV	
Whitehorse	Brownfield site (abandoned mine site); zoned for heavy utilities and future planning.
Haines Junction	Semi-open site near landfill, no apparent conflict.
Wind Farms	
Cyprus Mine Hill	Brownfield site, no apparent conflicts.
Mt. Sumanik	Proximity to Whitehorse; no apparent conflicts. However, planning issues must be addressed.[2]
Tehcho (Ferry Hill)	No apparent conflicts.
Geothermal	
Vista Mountain	Near brownfield site (Takhini Substation); No apparent conflicts; however, planning issues must be addressed.[1]
Pumped Storage	
Vangorda Pit	Faro mine site (brownfield site); No apparent conflicts; however, planning issues must be addressed.[3]
Hydro Storage Enhancements	
Mayo Lake	No apparent conflicts with any indicator.
Southern Lakes	No apparent conflicts with any indicator; borders multiple development zones.[4]
Mayo Outlet Channel Dredging	No apparent conflicts with any indicator.[4]
Refurbish/ Enhance Existing Hydro	Existing generating station site; no conflicts.
Mayo A	
Aishihik re-runnering	
Transmission Corridors	BMPs/routing by highway/assume can avoid conflicts with any indicator, e.g., assume avoid potential conflict with Caribou Hotel in Carcross which is near proposed centerlines for Whitehorse-Skagway corridor.
Aishihik-Burwash[5]	
Faro – Watson Lake	
Whitehorse – Atlin	
Whitehorse – Skagway[6]	
Whitehorse – Teslin	
Stewart- Keno	

Notes:

1. Infrastructure would be located in zones of the Mayo Road Development Area Regulation (Public Use and Institutional); First Nations Land Use; and Hinterland. 2005/I75.
2. Located in Whitehorse Periphery Development Regulation (Rural Residential 2013/207).
3. Infrastructure would be located in Hinterland zoning for Town of Faro 96-06.
4. Each of these projects may result in some visible changes when mitigation or dredging is being undertaken; BMPs are assumed to address any short-term disruptions, e.g., sustained boat access to Mayo Lake during dredging activities.
5. A section of the centreline for this transmission corridor as shown in the Midgard [2016], (see Appendix A) runs through Kluane National Park; Midgard notes that there is an option between Hwy 1 and Kluane Lake, which would have at least a medium effect on Land Use and Renewable Resource Plans and/or Aesthetics. The Kluane Lake wind farm resource option (and related transmission) is assumed to be in the area between Hwy 1 and Kluane Lake.
6. The Klondike Hwy from Skagway to Whitehorse is a popular drive for its scenery and historical significance, which is the proposed route for the Whitehorse to Skagway transmission line. The highway also abuts the Tsongas National Forest in Alaska (not the Klondike Gold Rush National Historical Park as suggested in Midgard [2016]), which may have an effect on the Aesthetics.

5.2.2 Non-Hydro Renewable Generation

The following non-hydro renewable generation options have at least one of the Tourism, Recreation, and Other Resources and Land Use indicators rated yellow or red, and therefore the resource option is not included in Table D 5-2.

5.2.2.1 Non-Fossil Thermal Generation - Biomass at Haines Junction

For the purpose of this evaluation, the biomass thermal generation resource option plant at Haines Junction is assumed to be located within city limits and likely near the school to take advantage of captured school waste heating load. It would require 400m buffer zones around buildings and potentially 500m to 1,000m buffers for sensitive receptors.

The potential concern regarding this site location for the biomass plant is that it is adjacent to undeveloped land zoned for residential use and on land zoned for community use/commercial.

Table D 5-3: Summary of Assessment for Non-Fossil Thermal Generation - Biomass

Project / Option	Indicator	Ranking	Assessment
Biomass (Haines Junction)	Recreational Values	**Low**	Assuming use of location recommended in Stantec report, which is zoned community use/commercial, the project is not anticipated to overlap with recreational sites/activities. Recreational values are rated low.
	Tourism Values	**Low**	Tourism activities in Haines Junction are assumed to be focused on servicing visitors to the Kluane National Park and Reserve of Canada. While the project may be audible and visible in town, it is not anticipated to change tourist activities nor is it anticipated to overlap with any known tourist sites within town limits.
	Aesthetics	**Medium**	Assumes siting near school, which is downtown and near residential and commercial areas, therefore aesthetics is rated medium.
	Non-renewable Resources	**Low**	No overlap with mineral, placer, or quartz claims.
	Other Renewable Resources	**Low**	No known conflicts.
	Land Use and Renewable Resource Plans	**Medium**	The location recommended in the Stantec report is adjacent to undeveloped land zoned for residential use and on land zoned for community use or commercial. It is anticipated that there will need to be some zoning variance for the project and adjacent residential development will need to be altered. Located in area for Alsek Renewable Resource Council Plan but no overlap with concerns is apparent.

5.2.2.2 Wind Farms

The following wind farm options have at least one of the Tourism, Recreation, and Other Resources and Land Use criteria indicators rated yellow or red, and therefore the resource option is not included in Table D 5-2.[5] The wind farm resource option assumes a 20 MW development on each site, with 10 turbines each of which has a 90-metre rotor diameter and 80-metre height. Ratings for Tourism, Recreation, and Other Resources and Land Use criteria take into consideration potential for concerns about wind farm effects on aesthetics and recreational or tourism values related to visual and auditory effects.

[5] Wind farms at Cyprus Mine Hill, Mt. Sumanik, Tehcho (Ferry Hill) and Thulsoo Mountain are included in Table D 5-2.

Table D 5-4: Summary of Assessment for Wind Farms

Project / Option	Indicator	Ranking	Assessment
Kluane Lake (west shore)	Recreational Values	**Medium**	Changes to landscape may change enjoyment of fishing on Kluane Lake.
	Tourism Values	**Medium**	Changes to landscape may change tourism value of fishing on Kluane Lake.
	Aesthetics	**Medium**	Anticipated to be visible from Alaska Hwy and Kluane Lake. May be visible from Kluane National Park. Potential noise disturbance.
	Non-renewable Resources	**Low**	No overlap with mineral, quartz, or placer claims.
	Other Renewable Resources	**Low**	No known conflicts.
	Land Use and Renewable Resource Plans	**Low**	Located in the Beaver Creek/Burwash/Destruction Bay Annual Limit Region but does not overlap with timber harvest plans or harvest licences. Located in area for Alsek Renewable Resource Council Plan but no overlap with areas of concern is apparent.
Miller's Ridge (west of, & close to, Carmacks)	Recreational Values	**Medium**	Miller's Ridge features a hiking trail that may potentially be affected. However, the Nansen Mine Road routes immediately under and south of the ridge for the wind farm.
	Tourism Values	**Medium**	Potentially precludes part of the hiking trail on Miller's Ridge but overall tourism in and around Carmacks should not be materially altered outside of Miller's Ridge trail.
	Aesthetics	**Medium**	Visible from Hwy 2 and due to elevated position, potentially visible from Carmacks. Potential noise disturbance.
	Non-renewable Resources	**Low**	Overlaps with 12 expired quartz claims.

Project / Option	Indicator	Ranking	Assessment
	Other Renewable Resources	**Low**	No known conflicts.
	Land Use and Renewable Resource Plans	**Medium**	Located in Carmacks West Moose Management Unit, but no activity cited in RRC Work Plan. Located in the Carmacks Annual Limit Region and overlaps with two cutting permits – one for the Village of Carmacks and one for Yukon Government, Department of Highways and Public Works.
Sugarloaf Mountain (southeast of Carcross)	Recreational Values	**Low**	Potentially affects value of Brute Mountain as hiking destination because infrastructure is anticipated to be visible from top. Do not expect major change in recreational activities.
	Tourism Values	**Low**	Potentially affects value of Brute Mountain as hiking destination because infrastructure is anticipated to be visible from top. Do not expect major change in tourism activities.
	Aesthetics	**Medium**	Infrastructure anticipated to be visible from Brute Mountain, which is endpoint for hike valued for its view. Potential noise disturbance.
	Non-renewable Resources	**Low**	Does not overlap with any leases or claims.
	Other Renewable Resources	**Low**	No known conflicts.
	Land Use and Renewable Resource Plans	**Medium**	Project is located in the Carcross Local Area Plan and Carcross Development Area Regulation, with the transmission line as it approaches Carcross from the south currently overlapping with the largest variety of zones: Mixed Residential Commercial, Residential, Tourist Commercial, and Commercial (1976/231). South of Carcross, the transmission line and the northern turbines are in areas zoned as Hinterland, which is a "'catch-all' open space designation that has been applied liberally to lands with no pre-determined purpose, most Settlement Lands, as well as environmentally sensitive lands" (Inukshuk Planning and Development Ltd. 2013). Located in the Whitehorse Annual Limit Region and Whitehorse-Southern Lakes Forest Management Planning Area but does not overlap with any cutting permits or Timber Harvest Plans.
Thulsoo Mountain	Recreational Values	**Medium**	Current location of project infrastructure may make camping at Otter Falls Campground less desirable, although it may not necessarily necessitate change in activities.

Project / Option	Indicator	Ranking	Assessment
	Tourism Values	Low	Potentially affects Otter Falls Campground and is located in outfitting concession 13 but is not anticipated to materially affect tourist activities.
	Aesthetics	Medium	Project is located in relatively close proximity to Otter Falls Campground and may be visible/audible from site.
	Non-renewable Resources	Medium	Project overlaps with multiple quartz claims, although is not anticipated to require a change in activities.
	Other Renewable Resources	Low	No apparent conflicts.
	Land Use and Renewable Resource Plans	Medium	Project infrastructure overlaps with two fuel wood licences, outfitting concession 13, which is discussed in tourism, and multiple trapping concessions.

5.2.2.3 Geothermal - McArthur Springs

The McArthur Springs project is located in the Ddhaw Ghro Habitat Protection Area. While the management plan for this area is still under development, protection areas are typically created to preserve culturally or environmentally important features (Environment Yukon 2016). According to planning documents the Ddhaw Ghro mountain range has multiple regionally significant features, including unglaciated alpine areas and plant communities, a culturally important hot spring, fannin sheep population, an intact mountain ecosystem, and cultural importance to the Northern Tutchone People (ScienceBase 2006).

Table D 5-5: Summary of Assessment for Geothermal - McArthur Springs

Project / Option	Indicator	Ranking	Assessment
McArthur Springs	Recreational Values	**Medium**	Changes in aesthetics anticipated to reduce attractiveness of area for recreational activities but a new access road in difficult terrain may open up area. New access may be seen as positive (e.g., increased camping, hiking, fishing) or negative (increased hunting in an area where the local RRC is trying to protect wildlife).
	Tourism Values	**Medium**	Changes in aesthetics anticipated to reduce attractiveness of area as a tourist destination but a new access road in difficult terrain may open up area.
	Aesthetics	**High**	Located in a protected area, which has cultural significance to the Northern Tutchone People and is valued for several environmental elements. In light of this, project infrastructure (plant site, production wells, induction well, access road) and operations would alter valued visual and auditory environment.
	Non-renewable Resources	**Medium**	Location designated as mining interest for Selkirk First Nation (SFN). While a new access road in difficult terrain my open up area to new opportunities, it is unlikely that parties will be able to take advantage of opportunities in light of area's status as a protected area.
	Other Renewable Resources	**Medium**	While a new access road in difficult terrain my open up area to new opportunities, it is unlikely that parties will be able to take advantage of opportunities in light of area's status as a protected area.
	Land Use and Renewable Resource Plans	**High**	Located in Mayo District Renewable Resource Council, the Project overlaps with two areas subject to high priority activities: managing the Ethel Lake Caribou Herd and monitoring sheep populations. Located in the Pelly Crossing Annual Limit Region but does not overlap with currently active Timber Harvest Plans or Cutting Permits. Overlaps with three trapping concessions, since project is located in a proposed protected area (Ddhaw Ghro Habitat Protection Area), project is not anticipated to interfere with trapping activities.

5.2.3 Hydro Renewable Generation

The following hydro renewable generation options have at least one of the Tourism, Recreation, and Other Resources and Land Use criteria indicators rated yellow or red, and therefore the resource option is not included in Table D 5-2.

5.2.3.1 Pumped Storage

The only pumped storage option included in Table D 5-2 is Vangorda Pit. Assessment of the remaining pumped storage resource options is provided in Table D 5-6. No attempt is made to assess any variances for specific sites developed at 50 GWh versus 100 GWh storage.

Table D 5-6: Summary of Assessment for Pumped Storage (excluding Vangorda Pit)

Project / Option	Indicator	Ranking	Assessment
Atlin – Black Mountain	Recreational Values	**Low**	According to the Wóoshtin wudidaa Atlin Taku Land Use Plan), the area has high recreational value for local community, including resource gathering and recreation; however, activities are centred on Indian/Porter Lake, Steamboat Mountain, and Fourth of July Creek, which are southeast of the upper reservoir lake. Associated linear infrastructure may make the upper reservoir lake, which may contain burbot, more accessible for recreational fishing.
	Tourism Values	**Low**	Project is located in a new/proposed protected area (Indian Lk – Hitchcock Ck At Ch' according to the Wóoshtin wudidaa Atlin Taku Land Use Plan). While site is located in area, it does not appear to overlap directly with known or currently planned tourism sites/activities.
	Aesthetics	**Low**	Locations noted as valued in the At Ch'ini Sha Protected Area are not in the vicinity of the project location. The project is not anticipated to be visible/audible from known viewpoints and nearby communities. Project infrastructure, however, will cross area with a visual quality objective of preservation, but this primarily applies to forestry practices.
	Non-renewable Resources	**Medium**	Project overlaps with eight mineral claims and one placer claim.
	Other Renewable Resources	**Low**	No known conflicts.
	Land Use and Renewable Resource Plans	**High**	Project is located in a proposed protected area (Indian Lk – Hitchcock Ck according to the Wóoshtin wudidaa Atlin Taku Land Use Plan). Focus of the protected area is Indian Lake and Hitchcock Creek, not the lake being used for upper reservoir. Objectives for protected area are to protect high-value caribou winter habitat, ensure management contributes to health of caribou and sheep populations, maintain high recreational values of area. According to the environmental evaluation, the project occurs within the Atlin and Carcross Caribou herd ranges and in a Wildlife Key Area for thin horn sheep. The evaluation for commercial, recreational, and Aboriginal (CRA) fishery notes that burbot may be present in the upper reservoir lake, which is valued by recreational and aboriginal fisheries. In addition, major hydroelectric development other than local run-of-the-river projects that "supply power to approved uses in the protected areas" are prohibited. The Yukon portion of the Project is located in the Tagish Local Advisory Area, which is represented by a local advisory council. Local advisory councils advise the Minister of Community Services but do not create bylaws or collect taxes.

Project / Option	Indicator	Ranking	Assessment
Canyon – Ittlemit	Recreational Values	**High**	The project does not overlap with known/currently planned recreational activities, although the presence of lake trout in Ittlemit Lake suggests that recreational fishery may be present and Canyon Lake is included in Environment Yukon material on recreational fishing with lake trout and whitefish present. The increase of methylmercury production as a result of the volume increase in Canyon Lake may alter recreational fishing activities as consumption patterns of lake trout may need to be altered.
	Tourism Values	**Medium**	The project is located in Outfitting Concession 13, which advertises hunts for moose, wolverine, wild wood bison, black and grizzly bears, dall sheep, wolf, mountain caribou, and fishing. If outfitter uses Canyon or Ittlemit lakes for fishing activities, they may be required to temporarily use other lakes due to an increase in methylmercury production. Independent tourists may also need to temporarily use other fishing lakes for the same reason. In addition, potential changes to aesthetics along Aishihik Road (route to Otter Falls) may make area less attractive as a tourist site.
	Aesthetics	**Medium**	Project infrastructure may be visible from Aishihik Road, which leads from Canyon to Otter Falls and Aishihik Village.
	Non-renewable Resources	**Low**	No overlap with mineral, placer, or quartz claims or leases.
	Other Renewable Resources	**Low**	No known conflicts.
	Land Use and Renewable Resource Plans	**Medium**	Overlaps with two trapping concessions, although it is not anticipated to require a change in trapping activities. Project is located in the Champagne and Aishihik Traditional Territory Strategic Forest Management Plan in an area that is low priority for planning and merchantable timber (Alsek Renewable Resource Council 2004) and two fuel wood licence areas.
Lindeman – Fraser	Recreational Values	**Medium**	The Chilkoot Trail runs along the west side of Lake Lindeman. The trail is a Historic Site and is likely valued by hikers for its hiking terrain and its place in Canadian history. A limited number of permits are issued. The presence of project infrastructure may not change activities but the change in aesthetics may change the desirability of using the northern part of the trail and the campgrounds next to Lindeman Lake.
	Tourism Values	**Medium**	The Chilkoot Trail runs along the west side of Lake Lindeman and is a tourist destination. The presence of project infrastructure may not

Project / Option	Indicator	Ranking	Assessment
			change activities but the change of in aesthetics may change the desirability of using the northern part of the trail and the campgrounds next to Lindeman Lake.
	Aesthetics	**Medium**	Project infrastructure (powerhouse, transmission line, potentially penstock) would likely be visible from trail and/or two campgrounds on the west side of Lindeman Lake but is not anticipated to disrupt known views.
	Non-renewable Resources	**Low**	No overlap with mineral, placer, and coal claims and leases.
	Other Renewable Resources	**Low**	The project is not anticipated to have any effect on other renewable resources.
	Land Use and Renewable Resource Plans	**Medium**	Project is located within the Atlin Taku Land Use Plan, although there appears to be no overlap with designated zones so project neither conflicts with nor causes substantive change in activity. Project is located in Chilkoot Trail National Historic Site of Canada. While project may not alter activities, National Historic Sites are regulated by some of the subsections of the *Canada National Parks Act* regarding usage. Since protected areas are included in the environmental evaluation, this has been rated as a medium.
Racine – Moon	Recreational Values	**High**	According to the evaluation of CRA fishery, multiple species are present in Racine Lake, while no fish are present in Moon Lake. Impoundment may increase methylmercury production, which could alter fishing patters as consumption patterns may need to be changed. The dam may obstruct flows between Racine Lake and Tagish Lake may also change flows at Racine Falls, which is a recreational site.
	Tourism Values	**Medium**	In addition to being used for recreational activities, the general area is used by an outfitter for hunting and fishing, but the project is not anticipated to materially alter activities.
	Aesthetics	**Low**	Since Racine Lake and Moon Lake are removed from major waterways and not near communities, it is anticipated that the presence of the project will not be visible or audible from known viewpoints and communities.
	Non-renewable Resources	**Medium**	Project overlaps with two mineral claims.
	Other Renewable Resources	**Low**	No known conflicts.

Project / Option	Indicator	Ranking	Assessment
	Land Use and Renewable Resource Plans	**High**	The eastern part of Racine Lake, Racine Creek, and Racine Falls are part of the Racine Falls Resource Management Area, which falls within the Atlin Land Use Plan. Racine Falls is a Goal 2 area by BC's Protected Areas Strategy, which is for special features and means that it is "set aside primarily to protect rare or vulnerable features." The dam may obstruct flows between Racine Lake and Tagish Lake may also change flows at Racine Falls, which is a recreational site.
Racine – Mt. Brown	Recreational Values	**High**	According to the evaluation of CRA fishery, multiple species are present in Racine Lake, while there is no fish sampling information for the unnamed lake that would be the upper reservoir. Impoundment may increase methylmercury production, which could alter fishing patters as consumption patterns may need to be changed. The dam may obstruct flows between Racine Lake and Tagish Lake and may also change flows at Racine Falls, which is a recreational site.
	Tourism Values	**Medium**	In addition to being used for recreational activities, the general area is used by an outfitter for hunting and fishing, but the project is not anticipated to materially alter activities.
	Aesthetics	**Low**	Since Racine Lake and Mt. Brown Lake are removed from major waterways and not near communities, it is anticipated that the presence of the project will not be visible or audible from known viewpoints and communities.
	Non-renewable Resources	**Medium**	Overlaps with two mineral claims.
	Other Renewable Resources	**Low**	No known conflicts.
	Land Use and Renewable Resource Plans	**High**	The eastern part of Racine Lake, Racine Creek, and Racine Falls are part of the Racine Falls Resource Management Area, which falls within the Atlin Land Use Plan. Racine Falls is a Goal 2 area by BC's Protected Areas Strategy, which is for special features. These areas are "set aside primarily to protect rare or vulnerable features." The dam may obstruct flows between Racine Lake and Tagish Lake and may also change flows at Racine Falls, which is a recreational site.
Squanga – Dalayee	Recreational Values	**High**	Campground with boat launch is located at Squanga Lake. Fish species present in Squanga and Dalayee lakes and the stream reach between them are important to CRA fisheries. Since impoundment of both lakes could increase the production of methylmercury, the project may alter fishing practices on both lakes.
	Tourism Values	**Medium**	The presence of project infrastructure may make the area less attractive for tourism; however, the project is not likely to alter activities.

Project / Option	Indicator	Ranking	Assessment
	Aesthetics	**Medium**	Project infrastructure may be visible or audible from the Squanga Lake campgrounds, making it less attractive as a camping ground; however, the project should not alter activities.
	Non-renewable Resources	**Medium**	Overlaps with 9 expired and 27 active quartz claims.
	Other Renewable Resources	**Low**	No known conflicts.
	Land Use and Renewable Resource Plans	**Medium**	Located in the Carcross/Tagish Renewable Resource Council. Overlaps with five trapping concessions.
Moon Lake (Tutshi – Moon)	Recreational Values	**Low**	Tutshi and Tagish lakes both contain multiple fish species that are important to the CRA fisheries. According to the environmental analysis, water levels are not anticipated to change at Tutshi Lake and are therefore not expected to change at Tagish Lake. Therefore, changes in fishing practices are not anticipated to be affected.
	Tourism Values	**Low**	The general area is used by an outfitter that has infrastructure on and near Tagish Lake. The presence of the project, though, is not currently anticipated to alter outfitting activities.
	Aesthetics	**Medium**	Project infrastructure is located in an area with a Visual Quality Objective of Retention. While these guidelines apply primarily to forestry practices, the provide context for areas that are deemed "scenic." However, the project does not require a dam on Tutshi Lake.
	Non-renewable Resources	**Medium**	The Midgard report indicates mineral claims in downstream portion of project area. Project overlaps with nine claims.
	Other Renewable Resources	**Low**	The Midgard report did not indicate any other renewable resource interests that might affect the project. Tenure of a Commercial Licence to Occupy for Guide Outfitters does not preclude other licenses on the project area.
	Land Use and Renewable Resource Plans	**Medium**	The eastern arm of Tutshi Lake is in the Tutshi Lake Protected Area, which is a culturally significant area for Carcross/Tagish First Nation and is used by members. Review would likely be needed to address any interests or concerns related to the project effects in this area of Tutshi Lake.

Project / Option	Indicator	Ranking	Assessment
			The western part of Tutshi Lake is part of a Use, Recreation and Enjoyment of the Public (UREP) map reserve. A UREP is on Crown land outside of Provincial Forests to guard against unwarranted disposition or unplanned use, which (in this area) would compromise current or potential recreation values or uses. The Midgard report notes that this map reserve exists on the downstream portion of the project, but does not suggest that the project would be compromised by this map reserve. The Midgard report notes that a protected area tenure exists on the downstream portion of Tutshi Lake, which explicitly precludes development of any hydroelectric projects or any water control facility. The Midgard report notes that this protected area is outside the project area.

5.2.3.2 Small Hydro Projects

Assessment of the all small hydro resource options is provided in Table D 5-7.

Table D 5-7: Summary of Assessment for Small Hydro Projects

Project / Option	Indicator	Ranking	Assessment
Drury Lake	Recreational Values	**High**	According to environmental evaluation, project area is a known site of CRA fisheries. Any changes required to fishing activities due to increase in methylmercury production may affect recreational value of area as activities will need to change.
	Tourism Values	**High**	Drury Lake is used by a fishing outfitter for trout, northern pike, and arctic grayling fishing. If changes to fishing activities are required as a result of increased methylmercury production, the outfitter may need to temporarily halt usage of Drury Lake or limit usage to hunting expeditions. Drury Lake falls within Outfitting Concession 14, which is advertised for hunting the following animals: stone sheep, moose and caribou, and bear and wolf.
	Aesthetics	**Low**	It is not anticipated that project infrastructure will be visible from known viewpoints.
	Non-renewable Resources	**Low**	Project overlaps with four expired quartz claims.
	Other Renewable Resources	**Low**	No known conflicts.

Project / Option	Indicator	Ranking	Assessment
	Land Use and Renewable Resource Plans	**Medium**	Project is located in single trapping concession and outfitter concession. The latter is discussed under tourism values. Project is located in the Southeast Yukon Forest Management Area (draft), but not within cutting permits and timber harvest plans.
Tutshi-Windy Arm	Recreational Values	**High**	Tutshi Lake is used for fishing, boating, and camping. Impoundment may lead to an increase in methylmercury production, which could temporarily change the use of Tutshi Lake as a recreational fishing location. Changes in the water level may also affect the boating on the lake and the boat launch at the southern end of the lake.
	Tourism Values	**Low**	Tutshi Lake has several known tourism sites, including the Yukon Suspension Bridge and campgrounds; however, project infrastructure is not anticipated to overlap with sites or alter activities.
	Aesthetics	**Medium**	Project infrastructure may be visible to individuals using the lake for boating and/or fishing but is not anticipated to cause major aesthetic changes.
	Non-renewable Resources	**Low**	No overlap with mineral tenures.
	Other Renewable Resources	**Low**	No known conflicts.
	Land Use and Renewable Resource Plans	**Medium**	The eastern arm of Tutshi Lake is in the Tutshi Lake Protected Area, which is a culturally significant area for Carcross/Tagish First Nation and is used by members. Review would likely be needed to address any interests or concerns related to the project effects in this area of Tutshi Lake as control dam is currently proposed at eastern end of lake and an access road would run along the northern side of the lake. The western part of Tutshi Lake is part of Use, Recreation and Enjoyment of the Public (UREP) map reserve. A UREP is on Crown land outside of Provincial Forests to guard against unwarranted disposition or unplanned use, which (in this area) would compromise current or potential recreation values or uses. The Midgard report notes that this map reserve exists on the downstream portion of the project, but does not suggest that the project would be compromised by this map reserve.
Wolf River	Recreational Values	**Medium**	Known fish species occurring in the Wolf River (see environmental evaluation) are important to recreational fishery and the river was cited as a high-value recreation area (Teslin Strategic Forest Management Plan). Project infrastructure is not anticipated to alter recreational activities on the river.

Project / Option	Indicator	Ranking	Assessment
	Tourism Values	**Medium**	Located in Outfitter Concession 19, although according to the Yukon Outfitters Association website, no outfitter is currently associated with the concession. The Wolf River is important for river trip outfitters but project infrastructure is not anticipated to disrupt activities.
	Aesthetics	**Low**	Project infrastructure is not anticipated to be visible/audible from known viewpoints.
	Non-renewable Resources	**Low**	Project does not overlap with known mineral tenure.
	Other Renewable Resources	**Low**	No known conflicts.
	Land Use and Renewable Resource Plans	**Medium**	Located in Teslin Renewable Resource Council area. Overlaps with three single holder traplines but is not expected to alter activities. Located in the Teslin Traditional Territory Forest Resource Management Area and within two cutting permits (held by the Teslin Tlingit Council and Village of Teslin), and the Sawmill Road Demonstration Forest Timber Harvest Plan, but is not anticipated to interfere with forestry activities.
Finlayson River	Recreational Values	**High**	Finlayson Lake is a recreational fishery site with Lake Trout, Artic Grayling, Northern Pike, and Whitefish present. Since impoundment could increase methylmercury production, recreational fishing activities may also need to change. In addition, changes to downstream flows could affect fish populations, making the lake a less attractive recreational site.
	Tourism Values	**High**	The Finlayson Lake Wildlife Viewpoint is not anticipated to be affected by project infrastructure on Finlayson Lake. There is a wilderness lodge located on Frances Lake. Depending on its location, project infrastructure may be visible and have an adverse effect on its ability to attract tourists. Project is located in Outfitting Concession 20, which is used for large game hunting. In light of the proximity of project infrastructure to the highway, project is not anticipated to alter outfitting activities.
	Aesthetics	**Low**	Finlayson Lake has a wildlife viewpoint at the northern end. Project infrastructure is anticipated to be at the southern end of the lake and therefore should not alter or detract from the view.

Project / Option	Indicator	Ranking	Assessment
	Non-renewable Resources	**Medium**	Project overlaps with one active and two expired placer claims and 18 expired and 82 active quartz claims, but project is not anticipated to affect activities.
	Other Renewable Resources	**Low**	No known conflicts.
	Land Use and Renewable Resource Plans	**Medium**	Project overlaps with outfitting concession 20, which is discussed under tourism. Project overlaps with one group trapping concession and seven individual concessions. Project overlaps with an active fuel wood licence and timber resources licence, and two issued fuel wood licences. Project is located in multiple annual limit regions (Watson Lake, Carmacks, Ross River-Faro) and the Southeast Yukon Forest Management Plan (draft) but is not anticipated to affect activities.
Anvil Creek	Recreational Values	**High**	Anvil Lake is the site of a known recreational fishery and there are cabins present on the lake. Since impoundment could increase methylmercury production, recreational fishing activities may also need to change.
	Tourism Values	**Medium**	Project is located in outfitting concession 9, which is known for big game hunting at remote, fly-in locations. Project infrastructure is not anticipated to overlap with activities.
	Aesthetics	**Medium**	There are cabins present on Anvil Lake. Depending on location, project infrastructure may be visible.
	Non-renewable Resources	**Medium**	Project overlaps with 22 quartz claims, but project is not anticipated to affect activities.
	Other Renewable Resources	**Low**	No known conflicts.
	Land Use and Renewable Resources	**Medium**	Project overlaps with outfitting concession 9, which is discussed under tourism. Project overlaps with one group trapping concession. Project is located in Ross River-Faro annual limit region and the Draft Faro Area of Interest and the Southeast Yukon Forest Management Plan (draft) but is not anticipated to affect activities.

Project / Option	Indicator	Ranking	Assessment
Atlin-Pine Creek (Surprise Lake)	Recreational Values	**High**	At the southwest end of Surprise Lake is a maintained recreation site, including campsites and boat launch. Project infrastructure, depending on the placement of the powerhouse, may affect the use of the campsite and boat launch and may affect the desirability of using the site. There are several trails/recreation sites along Pine Creek, which infrastructure may affect as well.
	Tourism Values	**High**	Changes to recreational values may have an adverse effect on tourism values at the same site, changing the desirability of visiting these sites and activities in the area.
	Aesthetics	**High**	Project infrastructure could be visible and/or audible.
	Non-renewable Resources	**High**	Project overlaps with 10 placer leases, and 109 claims (placer and mineral combined).
	Other Renewable Resources	**Low**	No overlaps anticipated.
	Land Use and Renewable Resource Plans	**Low**	Project located in the Atlin Taku Land Use Plan but does not appear to overlap with any designated zones.

5.2.3.3 Gladstone Diversion

The Gladstone Diversion resource option would divert water from the headwaters of Gladstone Creek into Isaac Creek, which flows into Sekulmun Lake and then Aishihik Lake.

Past studies by Yukon Energy of this resource option identified potential adverse effects to fish and fish habitat related to potential pathogen transfer (from diversion of waters from one watershed into another) as well as loss of Arctic Grayling spawning and rearing habitat in streams between the lakes and in Gladstone Creek.

As reviewed in Section 4.3 of Appendix A, past work by YEC has indicated concerns from the Department of Fisheries and Oceans (DFO) as well as from local First Nations. YEC reported that the results of a full year of baseline studies provided no evidence to support a concern regarding interbasin pathogen transfer. YEC has continued to work with local First Nations to seek support for this project.

Table D 5-8 provides a summary assessment of the project effects Tourism, Recreation and Other Resources and Land Use:

Table D 5-8: Summary of Assessment for Gladstone Diversion

Project / Option	Indicator	Ranking	Assessment
Gladstone Diversion	Recreational Values	**Medium**	Known fish species occurring in the project area (see environmental evaluation) are important to recreational fishery and could be affected by project development.
	Tourism Values	**Low**	Project is predominantly in outfitting concession 12, which is relatively small, with the eastern most reach of the project in outfitting concession 13. Project development is not anticipated to change outfitting activities or affect other tourist activities.
	Aesthetics	**Medium**	The project occurs within the traditional territory of three First Nations: Champagne and Aishihik First Nations, Kluane First Nation, and White River First Nation. There is a potential for project to be visible and/or audible from viewpoints valued by First Nations.
	Non-renewable Resources	**Medium**	Project overlaps with placer leases, placer claims, and quartz claims.
	Other Renewable Resources	**Low**	No overlaps anticipated.
	Land Use and Renewable Resource Plans	**Medium**	Project overlaps with Champagne and Aishihik FRMP but does not appear to overlap with areas of concern. Overlaps with two timber harvest licences. Overlaps with four single trapping concessions. Project's overlap with outfitting concessions discussed in tourism.

6.0 CULTURAL AND COMMUNITY WELL-BEING

6.1 RATING CRITERIA AND DATA SOURCES FOR S5: CULTURAL AND COMMUNITY WELL-BEING

The rating system outlined in Figure D 6-1 was adopted to guide evaluations of each resource project evaluation for each of the cultural and community well-being indicators.

Figure D 6-1: Summary of Rating Criteria for Cultural and Community Well-Being

Indicator	Low	Medium	High
Infrastructure and Services (S5-1)	Minimal stress to infrastructure and services[1]	Moderate stress to infrastructure and services (Does not require added management)	Material stress to infrastructure and services (Requires added management)
Public Safety, Worker Interaction, Human and Community Health (S5-2)	Minimal risk re: human and community health	Moderate risk re: human and community health	Material risk re: human and community health
Community, First Nation, and Personal Development (S5-3) [Positive effects - no colour]	Minimal development opportunity [Low Positive]	Moderate development opportunity [Medium Positive]	Material development opportunity [High Positive]

Note:
1. Projects may also have a positive effect on cultural and community well-being.

The cultural and community well-being indicators as defined in Table D 1-1 focus generally on whether the effect of the resource option on the indicator is positive or negative (Public Safety, Worker Interaction and Community Health [S5-2] only looks at the risk of negative effects) and the relative magnitude of the effect (L/M/H). Unless otherwise explicitly noted (e.g., S5-3 evaluates positive effects), the evaluations of each resource option for these indicators have identified only negative effects. Table D 6-1 provides ratings for assessing relative magnitude of effect from a resource option on each indicator, including the provision for a possible medium magnitude effect that differs from high magnitude. Each resource option tends to have some effect on each of these indicators.

Summary baseline information for population centres near resource options is included in Attachment 1. Information includes population counts, applicable land use plans, infrastructure and services.

In addition to outside sources, results from other evaluations were considered. Table D 6-1 presents the issues and other criteria considered for the S5 criteria evaluations in this section. Based on the rating system, assessments focused on risks, rather than benefits, related to the magnitude of project effects (i.e., larger and longer absolute effects in this instance receive higher ratings) relative to local community infrastructure, services, workforces, lifestyle, culture and values.

Table D 6-1: Issues and Other Criteria Considered in Evaluation of Cultural and Community Well-Being

S5 Criteria – Indicators	Considerations
Infrastructure & Services	Stress on infrastructure and services in existing communities from project and project workforce during construction and operation, including roads/highways, police, health, waste facilities, water supply, accommodations (overlap with public safety and worker interaction). A proxy metric for evaluating resource option effects on this indicator is capital spending and activities in Yukon estimates and operation work force and activities. There is also a potential also for positive effects (if project provides new infrastructure, access, services). Other indicators considered include: • En1-3: Commercial, Recreational or Aboriginal Fishery Species and Habitat; • En2-1: Consumptive Water Use; • Ec1-1: Yukon Opportunities During Construction; and • Ec1-2: Yukon Opportunities during Operation.
Public Safety, Worker Interaction, Human and Community Health	The evaluation of this indicator considers risks to public safety and worker interaction during construction and operation can be affected by size of project workforces, composition of workforce (i.e., local/non-local), size of near-by communities (There is overlap with the same metrics needed for infrastructure and services). Risks to human and community health include: direct effects during construction and operation on country foods, quality of air and/or water, and community safety. Other indicators considered include: • En1-3: Commercial, Recreational or Aboriginal Fishery Species and Habitat; • En5-2: Other Air Pollutants; • S2-5: Country Foods; • Ec1-1: Yukon Opportunities During Construction; and • Ec1-2: Yukon Opportunities during Operation.
Community, First Nation and Personal Development	The evaluation of this indicator focuses on potential for positive effects (if project provides opportunities for training, development, First Nation development agreements, etc.). It also considers risks to traditional lifestyle, values, culture (including traditional lifestyle), as well as effects on local jobs, business, training and development. Other indicators considered in this evaluation include: • S1-1: Settlement Lands, Interim Protected Lands; • S2-2: Land area loss re Traditional Lifestyle; • S2-5: Country Foods; • S3: Heritage Resource Potential; • S4-3: Aesthetics; • Ec1-1: Yukon Opportunities During Construction; and • Ec1-2: Yukon Opportunities during Operation.

Assessments focused on the risks related to the magnitude of project effects, including the amount of management likely needed to address stresses and risks, as well as specific development opportunities to be managed. Smaller projects and projects in certain locations (e.g., major centres and/or remote locations) tended to be of no material concern for the cultural and community well-being indicators, given the scale of the project construction[6] relative to the scale of potentially affected community infrastructure and services, worker interaction, and overall public safety. Projects with potentially large labour requirements near smaller and/or remote communities, especially those with multi-year construction periods, are expected to present more risks to local community infrastructure and services, lifestyle, culture and values. In contrast, projects near Whitehorse are anticipated to present no material concerns regarding cultural and community well-being indicators because Whitehorse is large enough to absorb a temporary, non-local workforce up to a certain size in terms of infrastructure, services and amenities.

In contrast to construction phase activities, operation phase activities are expected in all instances to have minimal effects on infrastructure and services, worker interaction and public safety.[7] Table D 6-2 summarizes the assessment with regard to indicator S5-1.

With regard to human and community health effects, the evaluation also focused on direct effects during operation on country foods, quality of air and/or water, and (if any issue) community safety. Overall, air and water related effects on health are expected to be minimal from construction and operation of resource options due to BMPs requirements and restrictions. In contrast, human and community health effects from limitations on use of country food (due to methylmercury effects on fish or other factors) are a specific concern that could require added management activity. Table D 6-3 summarizes the assessment with regard to indicator S5-2.

Community, First Nation and Personal Development effects consider all of the available information. Table D 6-4 summarizes the assessment with regard to Community, First Nation and Personal Development (S5-3), relying on Table E 2-3 from Appendix E, which summarizes community and other development opportunities for each resource option and provides the same evaluations for each resource option.

[6] Determination of resource options scale relied on the economic evaluations in Appendix E, and in particular Table E 2-1, Local Economic Impact: Yukon Opportunities during Construction. The larger a project's capital cost and impact on Yukon's gross domestic product (GDP), the larger in scale it is assumed to be.

[7] Table E 2-2 in Appendix E reviews information on expected non-fuel operating costs and jobs related to each resource option.

Table D 6-2: Cultural and Community Well-Being: Infrastructure and Services

	Magnitude of Project (Capex $million)	Percent of Capex ex. Major Equipment	Proximity to Communities	Duration of Construction	GDP impacts in Yukon - Jobs	Comments	Low	Medium	High
Fossil Thermal									
Diesel: 20 MW - Whitehorse	62	71%	Whitehorse	1-2 years	192	Minimal risks	■		
Diesel: 20 MW - Takhini	62	71%	Whitehorse	1-2 years	192	Minimal risks	■		
LNG: 20 MW - Whitehorse	100	60%	Whitehorse	1-2 years	257	Minimal risks	■		
LNG: 20 MW - Takhini	100	60%	Whitehorse	1-2 years	257	Minimal risks	■		
Non-Fossil Thermal									
Waste to Energy	35	26%	Whitehorse	1-2 years	38	Minimal risks	■		
Biogas (CHP)	7	74%	Haines Junction	1 year	21	Minimal risks	■		
Biomass 0.5 MW Boiler / Steam Turbine	11	73%	Whitehorse	1-2 years	34	Minimal risks	■		
Other Non-Hydro Renewable									
Storage Battery: 8 MW/40 MWh (lithium ion, 5hrs)	49	3%	Whitehorse	na	7	Minimal risks	■		
Solar PV: Whitehorse Fixed Tilt: 10 MW	36	27%	Whitehorse	36 weeks	40	Minimal risks	■		
Solar PV: Haines Junction Fixed Tilt: 5 MW	13	38%	Haines Junction	36 weeks	20	Minimal risks	■		
Wind: Cyprus Mine Hill, 20 MW	69	65%	Faro	2 years	186	Moderate risk during construction		■	
Wind: Kluane Lake, 20 MW	62	61%	Haines Junction	3 years	157			■	
Wind: Millers Ridge, 20 MW	73	67%	Carmacks	4 years	203			■	
Wind: Mt. Sumanik , 20 MW	64	62%	Whitehorse	5 years	166	Minimal risks	■		
Wind: Sugarloaf Mountain, 20 MW	62	61%	SE of Carcross	6 years	157	Moderate risk during construction		■	
Wind: Tehcho (Ferry Hill), 20 MW	64	62%	Stewart Crossing	7 years	166			■	
Wind: Thulsoo Mountain, 20 MW	72	67%	Canyon Creek and Champagne	8 years	199			■	
Geothermal: McArthur Springs (3.8 MW Av.)	121	95%	Pelly Crossing & Stewart Crossing	2.5 years	473	Moderate risk during construction		■	
Geothermal: Vista Mountain (1.6 MW Av.)	42	90%	Whitehorse	2 years	155	Minimal risks	■		
Hydro Generation									
Pumped Storage: Moon Lake (Tutshi-Moon)	218	94%	27 km from Carcross	4 years	878	Material risks during construction			■
Pumped Storage: Racine - Moon	473	53%	27 km from Carcross	4 years	1084				■
Pumped Storage: Lindeman-Fraser	484	72%	Fraser, BC - close	4 years	1509				■
Pumped Storage: Racine - Mt. Brown	284	78%	remote - 27 km from Carcross	4 years	956				■
Pumped Storage: Racine - Mt. Brown	486	81%	remote - 27 km from Carcross	4 years	1698				■
Pumped Storage: Atlin - Black Mountain	254	76%	42 km Atlin; 51 km Jake's Corner	4 years	831				■
Pumped Storage: Atlin - Black Mountain	464	82%	42 km Atlin; 51 km Jake's Corner	4 years	1649				■
Pumped Storage: Squanga - Dalayee	613	76%	Jake's Corner - close	4 years	2017				■
Pumped Storage: Canyon - Ittlemit	691	90%	Canyon Creek and Champagne	4 years	2686				■
Pumped Storage: Vangorda Pit	524	78%	Faro - close	4 years	1764				■
Small Hydro: Drury Lake	103	41%	between Faro and Little Salmon	3 years	182	Material risks during construction			■
Small Hydro: Tutshi - Windy Arm	133	45%	27 km from Carcross	3 years	259				■
Small Hydro: Wolf River	234	52%	Teslin 23 km	3 years	522				■
Small Hydro: Finlayson River	283	74%	128 km Ross River; 188 km Faro	3 years	897				■
Small Hydro: Anvil Creek	116	43%	Faro - close	3 years	286				■
Small Hydro: Atlin/Pine Creek	80	83%	Atlin - close	3 years	286				■
Other Hydro: Gladstone Diversion	40	80%	Destruction Bay	2 years	138	Moderate risk during construction		■	
Other Hydro: Southern Lakes Storage	11	90%	Mayo	na	41	Minimal risks	■		
Other Hydro: Mayo Lake Storage	approx 5	90%	Mayo	no construction	19	Minimal risks	■		
Other Hydro: Mayo Dredging	approx 15	50%	Mayo	1 season	32	Minimal risks	■		
Aishihik Re-runnering	5	50%	Canyon Creek & Champagne	na	10	Minimal risks	■		
Mayo A Refurbishment	27	50%	Mayo - close	na	59	Minimal risks	■		
Transmission Corridors									
Transmission: Whitehorse - Atlin (138 kV)	158	80%	each line runs by multiple communities	1-2 years	545	Minimal risks due to BMPs (e.g., accommodation plans), mobile nature of the construction workforce with short time period in any area)	■		
Transmission: Whitehorse - Skagway (230 kV)	251	80%		1-2 years	866		■		
Transmission: Whitehorse - Teslin (138 kV)	165	80%		1-2 years	569		■		
Transmission: Faro - Watson Lake (230 kV)	597	80%		1-2 years	2060		■		
Transmission: Aishihik - Destruction Bay (230 kV)	241	80%		1-2 years	832		■		
Transmission: Stewart-Keno City (138 kV & substations)	86	80%		1-2 years	291		■		

1. Capex, percentage of Capex not major equipment, and GDP Yukon job estimates from Appendix E, Table E2-1.

Table D 6-3: Cultural and Community Well-Being: Public Safety, Worker Interaction, Human and Community Health

	Project Magnitude during Construction [Appendix E, Table E2-1]		Proximity to Community	Comments	Evaluation		
	Construction cost ($million)	GDP impacts in Yukon - Jobs			Low	Medium	High
Fossil Thermal							
Diesel: 20 MW - Whitehorse	62	192	Whitehorse	Minimal risks			
Diesel: 20 MW - Takhini	62	192	Whitehorse	Minimal risks			
LNG: 20 MW - Whitehorse	100	257	Whitehorse	Minimal risks			
LNG: 20 MW - Takhini	100	257	Whitehorse	Minimal risks			
Non-Fossil Thermal							
Waste to Energy	35	38	Whitehorse	Minimal risks			
Biogas (CHP)	7	21	Haines Junction	Minimal risks			
Biomass 0.5 MW Boiler / Steam Turbine	11	34	Whitehorse	Minimal risks			
Other Non-Hydro Renewable							
Storage Battery: 8 MW/40 MWh (lithium ion, 5hrs)	49	7	Whitehorse	Minimal risks			
Solar PV: Whitehorse Fixed Tilt: 10 MW	36	40	Whitehorse	Minimal risks			
Solar PV: Haines Junction Fixed Tilt: 5 MW	13	20	Haines Junction	Minimal risks			
Wind: Cyprus Mine Hill, 20 MW	69	186	Faro	Moderate risk during construction			
Wind: Kluane Lake, 20 MW	62	157	Haines Junction				
Wind: Millers Ridge, 20 MW	73	203	Carmacks				
Wind: Mt. Sumanik , 20 MW	64	166	Whitehorse	Minimal risks			
Wind: Sugarloaf Mountain, 20 MW	62	157	SE of Carcross	Moderate risk during construction			
Wind: Tehcho (Ferry Hill), 20 MW	64	166	Stewart Crossing				
Wind: Thulsoo Mountain, 20 MW	72	199	Canyon Creek and Champagne				
Geothermal: McArthur Springs (3.8 MW Av.)	121	473	Pelly Crossing & Stewart Crossing	Moderate risk during construction			
Geothermal: Vista Mountain (1.6 MW Av.)	42	155	Whitehorse	Minimal risks			
Hydro Generation							
Pumped Storage: Moon Lake (Tutshi-Moon)	218	878	27 km from Carcross	Material risks during construction			
Pumped Storage: Racine - Moon	473	1,084					
Pumped Storage: Lindeman-Fraser	484	1,509	Fraser, BC - close	Material risks during construction; risk of methylmercury effects on fishery during operation could require added management			
Pumped Storage: Racine - Mt. Brown	284	956	remote - 27 km from Carcross				
Pumped Storage: Racine - Mt. Brown	486	1,698					
Pumped Storage: Atlin - Black Mountain	254	831	42 km Atlin; 51 km Jake's Corner				
Pumped Storage: Atlin - Black Mountain	464	1,649					
Pumped Storage: Squanga - Dalayee	613	2,017	Jake's Corner - close				
Pumped Storage: Canyon - Ittlemit	691	2,686	Canyon Creek and Champagne				
Pumped Storage: Vangorda Pit	524	1,764	Faro - close	Material risks during construction			
Small Hydro: Drury Lake	103	182	between Faro and Little Salmon	Material risks during construction; risk of methylmercury effects on fishery during operation could require added management			
Small Hydro: Tutshi - Windy Arm	133	259	27 km from Carcross				
Small Hydro: Wolf River	234	522	Teslin 23 km				
Small Hydro: Finlayson River	283	897	128 km Ross River; 188 km Faro				
Small Hydro: Anvil Creek	116	286	Faro - close				
Small Hydro: Atlin/Pine Creek	80	286	Atlin - close	Material risks during construction			
Other Hydro: Gladstone Diversion	40	138	Destruction Bay	Moderate risk during construction			
Other Hydro: Southern Lakes Storage	11	41	Mayo	Minimal risks			
Other Hydro: Mayo Lake Storage	approx 5	19	Mayo	Minimal risks			
Other Hydro: Mayo Dredging	approx 15	32	Mayo	Minimal risks			
Aishihik Re-runnering	5	10	Canyon Creek & Champagne	Minimal risks			
Mayo A Refurbishment	27	59	Mayo - close	Minimal risks			
Transmission Corridors							
Transmission: Whitehorse - Atlin (138 kV)	158	545	each line runs by multiple communities	Minimal risks due to BMPs (e.g., accommodation plans), mobile nature of the construction workforce with short time period in any area)			
Transmission: Whitehorse - Skagway (230 kV)	251	866					
Transmission: Whitehorse - Teslin (138 kV)	165	569					
Transmission: Faro - Watson Lake (230 kV)	597	2,060					
Transmission: Aishihik - Destruction Bay (230 kV)	241	832					
Transmission: Stewart-Keno City (138 kV & substations)	80	291					

Notes:

1. Methods and sources for Construction Costs excluding major equipment and jobs are discussed in Appendix E.

Table D 6-4: Cultural & Community Well-Being: Community, First Nation & Personal Development

	Project Size (Capex $million)	Notes re Community & Economic Development Opportunity (from Appendix E, Table E2-3)	Low Positive	Medium Positive	High Positive
Fossil Thermal					
Diesel: 20 MW - Whitehorse	62	No specific local development opportunties.	Low positive		
LNG: 20 MW - Whitehorse	100	Local opportunity to facilitate LNG use to displace other fossil fuel use in Whitehorse/Yukon.		Medium positive	
Non-Fossil Thermal					
Waste to Energy	35	Local opportunity to use renewable and (except for biogas) to supply waste heat to displace fossil fuel use. High operating jobs for Waste to Energy.		Medium positive	
Biogas (CHP)	7			Medium positive	
Biomass 0.5 MW Boiler / Steam Turbine	11			Medium positive	
Other Non-Hydro Renewable					
Storage Battery: 8 MW/40 MWh (lithium ion, 5hrs)	49	Minimal direct local development impact. Might facilitate solar or wind.	Low positive		
Solar PV: Whitehorse Fixed Tilt: 10 MW	36	Minimal direct local development impact.	Low positive		
Solar PV: Haines Junction Fixed Tilt: 5 MW	13		Low positive		
Wind: Cyprus Mine Hill, 20 MW	69	Moderate local economic development impacts from operations (ex. Mt Sumanik). Proposed Kluane & Sugarloaf Mountain sites are on aboriginal traditional land and assume land lease payments to the local FN; Kluane Lake option also facilitates development of an Aishihik-Destruction Bay Transmission Corridor.		Medium positive	
Wind: Kluane Lake, 20 MW	62				High positive
Wind: Millers Ridge, 20 MW	73			Medium positive	
Wind: Mt. Sumanik , 20 MW	64		Low positive		
Wind: Sugarloaf Mountain, 20 MW	62				High positive
Wind: Tehcho (Ferry Hill), 20 MW	64			Medium positive	
Wind: Thulsoo Mountain, 20 MW	72			Medium positive	
Geothermal: McArthur Springs (3.8 MW Av.)	121	Moderate local economic development impacts from operations (new access road).		Medium positive	
Geothermal: Vista Mountain (1.6 MW Av.)	42	Minimal local economic development impact	Low positive		
Hydro Generation					
Pumped Storage: Moon Lake (Tutshi-Moon)	218	Moderate local economic development impact based on Opex levels. In addition, options other than Squana Delayee, Canyon Ittlemit & Vangorda Pit each facilitate development of a portion of a Transmission Corridor resource option. The Vangorda Pit option may facilitate development of the Grizzly Pit mine deposit.			High positive
Pumped Storage: Racine - Moon	473				High positive
Pumped Storage: Lindeman-Fraser	484				High positive
Pumped Storage: Racine - Mt. Brown	284				High positive
Pumped Storage: Atlin - Black Mountain	254				High positive
Pumped Storage: Squanga - Dalayee	613			Medium positive	
Pumped Storage: Canyon - Ittlemit	691			Medium positive	
Pumped Storage: Vangorda Pit	524			Medium positive	
Small Hydro: Drury Lake	103	Moderate local economic development impact based on Opex level. All options other than Drury Lake and Anvil Creek also facilitate development of a Transmission Corridor (Tutshi-Windy Arm requires portion of Whitehorse-Skagway line, Wolf River and Atlin/Pine Creek facilitate Whitehorse-Atlin line, and Finlayson needs line extending from Faro toward Watson Lake).		Medium positive	
Small Hydro: Tutshi - Windy Arm	133				High positive
Small Hydro: Wolf River	234				High positive
Small Hydro: Finlayson River	283				High positive
Small Hydro: Anvil Creek	116			Medium positive	
Small Hydro: Atlin/Pine Creek	80				High positive
Other Hydro: Gladstone Diversion	40	Minimal local economic development impact; facilitate local First Nation income benefits.			High positive
Other Hydro: Southern Lakes Storage	11	Minimal local economic development impact	Low positive		
Other Hydro: Mayo Lake Storage	approx 5		Low positive		
Other Hydro: Mayo Dredging	approx 15		Low positive		
Aishihik Re-runnering	5	Minimal local economic development impact	Low positive		
Mayo A Refurbishment	27		Low positive		
Transmission Corridors					
Transmission: Whitehorse - Atlin (138 kV)	158	Moderate potential local economic development impact if stimulates small hydro (in Atlin and Teslin areas, or in Moon-Tutshi area); and if (for Whitehorse-Skagway corridor) stimulates sales of summer hydro or wind generation (to cruise ships).		Medium positive	
Transmission: Whitehorse - Skagway (230 kV)	251			Medium positive	
Transmission: Whitehorse - Teslin (138 kV)	165			Medium positive	
Transmission: Faro - Watson Lake (230 kV)	597	Material potential local economic development impacts (displace diesel generation in local communities with hydro, benefits to local businesses and population, opportunity to facilitate new mining and hydro or wind developments).			High positive
Transmission: Aishihik - Destruction Bay (230 kV)	241				High positive
Transmission: Stewart-Keno City (138 kV & substations)	80	Material local economic development impact by replacing end of life line, retains access to hydro generation, facilitates expanded capability for new mine developments in this region.			High positive

1. Capex from Appendix E, Table E2-1.

6.2 EVALUATION

6.2.1 Resource Options with No Material Concerns re: Cultural and Community Well-Being

Table D 6-5 provides a summary of the resource project options with low ratings for each of the cultural and community well-being indicators. Brief supporting information and analysis is provided in the table on the application of the S5 criteria indicators to these resource options.[8]

Table D 6-5: Resource Project Options with No Material Concerns

Resource Project Options	Comments re: All Indicators being Low
Fossil Fuel Thermal (Diesel)	
Whitehorse Landfill	In Whitehorse at a brownfield site with current industrial use; relative magnitude of project is anticipated to be low to medium.
Takhini Substation	Near Whitehorse and adjacent to brownfield site (substation); relative magnitude of project is anticipated to be low.
Energy Storage Facility	
Takhini Substation	Near Whitehorse and adjacent to brownfield site (substation); relative magnitude of project is anticipated to be low.
Solar PV	
Whitehorse	Brownfield site (abandoned mine site); zoned for heavy utilities and future planning. Construction anticipated to last less than a year (low).
Haines Junction	Near Haines Junction landfill. Construction anticipated to last less than a year (low).
Wind Farms	
Mt. Sumanik	Proximity to Whitehorse; no apparent conflicts.
Geothermal	
Vista Mountain	Proximity to Whitehorse; no apparent conflicts.
Hydro Storage Enhancements	
Mayo Lake	No apparent conflicts with any indicator.
Southern Lakes	No apparent conflicts with any indicator.
Mayo Outlet Channel Dredging	No apparent conflicts with any indicator.
Refurbish / Enhance Existing Hydro	
Mayo A	Existing generating station site; no conflicts.
Aishihik re-runnering	Existing generating station site; no conflicts.

6.2.2 Fossil Thermal - LNG

The LNG fossil thermal resource option is rated low (green) with regard to Infrastructure and Services, as well as Public Safety, Worker Interaction, Human and Community Health.

[8] Detailed review of mapping or local plan information has not been done for these resource options. If and when a resource option is subject to more detailed feasibility and planning review, it is possible that specific issues may arise that will need to be addressed in order to proceed.

The LNG fossil thermal resource option is rated medium positive with regard to Community, First Nation and Personal Development to reflect local opportunity to facilitate LNG use to displace other fossil fuel use in Whitehorse/Yukon.

6.2.3 Non-Hydro Renewable Generation

6.2.3.1 Non-Fossil Thermal

Waste-to-energy, biogas and biomass resource options are each rated green (low) with regard to Infrastructure and Services, as well as Public Safety, Worker Interaction, Human and Community Health. Waste-to-energy would provide relatively high level of operating jobs.

These three non-fossil thermal resource options are each rated medium positive with regard to Community, First Nation and Personal Development to reflect local opportunity to use renewable and (except for biogas) to supply waste heat to displace fossil fuel use. Waste-to-energy would provide a relatively high level of operating jobs.

6.2.3.2 Wind Farms

Wind projects located near communities other than Whitehorse, which is all of them excluding Mt. Sumanik, are categorized as either medium or high for the Cultural and Community Health and Well-being indicators because of their relative scale compared to neighbouring communities and the amount of management likely required to minimize potential adverse effects and, in the case of Community, First Nation and Personal Development, enhance positive effects.

The Kluane Lake and Sugarloaf Mountain wind farm resource options are rated high positive for Community, First Nation and Personal Development to reflect opportunities for First Nation lease revenues for two sites (Kluane Lake and Sugarloaf Mountain) and the opportunity to develop the new transmission corridor for the Kluane Lake site, which would allow Destruction Bay and likely Burwash Landing to stop relying on diesel generation.

6.2.3.3 Geothermal - McArthur Springs

The McArthur Springs geothermal resource option has a medium rating for each of the three Cultural and Community Health and Well-being indicators, reflecting the magnitude of its capital expenditures (Capex) and operating expenditures (Opex) costs, as well as any local development opportunities (positive effects) facilitated by the new access road that this option provides to the area.

6.2.4 Hydro Renewable Generation

6.2.4.1 Pumped Storage

Each of the pumped storage resource options has a red (high) rating for Infrastructure and Services effects during construction, reflecting the Capex cost levels (which are generally higher than the levels for all other resource options considered in the current Yukon Energy resource planning). Table D6-2 does not include the Capex costs needed to connect most of these sites (i.e., all sites other than Canyon-

Ittlemit and Vangorda Pit) to the existing grid, and therefore understates the actual construction requirements needed for development of most sites.

Each of the pumped storage resource options has a red (high) rating for Public Safety, Worker Interaction, Human and Community Health, reflecting material risks during construction and (for all options other than Moon Lake [Tutshi-Moon] and Vangorda Pit) the risk of methylmercury effects on fisheries during operation that could require added management.

The Squanga-Dalayee, Canyon-Ittlemit and Vangorda Pit pumped storage options each has a medium positive rating for Community, First Nation and Personal Development, reflecting the expectation that these options will provide moderate local or community development opportunities based on Opex levels. Each of the other pumped storage options has a high positive rating for this indicator, reflecting the opportunity to develop one of the transmission corridor resource options (e.g., Whitehorse-Skagway or Whitehorse-Atlin), and in the case of Tushi-Moon option, to facilitate other small hydro development at Tutshi-Windy Arm.

6.2.4.2 Small Hydro Projects

Each of the small hydro resource options other than Drury Lake and Anvil Creek has a high rating for each of the three Cultural and Community Health and Well-being indicators, reflecting material risks during construction, the risk of methylmercury effects on fisheries during operation that could require added management (this risk does not apply to Atlin/Pine Creek option), and the positive effects opportunity (except for the Drury Lake and Anvil Creek options) to develop one of the transmission corridor resource options (e.g., Whitehorse-Skagway, Whitehorse-Atlin, or Faro-Watson Lake).

Drury Lake and Anvil Creek small hydro have a high (red) rating for each of these indicators other than for Community, First Nation and Personal Development. For this last indicator, Drury Lake and Anvil Creek have a medium positive rating to reflect the moderate level of local development based on the level of Opex spending.

6.2.4.3 Other Hydro - Gladstone Diversion

The Gladstone Diversion resource option has a yellow (medium) rating for Infrastructure and Services, as well as for Public Safety, Worker Interaction, Human and Community Health to reflect moderate risk during construction.

The Gladstone Diversion resource option has a high positive rating for Community, First Nation and Personal Development, reflecting the opportunity to facilitate local First Nation income benefits.

6.2.5 Transmission Corridor Options

Each of the transmission corridor options has a low (green) rating for Infrastructure and Services, as well as for Public Safety, Worker Interaction, Human and Community Health to reflect moderate risk during construction. This reflects minimal risks during construction and operation.

Faro-Watson Lake, Aishihik-Destruction Bay and Stewart-Keno City transmission corridor options are each rated high positive for Community, First Nation and Personal Development, reflecting opportunities to

displace local diesel (or sustain existing transmission capability to do this, as in the case of the Stewart-Keno City option), as well as to facilitate new mining and renewable generation (hydro or wind) development. The three remaining transmission corridor options (Whitehorse-Atlin, Whitehorse-Skagway, and Whitehorse-Teslin) are each rated medium positive for Community, First Nation and Personal Development, reflecting potential local development effects if they facilitate renewable generation (pumped storage or small hydro) and, in the case of the Skagway connection, the sale of summer renewable generation (hydro or wind) to cruise ships.

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ATTACHMENT 1:

Baseline Information for S4 and S5 Indicators

Table D A1-1: Baseline Information for Whitehorse, Yukon

Projects	Waste-to-energy, biogas, solar generation, Vista Mountain Geothermal, Sumanik Wind Farm, Diesel Plant, LNG Facility, energy storage facility.
Population	29,057
Traditional Territory	Kwanlin Dun and Ta'an Kwach'an traditional territories.
Available Recreation Activities	Standard suite of recreational activities available, outdoor activities include skiing at Mt. Sima. Facilities include Canada Games Centre, arena, recreation centre, multiple parks, trail network.
Tourist Activities	Standard suite of tourist activities.
Applicable Land Use Plans	Whitehorse Official Community Plan; Whitehorse and Southern Lakes Forest Resources Management Plan; Mayo Street Development Area; Whitehorse Periphery Development Area; Laberge Renewable Resource Council.
Community Infrastructure and Services	Multiple primary and secondary schools, Yukon College, library services, daycare, RCMP detachment, professional fire department, emergency medical services, hospital, health centre, both First Nations offer health and social services, dental services, hearing services, landfill, water and wastewater services.

Table D A1-2: Baseline Information for Haines Junction, Yukon

Projects	Biomass, solar generation, Kluane Lake Wind Farm[1], Thulsoo Mountain Wind Farm, Canyon-Ittlemit Pumped Storage.
Population	896
Traditional Territory	Champagne-Aishihik.
Available Recreation Activities	Hiking, camping, and fishing, trail network, recreation complex with indoor ice arena, summer pool, curling link, community hall.
Tourist Activities	Hiking, camping, and fishing; Kluane National Park.
Applicable Land Use Plans	Beaver Creek/Burwash/Destruction Bay FRMPA, Haines Junction Official Community Plan.
Community Infrastructure and Services	K-12 school, Yukon College campus, library services, RCMP detachment, volunteer fire service, emergency medical services, health centre, dental services, Champagne and Aishishik First Nations Health and Social Services, landfill, water and wastewater services, recycling.

Note:
1. Kluane Lake Wind Farm is located in Kluane First Nation traditional territory.

Table D A1-3: Baseline Information for Carmacks, Yukon

Projects	Miller's Ridge Wind Farm.
Population (includes surrounding area, including Marsh Creek)	548
Traditional Territory	Little Salmon/Carmacks First Nation.
Available Recreation Activities	Community recreation complex (with pool), mountain biking, cross-country skiing, snowmobile hiking.
Tourist Activities	Museum, interpretive centre, hiking.
Applicable Land Use Plans	Community-based Fish and Wildlife Work Plan Little Salmon Carmacks First Nation Traditional Territory, 2012-2017; Carmacks Annual Limit Region.
Community Infrastructure and Services	K-12 school, Yukon College campus, library services, RCMP detachment, volunteer fire services, emergency medical services, health services, Little Carmacks/Salmon First Nation health and family services, dental services, daycare, municipal landfill site, water and wastewater services.

Table D A1-4: Baseline Information for Faro, Yukon

Project	Cyprus Hill Wind Farm, Faro Pit Pumped Storage, Vangorda Pit Pumped Storage, Finlayson and Anvil Creek Small Hydro.
Population	388
Traditional Territory	Kaska Dena, Ross River Dena Council.
Available Recreation Activities	Summer pool, indoor ice arena, trail network, hiking, wildlife viewing, camping, fishing, and hunting.
Tourist Activities	Hiking, wildlife viewing, camping, fishing, and hunting.
Applicable Land Use Plans	Ross River – Faro Annual Limit Region; Draft Southeast Yukon Forest Management.
Community Infrastructure and Services	K-12 school, Yukon College campus, library services, RCMP detachment, volunteer fire service, emergency medical services, health centre, youth dental services, waste and wastewater services, landfill, gymnasium.

Table D A1-5: Baseline Information for Carcross, Yukon

Projects	Sugarloaf Mountain Wind Farm, Tutshi-Windy Lake Small Hydro, Racine-Mt. Brown Pumped Storage, Lindemann-Fraser Pumped Storage, Tutshi-Moon Pumped Storage, Racine-Moon Pumped Storage, Squanga-Dalayee Pumped Storage.
Population	771
Traditional Territory	Carcross/Tagish First Nation.
Available Recreation Activities	Hiking, mountain biking, camping, skiing, snowmobiling, ice fishing.
Tourist Activities	Same as recreational activities, wildlife viewing, heritage buildings, on Southern Lakes Circuit Drive.
Community Infrastructure and Services	K-9 school, Yukon College campus, RCMP detachment, volunteer fire service, health centre, social services, youth dental services, childcare services, landfill, water and wastewater services, summer community pool, drop-in at school gymnasium.

Table D A1-6: Baseline Information for Stewart Crossing, Yukon

Projects	Tehcho (Ferry Hill) Wind Farm.
Population	25
Traditional Territory	NND Traditional Territory.
Community Infrastructure and Services	Closest health centre is in Pelly Crossing, gas station, emergency services located in Mayo.

Table D A1-7: Baseline Information for Teslin, Yukon

Projects	Wolf River
Population	499
Traditional Territory	Teslin Tlingit Council.
Available Recreation Activities	Recreation complex and programming, including indoor ice arena, baseball diamond, skateboard park; trail network, skiing, boating, fishing, hiking.
Tourist Activities	Museum, on Southern Lakes Circuit Drive, Teslin Tlingit Heritage Centre, museum, fishing, hunting, Nisutlin River Delta National Wildlife Area.
Applicable Land Use Plans	Teslin Tlingit Council has a Department of Lands and Resources that oversees land and resource use.
Community Infrastructure and Services	Pre-K to Grade 9 school, Yukon College campus, Health Centre, RCMP detachment, volunteer fire service, emergency medical services, gravel airport, water and wastewater services, landfill.

Table D A1-8: Baseline Information for Atlin, British Columbia

Projects	Atlin-Black Mountain Pumped Storage, Atlin (Pine Creek) Small Hydro, Surprise Small Hydro.
2011 Population	402 (Stikine Region Regional District Electoral Area).
Traditional Territory	Taku River Tlingit First Nation.
Available Recreation Activities	Camping, boating (motorized, canoes, kayaks), fishing, hunting.
Tourist Activities	Camping, boating (motorized, canoes, kayaks), fishing, hunting, annual music festival.
Applicable Land Use Plans	Atlin Taku Land Use Plans Use, Recreation and Enjoyment of the Public Reserves (UREP) – Tutshi Lake and River.
Community Infrastructure and Services	Health clinic, RCMP, fire department, BCEHS, school, college campus.
Local Business	Grocery stores, hardware store, gas station, restaurants, laundromat, air transportation, and construction services.

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APPENDIX E:
ECONOMIC EVALUATION
TECHNICAL REPORT

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1.0 INTRODUCTION

Economic criteria and indicators for evaluating resource options as finalized in Appendix B are copied below in Table E 1-1.

The technical economic evaluation of each resource option is addressed in Appendix E, with separate sections for each of the economic criteria in Table E 1-1.

At the start of each section of Appendix E, the distinct issues, rating criteria and data sources for each criteria are summarized. As outlined in Section 7 of Appendix B, the ratings for the evaluation of each indicator are classified in terms of high, medium, and low as follows:

- **High (red when non-positive - no colour when positive effect)** means the resource option has a high expected effects linkage to the indicator (depending on the indicator, the likely effects may be adverse, beneficial or simply signify linkage/overlap without much additional guidance);
- **Medium (yellow when non-positive - no colour when positive effect)** means the resource option has potential expected linkage to the indicator that falls between low and high ratings; and
- **Low (green when non-positive - no colour when positive effect)** means the resource option likely has minimal, if any, expected effects linkage to the indicator (again, depending on the indicator, any potential minimal effects may be adverse, beneficial or simply signify no linkage/overlap with the indicator, i.e., no effects pathway).

No linkage or Not Applicable, which is shown as green, is separated out in the economic evaluations to identify circumstances where there is no apparent or likely link between a resource project option and a given economic indicator.

As each resource project option was reviewed, it was assumed that standard best management practices (BMPs) would be applied during the construction and operation stages to mitigate adverse effects and enhance positive effects. Where standard BMPs are expected to prevent any likely impact of concern on an indicator, a green or low impact rating was adopted.

Table E 1-1: Resource Options Evaluation Matrix – Economic Criteria & Indicators

ID	Criteria	Indicator	Metric ID	Metric
Economic Criteria				
Ec1	**Local Economic Impacts**	Yukon Opportunities during Construction	Ec1-1	Capital Cost - Civil and Other Local Share (L/M/H)
		Yukon Opportunities during Operation	Ec1-2	Operation Costs - Yukon Labour & Business Opportunity (L/M/H)
		Community & Other Development Opportunity	Ec1-3	Community, Industry Development Opportunity (L/M/H)
Ec2	**Climate Change Risk Affecting Resource Financial Attributes**	Susceptibility to Extreme Weather Events/Conditions	Ec2-1	Susceptible to Extreme Heat/Drought (L/M/H)
			Ec2-2	Susceptible to Extreme Precipitation - flood/snow
			Ec2-3	Susceptible to Extreme Wind Events (L/M/H)
			Ec2-4	Susceptible to Ice Related Processes/Events (L/M/H)
		Conditions Susceptible to Climate Change	Ec2-5	Extent of Permafrost in project footprint (L/M/H)

2.0 LOCAL ECONOMIC IMPACTS

2.1 RATING CRITERIA AND DATA SOURCES FOR EC1: LOCAL ECONOMIC IMPACTS

The rating system outlined in Figure E 2-1 was adopted to guide evaluations of each resource project option for each of the local economic impacts indicators. The rating system was selected in each instance based on the range of resource options under review and the objective to highlight clear differences in relative economic effects based on differences in capital expenditure (Capex), operating expenditure (Opex) or other specific community and development economic effect factors. Effects are positive for each indicator, and therefore no colours are used for rating of these indicators.

Figure E 2-1: Summary of Rating Criteria for Local Economic Impacts

Indicator	Low Positive	Medium Positive	High Positive
Yukon Opportunities during Construction (Ec1-1)	Capex <$100M, Yukon GDP <$50M (approximate range)	Capex $100 -$200M, Yukon GDP $50-$100M (approximate range)	Capex >$200M, Yukon GDP >$100M (approximate range)
Yukon Opportunities during Operation (Ec1-2)	Non-fuel Opex <$1.0M/yr.	Non-fuel Opex $1 to $2M/yr.	Non-fuel Opex >$2.0M/yr.
Community & Other Development Opportunity (Ec1-3)	Minimal development opportunity	Moderate development opportunity	Material development opportunity

The local economic impacts indicators as defined in Table E 1-1 focus on the relative magnitude of the local economic impact (L/M/H) for each resource project option. The evaluation examines the relative magnitude of absolute positive effect for each resource option (e.g., total dollars per project rather than dollars per kWh or percentages of overall project Capex or Opex going to local effects), assuming that this will be the most important basis for comparative evaluation. Where relevant, other factors may also be noted, e.g., development of new access for a region, use of local feedstocks for fuel.

Local Economic Impact criteria indicators have been evaluated based on the following:

- Yukon Energy project studies for the resource options (as reviewed in Appendix A). This assessment generally adopted costs as provided by others without attempting to address possible inconsistencies.
- Yukon input-output model based on 2010 Statistics Canada multipliers. The industry selected may not always be the proper industry that matches to the construction of the resource option.
- Results from other evaluations, including Social Criteria S4-4 (Non-renewable Resources) and S5-3 (Community, First Nation and Personal Development).

- Summary background Yukon economy information (see Attachment 1 to this appendix).

The following approach and assumptions were used in the evaluation process:

- **Yukon Opportunities during Construction** (see Table E 2-1 for the detailed information used):
    - The total capital construction cost (Capex), usually in 2016$, was identified for each resource project option based on the available Yukon Energy resource options studies.
        - In the few cases where no estimate was readily available (e.g., Mayo Lake Storage and Mayo Lake Outlet Channel Dredging), Table E 2-1 shows that approximate amounts were adopted for the evaluation.
        - These estimates were used as one key metric of construction-phase local economic impacts (separating all projects into three groups, i.e., less than $100 million Capex (low), between $100 and $200 million Capex (medium) and over $200 million Capex (high).
    - Separately, the local portion of the Capex and related gross domestic product (GDP) impacts in Yukon was estimated for each resource project option based on the available Yukon Energy resource studies and the Yukon input-output model based on Statistics Canada multipliers:
        - Where feasible from the available Yukon Energy resource options studies, the portion of the Capex identified for major equipment was removed (assuming that such equipment costs will be spent outside Yukon) in order to provide an indicator of the civil and other costs that local businesses and population can participate in by carrying out activities such as clearing, roads, building and structures (unless brought from outside of Yukon).[1] This indicator may understate economic leakage from Yukon for construction costs, e.g., installation of major equipment may often involve a specialized work force and management brought into Yukon only for the duration of time needed for this specific work.[2]
        - In cases where no estimate was readily available of the major equipment portion of Capex, Table E 2-1 shows the assumed percentages that were adopted for the evaluation.
        - After the above initial identification of the construction costs that facilitate local business and population participation, the Yukon input-output model was used to

[1] It was recognized that looking only at major equipment was a crude indicator of non-local Capex spending. However, review of available information indicated that information on civil or other "local" spending was much less consistently available.
[2] The Stewart-Keno City transmission project, for example, indicates the major equipment costs are 20 to 25% of substation and transmission line Capex cost estimates. However, these costs plus costs for installation equal to 64% of overall transmission line Capex costs.

estimate the impact to Yukon GDP, employment income within Yukon and jobs that construction activities can create.[3]

- These estimates were used as a separate key metric of local economic impacts during construction (separating all projects into three groups, i.e., less than $50 million Yukon GDP impact (low), between $50 and $100 million Yukon GDP impact (medium), and over $100 million Yukon GDP impact (high).

- The results of the GDP assessment rating were compared with the total Capex rating and were found to generally yield consistent results. In the few cases where there was some variance, judgement was used to provide a final rating of the resource option for economic opportunity impacts during construction in Yukon.

- **Yukon Opportunities during Operation** (see Table E 2-2 for the detailed information used):
  - After review of available information in the Yukon Energy studies, the analysis focused on non-fuel operations and maintenance (O&M) cost estimates (Opex) for each option as the best available overall indicator of potential resource option operating spending impacts on the Yukon economy.[4] Where relevant and feasible, other operation features were also noted, e.g., use or local feedstocks for fuel, numbers of jobs.
  - Table E 2-2 identifies where assumptions were required to assess non-fuel Opex for an option.
  - The O&M estimates were used as a key metric of operation local economic impacts (separating all projects into three groups, i.e., less than $1 million per year Opex (low), between $1 and $2 million per year Opex (medium), and over $2 million per year Opex (high).

- **Community and Other Development Opportunity** (see Table E 2-3 for the detailed assessment):
  - Consideration was given to any specific new opportunities that each resource option would provide to community and other developments. This includes effects from new roads, transmission lines and business opportunities during operation of the resource option. Projects with notable specific new opportunities to be addressed and managed were rated high.
  - Rating of resource options for Community and Other Development Opportunity (Ec1-3 economic indicator) yields a similar assessment in practice to the rating of resource options for Community, First Nation, and Personal Development (S5-3).

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[3] Direct and indirect, based on the Yukon input-output model (2010 Statistics Canada multipliers) http://economics.gov.yk.ca/impact.aspx [detailed industry multipliers: "electric power engineering construction" for hydro, thermal and transmission options, "other engineering construction" for all other options]. There would also be a construction GDP employment impact for the cost of major equipment based on the local wholesale margin and multipliers; however, it is not practical at this stage to estimate these values and, even though it would indicate a slightly higher multiplier impacts in Yukon, such a change would not appear to affect the overall evaluation ranking of the resource options.

[4] Annual operating spending changes over time for some resource options: a) to reflect inflation and b) other factors such as reduced annual generation, etc. To avoid inconsistency the first year annual operating cost was used for the ranking purposes.

The economic evaluation of resource options does not show any useful basis for separate assessment of many sub-options for specific resource options, including Whitehorse landfill versus Takhini substation locations for fossil fuel thermal options, different technologies for the storage battery option, and various smaller scale options of the solar options in Whitehorse and Haines Junction.

Table E 2-1: Local Economic Impact: Yukon Opportunities during Construction

	Installed Capacity, MW	Annual Average Energy GW.h	Construction cost[4] ($ million)			Construction GDP impact ($ million, excl. jobs) - direct plus indirect within Yukon				Evaluation				
			Total Construction cost[4]	Major Equipment costs	% of Major Equipment costs	Construction cost excl. Major Equipment costs	GDP basic prices	Labour income	Jobs	Capex (million$)	GDP values (million$)	Low Positive Capex<$100M GDP<$50M (approx.)	Medium Positive Capex$100-200M GDP$50-100M (approx.)	High Positive Capex>$200M GDP>$100M (approx.)
Fossil Thermal														
Diesel: 20 MW - Whitehorse	20.0	up to >166	62.48	17.96	29%	44.52	28.65	11.11	192	62	29	**Low Positive**		
LNG: 20 MW - Whitehorse	20.0	up to >166	100.12	40.51	40%	59.61	38.36	14.88	257	100	38	**Low Positive**		
Non-Fossil Thermal														
Waste to Energy	1.6	10	34.60	25.50	74%	9.10	3.69	2.47	38	35	4	**Low Positive**		
Biogas (CHP)	0.2	0.4	6.98	1.80	26%	5.18	2.10	1.41	21	7	2	**Low Positive**		
Biomass 0.5 MW Boiler / Steam Turbine	0.5	3	11.28	3.04	27%	8.24	3.35	2.24	34	11	3	**Low Positive**		
Other Non-Hydro Renewable														
Storage Battery: 8 MW/40 MWh (lithium ion, 5hrs)	8.0	0.04	49.48	47.75	97%	1.72	0.70	0.47	7	49	1	**Low Positive**		
Solar PV: Whitehorse Fixed Tilt: 10 MW	10.0	10	35.64	26.09	73%	9.54	3.87	2.59	40	36	4	**Low Positive**		
Solar PV: Haines Junction Fixed Tilt: 5 MW	5.0	5	12.82	7.92	62%	4.90	1.99	1.33	20	13	2	**Low Positive**		
Wind: Cyprus Mine Hill, 20 MW	20.0	50	69.00	24.00	35%	45.00	18.27	12.21	186	69	18	**Low Positive**		
Wind: Kluane Lake, 20 MW	20.0	48	62.00	24.00	39%	38.00	15.43	10.31	157	62	15		**Medium Positive[4]**	
Wind: Millers Ridge, 20 MW	20.0	57	73.00	24.00	33%	49.00	19.89	13.30	203	73	20	**Low Positive**		
Wind: Mt. Sumanik , 20 MW	20.0	42	64.00	24.00	38%	40.00	16.24	10.86	166	64	16	**Low Positive**		
Wind: Sugarloaf Mountain, 20 MW	20.0	32	62.00	24.00	39%	38.00	15.43	10.31	157	62	15	**Low Positive**		
Wind: Tehcho (Ferry Hill), 20 MW	20.0	33	64.00	24.00	38%	40.00	16.24	10.86	166	64	16	**Low Positive**		
Wind: Thulsoo Mountain, 20 MW	20.0	54	72.00	24.00	33%	48.00	19.49	13.03	199	72	19	**Low Positive**		
Geothermal: McArthur Springs (3.8 MW Av.)	3.8	25	120.50	6.40	5%	114.10	46.32	30.97	473	121	46		**Medium Positive**	
Geothermal: Vista Mountain (1.6 MW Av.)	1.6	11	41.50	4.15	10%	37.35	15.16	10.14	155	42	15	**Low Positive**		
Hydro Generation														
Pumped Storage: Moon Lake (Tutshi-Moon)	20.2	54	217.60	14.00	6%	203.60	131.03	50.81	878	218	131			**High Positive**
Pumped Storage: Racine - Moon	15.0	50	473.00	221.63	47%	251.37	161.77	62.74	1084	473	162			**High Positive**
Pumped Storage: Lindeman-Fraser	15.0	50	483.80	133.98	28%	349.82	225.13	87.31	1509	484	225			**High Positive**
Pumped Storage: Racine - Mt. Brown	15.0	50	284.00	62.45	22%	221.55	142.58	55.29	956	284	143			**High Positive**
Pumped Storage: Atlin - Black Mountain	15.0	50	253.80	61.21	24%	192.59	123.94	48.06	831	254	124			**High Positive**
Pumped Storage: Squanga - Dalayee	25.0	100	613.40	145.91	24%	467.49	300.86	116.67	2017	613	301			**High Positive**
Pumped Storage: Canyon - Ittlemit	25.0	100	691.20	68.52	10%	622.68	400.73	155.40	2686	691	401			**High Positive**
Pumped Storage: Vangorda Pit	40.0	134	523.80	114.94	22%	408.86	263.13	102.04	1764	524	263			**High Positive**
Small Hydro: Drury Lake	8.1	32	103.30	61.10	59%	42.20	27.16	10.53	182	103	27	**Low Positive**		
Small Hydro: Tutshi - Windy Arm	7.2	57	133.20	73.27	55%	59.93	38.57	14.96	259	133	39		**Medium Positive**	
Small Hydro: Wolf River	20.0	96	233.80	112.72	48%	121.08	77.92	30.22	522	234	78			**High Positive**
Small Hydro: Finlayson River	17.6	138.90	282.50	74.62	26%	207.88	133.78	51.88	897	283	134			**High Positive**
Small Hydro: Anvil Creek	9.8	41.30	115.98	49.60	43%	66.38	42.72	16.57	286	116	43		**Medium Positive**	
Small Hydro: Atlin/Pine Creek	5.7	36.3 to Yukon	79.70	13.38	17%	66.32	42.68	16.55	286	80	43		**Medium Positive[4]**	
Other Hydro: Gladstone Diversion	N/A	36.60	40.00	8.00	assume 20%	32.00	20.59	7.99	138	40	21	**Low Positive**		
Other Hydro: Southern Lakes Storage	1.0	6.40	10.50	1.05	assume 10%	9.45	6.08	2.36	41	11	6	**Low Positive**		
Other Hydro: Mayo Lake Storage	N/A	2 to 4	approx. 5	0.50	assume 10%	4.50	2.90	1.12	19	5	3	**Low Positive**		
Other Hydro: Mayo Dredging	N/A	1 to 2	approx. 15	7.50	assume 50%	7.50	4.83	1.87	32	15	5	**Low Positive**		
Aishihik Re-runnering	1.00	3	4.70	2.35	assume 50%	2.35	1.51	0.59	10	5	2	**Low Positive**		
Mayo A Refurbishment	2.30	10	27.40	13.70	assume 50%	13.70	8.82	3.42	59	27	9	**Low Positive**		
Transmission Corridors	Transfer Capacity													
Transmission: Whitehorse - Atlin (138 kV)	97.0	N/A	158.00	31.60	assume 20%	126.40	81.35	31.55	545	158	81		**Medium Positive**	
Transmission: Whitehorse - Skagway (230 kV)	443.0	N/A	251.00	50.20	assume 20%	200.80	129.23	50.11	866	251	129			**High Positive**
Transmission: Whitehorse - Teslin (138 kV)	95.0	N/A	165.00	33.00	assume 20%	132.00	84.95	32.94	569	165	85		**Medium Positive**	
Transmission: Faro - Watson Lake (230 kV)	190.0	N/A	597.00	119.40	assume 20%	477.60	307.36	119.19	2060	597	307			**High Positive**
Transmission: Aishihik - Destruction Bay (230 kV)	484.0	N/A	241.00	48.20	assume 20%	192.80	124.08	48.12	832	241	124		**Medium Positive**	
Transmission: Stewart-Keno City (138 kV & substations)	N/A	N/A	86.00	18.50	22%	67.50	43.44	16.85	291	80	43	**Low Positive**		

1. Yukon GDP impact analysis are based on Yukon input-output model available at http://economics.gov.yk.ca/impact.aspx [2010 Statistics Canada multipliers, simple multipliers (direct plus indirect) within Yukon applied to estimated construction cost excluding major equipment; detailed aggregation for industry "Electric power engineering construction" for thermal, hydro & transmission options; "Other engineering construction" for all other options].

2. The construction cost estimates for some options do not provide breakdown of the costs to identify amount related to major equipment, and even when estimates are provided they may not provide reliable or consistent numbers for the GDP analysis. For example, the major equipment cost for Waste to Energy option shown in the table above is the cost for "complete facility installed and commissioned", which may include other construction related costs. For Storage Battery options the major equipment cost includes "Capital cost" plus "replacement cost" [this assumes replacement of all batteries after 15 years for lead acid batteries and after 20 years for lithium ion batteries]. No breakout of equipment costs is provided for transmission corridor options, or certain other projects as noted. The capital cost for these options would require further breakdown in order to estimate major equipment related costs to be excluded for the GDP analysis.

3. Most of the pumped storage hydro options (as well as the Atlin/Pine Creek small hydro option) are located in the northern BC close to the Yukon border. The locations are very close to Yukon compared to any other major population centres in BC and access to the construction site would be from Yukon. Therefore, all capital spending and employment opportunities are assumed to be within Yukon resources.

4. Kluane Lake Wind and Atlin/Pine Creek Small Hydro ratings reflect need for material transmission Capex not included in this table (see Appendix A, section 5.1). No capital costs are yet included for most of the transmission needed to connect certain options to grid: Kluane wind farm ($241 million Aishihik-Destruction Bay transmission corridor); all pumped storage options other Vangorda Pit and Canyon-Ittlemit (estimated capex ranges from $100 to $125 million); all small hydro other than Drury Lake and Anvil Creek (estimated capex ranges from $94 to $221 million).

Table E 2-2: Local Economic Impact: Yukon Opportunities during Operation

	Installed Capacity, MW	Annual Average Energy GW.h	Operation cost ($ million, excludes feedstock/fuel costs)		Notes	Evaluation			
			Annual Operation Cost	Jobs		Nonfuel Opex $M/yr	Low Positive Non-fuel Opex <$1M/yr	Medium Positive Non-fuel Opex $1 to 2 M/yr	High Positive Non-fuel Opex >$2M/yr
Fossil Thermal									
Diesel: 20 MW - Whitehorse	20.0	up to >166	up to 1.19	N/A	Non-fuel O&M likely to be well under $1 million/yr with actual usage. Fuel sourced from outside Yukon, and used when required.	up to 1.19	**Low Positive**		
LNG: 20 MW - Whitehorse	20.0	up to >166	up to 1.19	N/A		up to 1.19	**Low Positive**		
Non-Fossil Thermal									
Waste to Energy	1.6	10	3.36	18	Fuel feedstocks from local sources (cost excluded here). Economics assume year-round operation. Except for biogas, assumes sale of waste heat.	3.36			**High Positive**
Biogas (CHP)	0.2	0.4	0.26	N/A		0.26	**Low Positive**		
Biomass 0.5 MW Boiler / Steam Turbine	0.5	3	0.62	5		0.62	**Low Positive**		
Other Non-Hydro Renewable									
Storage Battery: 8 MW/40 MWh (lithium ion, 5hrs)	8.0	0.04	0.26	N/A		0.26	**Low Positive**		
Solar PV: Whitehorse Fixed Tilt: 10 MW	10.0	10	0.37	N/A		0.37	**Low Positive**		
Solar PV: Haines Junction Fixed Tilt: 5 MW	5.0	5	0.14	N/A		0.14	**Low Positive**		
Wind: Cyprus Mine Hill, 20 MW	20.0	50	1.36	2	Wind farm options earn medium positive rating, except for the two options with FN land lease payments. Assumes employ two technicians working out of an office near any of wind farm. About 20% of O&M costs are fixed; variable costs include maintenance costs and royalties. Two site options [Kluane Lake & Sugarloaf Mountain] are on aboriginal traditional land and assume land lease payments to the local FN (reflected in high positive rating). Kluane Lake required new transmission to Haines Junction or Aishihik area.	1.36		**Medium Positive**	
Wind: Kluane Lake, 20 MW	20.0	48	1.31	2		1.31			**High Positive**
Wind: Millers Ridge, 20 MW	20.0	57	1.44	2		1.44		**Medium Positive**	
Wind: Mt. Sumanik , 20 MW	20.0	42	1.12	2		1.12		**Medium Positive**	
Wind: Sugarloaf Mountain, 20 MW	20.0	32	0.98	2		0.98			**High Positive**
Wind: Tehcho (Ferry Hill), 20 MW	20.0	33	0.97	2		0.97		**Medium Positive**	
Wind: Thulsoo Mountain, 20 MW	20.0	54	1.39	2		1.39		**Medium Positive**	
Geothermal: McArthur Springs (3.8 MW Av.)	3.8	25	1.30	N/A		1.30		**Medium Positive**	
Geothermal: Vista Mountain (1.6 MW Av.)	1.6	11	0.58	NA		0.58	**Low Positive**		
Hydro Generation									
Pumped Storage: Moon Lake (Tutshi-Moon)	20.2	54	1.90	N/A	All sites (except Moon and Vangorda Pit) annual O&M cost estimated at 2.0% of capital cost before IDC plus $0.005/kW.h for generation and pumped energy. Moon option O&M cost as per Midgard report, with provision specifically for BC resource fees. Vangorda Pitt O&M cost adjusted from EMC[2] Picacho report to provide $0.005/kW.h cost for pumped storage.	1.90		**Medium Positive**	
Pumped Storage: Racine - Moon	15.0	50	9.20	N/A		9.20			**High Positive**
Pumped Storage: Lindeman-Fraser	15.0	50	9.50	N/A		9.50			**High Positive**
Pumped Storage: Racine - Mt. Brown	15.0	50	5.80	N/A		5.80			**High Positive**
Pumped Storage: Atlin - Black Mountain	15.0	50	5.20	N/A		5.20			**High Positive**
Pumped Storage: Squanga - Dalayee	25.0	100	12.50	N/A		12.50			**High Positive**
Pumped Storage: Canyon - Ittlemit	25.0	100	13.90	N/A		13.90			**High Positive**
Pumped Storage: Vangorda Pit	40.0	134	2.40	N/A		2.40			**High Positive**
Small Hydro: Drury Lake	8.1	32	2.10	N/A	Small hydro option annual O&M cost estimated at 2.0% of capital cost before IDC plus $0.005/kW.h variable cost for generation. Atlin/Pine Creek rated High Positive after considering need for added O&M on transmission required to connect to Yukon grid.	2.10			**High Positive**
Small Hydro: Tutshi - Windy Arm	7.2	57	2.79	N/A		2.79			**High Positive**
Small Hydro: Wolf River	20.0	96	4.88	N/A		4.88			**High Positive**
Small Hydro: Finlayson River	17.6	139	6.02	N/A		6.02			**High Positive**
Small Hydro: Anvil Creek	9.8	41	2.39	N/A		2.39			**High Positive**
Small Hydro: Atlin/Pine Creek	5.7	36.3 avail to Yukon	1.77	N/A		1.77			**High Positive**
Other Hydro: Gladstone Diversion	N/A	37	likely<1.0	N/A		likely<1.0	**Low Positive**		
Other Hydro: Southern Lakes Storage	1.0	6	likely<1.0	N/A		likely<1.0	**Low Positive**		
Other Hydro: Mayo Lake Storage	N/A	2 to 4	likely<1.0	N/A		likely<1.0	**Low Positive**		
Other Hydro: Mayo Dredging	N/A	1 to 2	likely<1.0	N/A		likely<1.0	**Low Positive**		
Aishihik Re-runnering	1.00	3	likely<0.5	N/A		likely<0.5	**Low Positive**		
Mayo A Refurbishment	2.30	10	likely<0.5	N/A		likely<0.5	**Low Positive**		
Transmission Corridors	Transfer Capacity								
Transmission: Whitehorse - Atlin (138 kV)	97.0	N/A	0.24	N/A	Ongoing O&M includes labour costs, brushing costs, and other non-labour costs, adjusted for corridor length and difficulty factors.	0.24	**Low Positive**		
Transmission: Whitehorse - Skagway (230 kV)	443.0	N/A	0.29	N/A		0.29	**Low Positive**		
Transmission: Whitehorse - Teslin (138 kV)	95.0	N/A	0.24	N/A		0.24	**Low Positive**		
Transmission: Faro - Watson Lake (230 kV)	190.0	N/A	0.61	N/A		0.61	**Low Positive**		
Transmission: Aishihik - Destruction Bay (230 kV)	484.0	N/A	0.22	N/A		0.22	**Low Positive**		
Transmission: Stewart-Keno City (138 kV & substations)	N/A	N/A	likely<0.2	N/A		likely<0.2	**Low Positive**		

Table E 2-3: Local Economic Impact: Community and Other Development Opportunity

	Evaluation			
	Notes	Low Positive	Medium Positive	High Positive
Fossil Thermal				
Diesel: 20 MW - Whitehorse	No specific local development opportunities.	Low Positive		
LNG: 20 MW - Whitehorse	Local opportunity to facilitate LNG use to displace other fossil fuel use in Whitehorse/Yukon.		Medium Positive	
Non-Fossil Thermal				
Waste to Energy	Local opportunity to use renewable and (except for biogas) to supply waste heat to displace fossil fuel use. High operating jobs for Waste to Energy.		Medium Positive	
Biogas (CHP)			Medium Positive	
Biomass 0.5 MW Boiler / Steam Turbine			Medium Positive	
Other Non-Hydro Renewable				
Storage Battery: 8 MW/40 MWh (lithium ion, 5hrs)	Minimal direct local development impact. Might facilitate solar or wind.	Low Positive		
Solar PV: Whitehorse Fixed Tilt: 10 MW	Minimal direct local development impact.	Low Positive		
Solar PV: Haines Junction Fixed Tilt: 5 MW		Low Positive		
Wind: Cyprus Mine Hill, 20 MW	Moderate local economic development impacts from operations (ex. Mt Sumanik). Proposed Kluane & Sugarloaf Mountain sites are on aboriginal traditional land and assume land lease payments to the local FN; Kluane Lake option also facilitates development of an Aishihik-Destruction Bay Transmission Corridor.		Medium Positive	
Wind: Kluane Lake, 20 MW				High Positive
Wind: Millers Ridge, 20 MW			Medium Positive	
Wind: Mt. Sumanik , 20 MW		Low Positive		
Wind: Sugarloaf Mountain, 20 MW				High Positive
Wind: Tehcho (Ferry Hill), 20 MW			Medium Positive	
Wind: Thulsoo Mountain, 20 MW			Medium Positive	
Geothermal: McArthur Springs (3.8 MW Av.)	Moderate local economic development impacts from operations (new access road).		Medium Positive	
Geothermal: Vista Mountain (1.6 MW Av.)	Minimal local economic development impact.	Low Positive		
Hydro Generation				
Pumped Storage: Moon Lake (Tutshi-Moon)	Moderate local economic development impact based on Opex levels. In addition, options other than Squanga Dalayee, Canyon Ittlemit & Vangorda Pit each facilitate development of a portion of a Transmission Corridor resource option. The Vangorda Pit option may facilitate development of the Grizzly Pit mine deposit.			High Positive
Pumped Storage: Racine - Moon				High Positive
Pumped Storage: Lindeman-Fraser				High Positive
Pumped Storage: Racine - Mt. Brown				High Positive
Pumped Storage: Atlin - Black Mountain				High Positive
Pumped Storage: Squanga - Dalayee			Medium Positive	
Pumped Storage: Canyon - Ittlemit			Medium Positive	
Pumped Storage: Vangorda Pit			Medium Positive	
Small Hydro: Drury Lake	Moderate local economic development impact based on Opex level. All options other than Drury Lake and Anvil Creek also facilitate development of a Transmission Corridor (Tutshi-Windy Arm requires portion of Whitehorse-Skagway line, Wolf River and Atlin/Pine Creek facilitate Whitehorse-Atlin line, Finlayson needs line extending from Faro toward Watson Lake).		Medium Positive	
Small Hydro: Tutshi - Windy Arm				High Positive
Small Hydro: Wolf River				High Positive
Small Hydro: Finlayson River				High Positive
Small Hydro: Anvil Creek			Medium Positive	
Small Hydro: Atlin/Pine Creek				High Positive
Other Hydro: Gladstone Diversion	Minimal local economic development impact; facilitate local First Nation income benefits.			High Positive
Other Hydro: Southern Lakes Storage	Minimal local economic development impact.	Low Positive		
Other Hydro: Mayo Lake Storage		Low Positive		
Other Hydro: Mayo Dredging		Low Positive		
Aishihik Re-runnering	Minimal local economic development impact.	Low Positive		
Mayo A Refurbishment		Low Positive		
Transmission Corridors				
Transmission: Whitehorse - Atlin (138 kV)	Moderate potential local economic development impact if stimulates small hydro (in Atlin and Teslin areas, or in Moon-Tutshi area); and if (for Whitehorse-Skagway corridor) stimulates sales of summer hydro or wind generation (to cruise ships).		Medium Positive	
Transmission: Whitehorse - Skagway (230 kV)			Medium Positive	
Transmission: Whitehorse - Teslin (138 kV)			Medium Positive	
Transmission: Faro - Watson Lake (230 kV)	Material potential local economic development impacts (displace diesel generation in local communities with hydro, benefits to local businesses and population, opportunity to facilitate new mining and hydro or wind developments).			High Positive
Transmission: Aishihik - Destruction Bay (230 kV)				High Positive
Transmission: Stewart-Keno City (138 kV & substations)	Material local economic development impact by replacing end of life line, retains access to hydro generation, facilitates expanded capability for new mine developments.			High Positive

2.2 EVALUATIONS

2.2.1 Resource Options with No Material Concerns re: Local Economic Impacts

Tables E 2-1 to E 2-3 show a low positive rating for each of the local economic impact indicators for the following resource project options:

- Fossil fuel thermal - diesel generation options.
- Non-hydro renewable:
    - Storage Battery;
    - Solar PV; and
    - Geothermal - Vista Mountain.
- Hydro Generation:
    - Other Hydro – Southern Lakes Enhanced Storage, Mayo Lake Enhanced Storage, and Mayo Lake Outlet Channel Dredging; and
    - Refurbishment/Maintenance – Aishihik Rerunnering, Mayo A Refurbishment.

2.2.2 Fossil Fuel Thermal Generation

2.2.2.1 LNG Thermal Generation

Liquefied natural gas (LNG) thermal generation in Whitehorse has a low positive rating for both construction and operation Yukon opportunities.

This resource option has a medium positive rating for community and other development opportunities, reflecting local opportunities facilitated by this option (through its development of an LNG supply chain) to use LNG to displace other fossil fuel use in Whitehorse/Yukon.

2.2.3 Non-Hydro Renewable Generation

2.2.3.1 Non-Fossil Thermal Generation

Each of the non-fossil thermal generation resource options has a low positive rating for Yukon opportunities during construction, and each option other than Waste to Energy also has a low positive rating for Yukon opportunities during operation. Waste to Energy has a high positive rating for Yukon opportunities during operation, reflecting its high annual Opex cost level and the level of operation jobs.

Each of the non-fossil thermal generation resource options has a medium positive rating for community and other development opportunities, reflecting local opportunities to use renewable energy resources, as well as local opportunities (except for biogas) to use waste heat to displace fossil fuel use.

2.2.3.2 Wind Farms

Each of the wind farm resource options other than Kluane Lake has a low positive rating for Yukon opportunities during construction. Kluane Lake has a medium positive rating for Yukon opportunities during construction, reflecting the additional development (not reflected in the Kluane Lake costs as estimated in the Table E 2-1) for the new transmission line required to connect the Kluane Lake wind far to the existing grid at Haines Junction or the WAF 138 kV grid near Aishihik.

Each of the wind farm options other than Kluane Lake and Sugarloaf Mountain have a medium positive rating for Yukon opportunities during operation and (except for Mt. Sumanik) for community and other development opportunity. The medium positive ratings reflect the level of annual Opex costs and the expectation that these costs will provide some local opportunities. Mt. Sumanik has a low positive rating for community and other development opportunity to reflect its proximity to Whitehorse and the extent to which this proximity will reduce the overall effect on local community development.

The high positive ratings for Kluane Lake and Sugarloaf Mountain for Yukon opportunities during operation and for community and other development opportunity reflect opportunities for First Nation lease revenues for the two sites (Kluane Lake and Sugarloaf Mountain) and the opportunity to develop the new transmission corridor for the Kluane Lake site, which will allow Destruction Bay and likely Burwash Landing to stop relying on diesel generation.

2.2.3.3 Geothermal - McArthur Springs

The McArthur Springs geothermal resource option has a medium positive rating for each of the three Local Economic Impact indicators, reflecting the magnitude of its Capex and Opex costs, as well as any local development opportunities facilitated by the new access road that this option provides to the area.

2.2.4 Hydro Generation

2.2.4.1 Pumped Storage

Each of the pumped storage resource options has a high positive rating for Yukon opportunities during construction, reflecting the Capex cost levels (which are generally higher than the levels for all other resource options considered in this Resource Plan). Table E 2-1 does not include Capex costs needed to connect most of these sites (i.e., all sites other than Canyon-Ittlemit and Vangorda Pit) to the existing grid, and therefore understates the actual Capex cost requirements needed for development of most sites.

Each of the pumped storage resource options other than Tutshi-Moon has a high positive rating for Yukon opportunities during operation, reflecting the Opex cost levels, which are generally higher than the levels for all other resource options considered in this Resource Plan. The Tutshi-Moon site has a medium positive rating for Yukon opportunities during operation. These operation opportunities are expected to be focused inside the facility and the utility.

The Squanga-Dalayee, Canyon-Ittlemit and Vangorda Pit pumped storage options each has a medium positive rating for community and other development opportunity, reflecting the expectation that these

options will provide moderate local or community development opportunities based on Opex levels. Each of the other pumped storage options has a high positive rating for this indicator reflecting opportunity to develop one of the Transmission Corridor resource options (e.g., Whitehorse-Skagway or Whitehorse-Atlin), and (in the case of Tutshi-Moon option) to facilitate other small hydro development at Tutshi-Windy Arm.

2.2.4.2 Small Hydro

Based on Capex cost levels and estimates of Yukon GDP effects, the following small hydro resource ratings occur for Yukon opportunities during construction:

- Wolf River and Finlayson River have a high positive rating;
- Tutshi-Windy Arm, Anvil Creek and Atlin/Pine Creek options have a medium positive rating (the Atlin/Pine Creek medium rating reflects the additional development [not reflected in the Kluane Lake costs as estimated in the Table E 2-1] for the new transmission line needed to connect the project to the Yukon grid at Jakes Corner); and
- Drury Lake has a low positive rating.

Each of the small hydro resource options has a high positive rating for Yukon opportunities during operation, reflecting the Opex cost levels (the Atlin/Pine Creek rating reflects Opex expected for required new transmission connection as well as the hydro facility expansion). These operation opportunities are expected to be focused inside the facility and the utility.

Drury Lake and Anvil Creek small hydro has a medium positive rating for community and other development opportunity to reflect the level of Opex spending. Each of the other small hydro options has a high positive rating to reflect that it facilitates the development of a specific transmission corridor.

2.2.4.3 Other Hydro - Gladstone Diversion

The Gladstone Diversion resource option has a low positive rating for Yukon opportunities during construction and operation, and a high positive rating for community and other development opportunity. The high positive rating reflects the opportunity to facilitate local First Nation income benefits.

2.2.5 Transmission Corridors

Based on Capex cost levels and estimates of Yukon GDP effects, the following transmission corridor resource ratings occur for Yukon opportunities during construction:

- Whitehorse-Skagway and Faro-Watson Lake each have a high positive rating;
- Whitehorse-Atlin, Whitehorse-Teslin, and Aishihik-Destruction Bay each have a medium positive rating; and
- Stewart-Keno City has a low positive rating.

Based on Opex cost levels, each of the transmission corridor options has a low positive rating for Yukon opportunities during operation.

Faro-Watson Lake, Aishihik-Destruction Bay and Stewart-Keno City transmission corridor options are each rated high positive for local community and other development opportunities, reflecting opportunities to displace local diesel (or sustain existing transmission capability to do this, as in the case of the Stewart-Keno City option), as well as to facilitate new mining and renewable generation (hydro or wind) development. The three remaining transmission corridor options (Whitehorse-Atlin, Whitehorse-Skagway, and Whitehorse-Teslin) are each rated medium positive, reflecting potential local development impacts if they facilitate renewable generation (pumped storage or small hydro) and, in the case of the Skagway connection, the sale of summer renewable generation (hydro or wind) to cruise ships.

3.0 CLIMATE CHANGE RISK

3.1 RATING CRITERIA AND DATA SOURCES FOR EC2: CLIMATE CHANGE RISK AFFECTING RESOURCE FINANCIAL ATTRIBUTES

The rating system outlined in Figure E 3-1 was adopted to guide evaluations of each resource project option for each of the climate change risk indicators. These assessments address the extent to which financial attributes of the resource options are potentially affected by various climate change risk factors.

Figure E 3-1: Summary of Rating Criteria for Climate Change Risk

Indicator	Low	Medium	High
Susceptible to Extreme Weather/Events Conditions (Ec2-1) Extreme Heat/Drought (Ec2-2) Extreme Precipitation (Ec2-3) Extreme Wind Events (Ec2-4) Ice Related Processes	Not Specifically Susceptible, or Not Applicable	Potentially Susceptible	Specifically Susceptible
Conditions Susceptible to Climate Change - Extent of Permafrost in Project Footprint (Ec2-5)	Not Specifically Susceptible, or Not Applicable	Potentially Susceptible	Specifically Susceptible

The climate change risk indicators as defined in Table E 1-1 focus on the relative magnitude of the risk (L/M/H) for each resource project option. Green (low) shows minimal concerns, meaning that the resource option is not specifically susceptible to the specified risk or the risk is not applicable to the resource option. In contrast, red (high) identifies resource options that are known to be specifically susceptible to the risk (and thus at risk for relatively high adverse economic effects, either in design, construction or operation). Yellow (medium) addresses resource options where there is uncertainty as to the relative magnitude of the risk, based on current information.

Climate Change Risk criteria indicators have been evaluated based on information available from:

- Yukon Energy project studies for the resource options (as reviewed in Appendix A); and
- Results from other evaluations, including environmental criteria En4-3 (Permafrost).

Many resource options are not specifically susceptible to climate change risks beyond what might be called "normal" susceptibility, i.e., exposures to risks of extreme weather events similar to the exposure of other community activities. The evaluation is directed at identifying resource options where the specified risk is clearly of direct and special importance relative to the risk exposure for the other resource options relevant to the current Resource Plan evaluation. See Table E 3-1 for the detailed evaluation.

Table E 3-1: Climate Change Risk: Indicator Evaluation of Resource Options

	Susceptibility to Extreme Weather Events/Conditions (L/M/H)					Conditions Susceptible to Climate Change
	Notes	Extreme Heat/Drought	Extreme Precipitation - flood/snow	Extreme Wind Events	Ice Related Processes/Events	Extent of Permafrost in Project Footprint
Fossil Thermal						
Diesel: 20 MW - Whitehorse		Low	Low	Low	Low	Low
LNG: 20 MW - Whitehorse		Low	Low	Low	Low	Low
Non-Fossil Thermal						
Waste to Energy		Low	Low	Low	Low	Low
Biogas (CHP)		Low	Low	Low	Low	Low
Biomass 0.5 MW Boiler / Steam Turbine		Medium	Low	Low	Low	Low
Other Non-Hydro Renewable						
Storage Battery: 8 MW/40 MWh (lithium ion, 5hrs)		Low	Low	Low	Low	Low
Solar PV: Whitehorse Fixed Tilt: 10 MW	When working in cold climates, the voltage changes as a function of temperature becomes a critical design component.	Low	Low	Low	Low	Low
Solar PV: Haines Junction Fixed Tilt: 5 MW		Low	Low	Low	Low	Low
Wind: Cyprus Mine Hill, 20 MW	Turbine output will decrease below -30°C (all sites other than Kluane Lake) and wind turbines generally stop working below 40°C. For all sites other than Kluane Lake, 10% loss assumed for icing impacts. Kluane Lake transmission access also likely affected by permafrost conditions. Assume wind resource potentially susceptible to extreme wind events.	Low	Low	Medium	High	Low
Wind: Kluane Lake, 20 MW		Low	Low	Medium	Low	High
Wind: Millers Ridge, 20 MW		Low	Low	Medium	High	Low
Wind: Mt. Sumanik , 20 MW		Low	Low	Medium	High	Low
Wind: Sugarloaf Mountain, 20 MW		Low	Low	Medium	High	Low
Wind: Tehcho (Ferry Hill), 20 MW		Low	Low	Medium	High	Low
Wind: Thulsoo Mountain, 20 MW		Low	Low	Medium	High	Low
Geothermal: McArthur Springs (3.8 MW Av.)	Potential permafrost conditions affecting road / transmission access.	Low	Low	Low	Low	Medium
Geothermal: Vista Mountain (1.6 MW Av.)		Low	Low	Low	Low	Low
Hydro Generation						
Pumped Storage: Moon Lake (Tutshi-Moon)	Hydro resource options are specifically susceptible to drought, and therefore each of these options is rated on this basis. There is inadequate information to rate any material differences among these projects - however, storage can assist resiliency, along with capacity being set well below maximum potential. Potential permafrost conditions are assumed for options requiring material new transmission development.	High	Low	Low	Low	Medium
Pumped Storage: Racine - Moon		High	Low	Low	Low	Medium
Pumped Storage: Lindeman-Fraser		High	Low	Low	Low	Medium
Pumped Storage: Racine - Mt. Brown		High	Low	Low	Low	Medium
Pumped Storage: Racine - Mt. Brown		High	Low	Low	Low	Medium
Pumped Storage: Atlin - Black Mountain		High	Low	Low	Low	Medium
Pumped Storage: Atlin - Black Mountain		High	Low	Low	Low	Medium
Pumped Storage: Squanga - Dalayee		High	Low	Low	Low	Medium
Pumped Storage: Canyon - Ittlemit		High	Low	Low	Low	Low
Pumped Storage: Vangorda Pit		High	Low	Low	Low	Low
Small Hydro: Drury Lake	Hydro resource options are specifically susceptible to drought. Storage can assist resiliency, along with capacity for some options being set well below maximum potential. Geotechnical risk and the presence of permafrost noted for Drury Lake option. Permafrost risk assumed for new transmission.	High	Low	Low	Low	High
Small Hydro: Tutshi - Windy Arm		High	Low	Low	Low	Medium
Small Hydro: Wolf River		High	Low	Low	Low	Medium
Small Hydro: Finlayson River		High	Low	Low	Low	Medium
Small Hydro: Anvil Creek		High	Low	Low	Low	Medium
Small Hydro: Atlin/Pine Creek		High	Low	Low	Low	Medium
Other Hydro: Gladstone Diversion	Gladstone Diversion assumed to be susceptible to drought risk (red rating). It is assumed that drought related risks are only moderate for the storage enhancement options.	High	Low	Low	Low	Low
Other Hydro: Southern Lakes Storage		Medium	Low	Low	Low	Low
Other Hydro: Mayo Lake Storage		Medium	Low	Low	Low	Low
Other Hydro: Mayo Dredging		Low	Low	Low	Low	Low
Aishihik Re-runnering	The viability or design of these options is assumed not to be susceptible to these risks.	Low	Low	Low	Low	Low
Mayo A Refurbishment		Low	Low	Low	Low	Low
Transmission Corridors						
Transmission: Whitehorse - Atlin (138 kV)	Potential risks include additional snow clearing costs from heavy snow, structure & conductor damage, contact between phases and transmission structure or guys, phase contact with trees or buildings, trees falling into line (wind event related risks), forest fire ignition (extended heat/drought risk). Permafrost in project footprint would increase capital costs (specific risk for Aishihik-Destruction Bay option).	Low	Medium	Medium	Medium	Medium
Transmission: Whitehorse - Skagway (230 kV)		Low	Medium	Medium	Medium	Medium
Transmission: Whitehorse - Teslin (138 kV)		Low	Medium	Medium	Medium	Medium
Transmission: Faro - Watson Lake (230 kV)		Medium	Medium	Medium	Medium	Medium
Transmission: Aishihik - Destruction Bay (230 kV)		Medium	Medium	Medium	Medium	High
Transmission: Stewart-Keno City (138 kV & sub.)		Medium	Medium	Medium	Medium	Medium

3.2 EVALUATIONS

3.2.1 Resource Options with No Material Concerns re: Climate Change Risk

Tables E 3-1 shows a green rating for each of the climate change risk indicators for the following resource project options:

- Fossil fuel thermal options (diesel and LNG).
- Non-hydro renewable:
    - Non-fuel thermal options (waste to energy, biogas and biomass);
    - Storage Battery;
    - Solar PV;
    - Geothermal - Vista Mountain;
    - Other Hydro - Mayo Outlet Channel Dredging; and
    - Refurbishment/Maintenance - Aishihik Rerunnering, Mayo A Refurbishment).

3.2.2 Non-Hydro Renewable Generation

3.2.2.1 Biomass

The biomass generation option has a yellow (medium) rating for susceptibility to extreme heat/drought (e.g., forest fires). Biomass generation has a green (low) rating for all other Climate Change Risk indicators.

3.2.2.2 Wind Farms

Each of the wind farm site options has a green (low) rating for susceptibility to extreme heat/drought, as well as extreme precipitation (flood/snow). All wind farm sites other than Kluane Lake have a green rating as well for the extent of permafrost in project footprint (Kluane Lake has a red [high] rating based on extensive discontinuous permafrost affecting the new transmission routing needed for this option).

Each of the wind farm site options has a yellow (medium) rating for susceptibility to extreme wind events.

Each of the wind farm site options other than Kluane Lake has a red (high) rating for susceptibility to ice-related processes/events (Kluane Lake has a green [low] rating).

3.2.2.3 Geothermal - McArthur Springs

McArthur Springs has a green (low) rating for all four indicators regarding susceptibility to extreme weather events/conditions.

McArthur Springs has a yellow (medium) rating for the extent of permafrost in project footprint, reflecting potential permafrost conditions affecting new road and transmission access to this site.

3.2.3 Hydro Renewable Generation

3.2.3.1 Pumped Storage

With regard to susceptibility to extreme water events/conditions, each of the pumped storage resource options has the following ratings:

- Extreme heat/drought - red (high) rating, reflecting specific susceptibility to drought; and
- Extreme precipitation (flood/snow), extreme wind events, and ice-related processes/events - green (low) rating.

With regard to the extent of permafrost in project footprint, each option other than Canyon-Ittlemit and Vangorda Pit has a medium rating reflecting potential permafrost conditions affecting material new transmission access development requirements. Canyon-Ittlemit and Vangorda Pit have a green rating, reflecting proximity to existing transmission.

3.2.3.2 Small Hydro

With regard to susceptibility to extreme water events/conditions, each of the small hydro resource options has the following ratings:

- Extreme heat/drought - red (high) rating, reflecting specific susceptibility to drought; and
- Extreme precipitation (flood/snow), extreme wind events, and ice-related processes/events - green (low) rating.

With regard to the extent of permafrost in project footprint, each option other than Drury Lake has a medium rating reflecting potential permafrost conditions affecting material new transmission access development requirements. Drury Lake has a red (high) rating based on geotechnical risks and presence of permafrost noted in previous KGS reports.

3.2.3.3 Other Hydro (excluding Mayo Outlet Channel Dredging)

Each of these resource options has a green (low) rating regarding susceptibility to extreme precipitation (flood/snow), extreme wind events, ice-related process/events, and the extent of permafrost in the project footprint.

Regarding susceptibility to extreme heat/drought conditions, Gladstone Diversion has a red (high) rating, and each of the enhanced storage options (Mayo Lake and Southern Lakes) has a yellow (moderate) rating (reflecting the modest nature of these enhancements within the overall existing hydro generation regime).

3.2.4 Transmission Corridors

The transmission corridor options tend (by their linear nature) to be susceptible to extreme weather events and/or permafrost condition risks. Accordingly, each of these resource options has a yellow (medium) rating for all of the climate risk indicators, with the following exceptions:

- Regarding susceptibility to extreme heat/drought, which increases forest fire risks, the Whitehorse-Atlin, Whitehorse-Teslin, and Whitehorse-Skagway transmission corridor options are rated green (low) reflecting the extent that each route covers well developed areas and/or mountain areas.
- Regarding susceptibility to the extent of permafrost in project footprint, the Aishihik-Destruction Bay transmission corridor option has a red (high) rating, reflecting the extensive discontinuous permafrost affecting the new transmission routing needed for this option.

ATTACHMENT 1:
Baseline Information

In 2015, Yukon's population grew for the 12th consecutive year,[1] and as of June 2015, Yukon's population was estimated at 37,343,[2] (an approximate 20% increase over the last ten years, representing an annual average increase of 1.8%). Notably, the City of Whitehorse accounted for over 77% of the total population in Yukon at 28,872, and Whitehorse's population gains accounted for the majority of overall population growth in Yukon in 2015 over 2014 (about 85% of the annual change).

As of November 2015, the Yukon labour force averaged 21,200,[3] up 700 from 2014 level. The unemployment rate was 4.2%, the lowest unemployment rate amongst Canadian provinces and territories, and lower than the national unemployment rate of 7.1%. For the same period in the prior year the territorial unemployment rate was at 4.4%.

The service-producing sector accounted for about 84% of total employment, while 16.0% were employed in the goods-producing sector. Approximately 39.5% of working Yukoners were employed by one of the levels of government in the territory, while the remaining 60.5% were employed in the private sector with about 26.2% as self-employed.

In 2014, Yukon's real gross domestic product (GDP) contracted for a second consecutive year (after nine consecutive year over year increases), decreasing by approximately 0.8% to $2.264 billion. An annual decline in mineral production as a result of weak mineral prices and an ongoing slowdown in the global mining industry was the primary contributor to the reduction in GDP.[4] In summary:

- GDP from mining, quarrying and oil and gas extraction was a significant contributor to Yukon's economy at 19% of total GDP in 2014 (at $2007); however, it was down from an estimated contribution of over 21% in 2012 and 2013;
- GDP related to Public Administration contributed about 21% to 22% to Yukon's GDP over the last five years (2010-2014), highlighting the important role the public sector plays in Yukon's economy; and
- The construction sector also provides notable impact to GDP with about 7% to 7.5% contribution to Yukon's GDP over the last three years (2012-2014), declining from 10%-11% in 2010 and 2011.

Whitehorse is the largest electricity load centre[5] and accounts for largest portion of Yukon businesses. In 2013, Whitehorse businesses accounted for about 77% of all territorial businesses surveyed and about 82% of employees.[6] Government activity provides considerable economic stability to the Whitehorse area, with Whitehorse serving as the headquarters for territorial and federal government offices. The

[1] Review of the impact of Faro Mine in the 1980s and 1990s shows that closure of a large mine development may impact the overall Yukon population. The 2013 Yukon Economic Outlook also notes that following the final closure of the Faro mine in 1998, Yukon experienced six consecutive years of declining population, which saw the population fall just below 30,000 in 2003.
[2] Yukon Bureau of Statistics, Population Report June 2015.
[3] Source: Yukon Bureau of Statistics. 2015. Yukon Employment November 2015. Retrieved from: http://www.eco.gov.yk.ca/stats/pdf/employment_nov15.pdf [accessed on December 18, 2015].
[4] Source: Statistics Canada. 2015. CANSIM Table 379-0030 Gross domestic product (GDP) by North American Industry Classification System (NAICS), chained 2007 dollars. Retrieved from: http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=3790030 [accessed December 17, 2015].
[5] In 2015, Whitehorse residential and commercial energy sales accounted for about 67% of total Yukon-wide retail electricity sales including both AEY and Yukon Energy sales (source for Whitehorse and AEY sales is AEY 2016-17 GRA, Table 3 on page 2-4).
[6] Source: Government of Yukon Socio-Economic Web Portal http://www.sewp.gov.yk.ca/subject (accessed on June 24, 2016).

public sector was the largest source of employment in 2011, employing about 27% of the total population aged 15 years and over.[7] Tourism has also become a major source of economic growth for the city. Outside of the public sector, the following sectors were the largest sources of employment in 2011: 12.8% of the population aged 15 years and over were employed in the retail trade, 9.0% employed in construction, 7.1% in accommodation and food services, and 6.9% in health care and social assistance.

[7] Source: Government of Yukon Socio-Economic Web Portal http://www.sewp.gov.yk.ca/subject (accessed on June 24, 2016).