Project Report

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Government of Northwest Territories
Yellowknife, NWT

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Sachs Harbour Wind Scoping Study

Issued for Use

Rev. 0

Hatch Ltd.

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1. Introduction

This report presents the results of a study investigating the potential site and turbine options for wind power generation at Sachs Harbour. The report has been prepared by Hatch for the Government of Northwest Territories.

The study characterizes the potential for wind power with respect to wind speed, site options, and costs and benefits of several suitable wind sites. We envision that the successful completion of this wind project will facilitate a landmark change for Sachs Harbour, and that our participation will help secure the area's sustainable future through resilient and clean energy solutions.

The assessment includes:

- Review of existing wind data, and wind projections for selected sites
- Identification of suitable sites based on topographic and interconnection constraints
- High level review of geotechnical and civil constraints at Sachs Harbour
- Selection of suitable turbine models including cold weather package
- Projection of wind power production with respect to environmental and technical losses
- Overview of regulatory, permitting, civil, and logistic constraints
- Analysis of project, equipment, and maintenance costs
- Final recommendations based on costs and project constraints

The study also includes the construction schedule for the project as well as the detailed list of logistical costs associated with this project. Cost estimates are provided with an uncertainty of ± 50% and do not account for integration costs. It is expected that a detailed integration study will be carried out in the near future to validate and further refine the cost estimates for this project.

2. Wind Resource

2.1 Wind Measurement Campaign

The Sachs Harbour site was instrumented with two meteorological ("Met") stations.

The Met mast 0002 was located at 6.5km west of the Sachs Harbour Airport along the main road. The Met mast was equipped with three anemometers and one wind vane mounted on booms at three measurement heights (30m, 20m and 10m). All anemometers were the NRG 40 model and the wind vane was a NRG 200P model.

No temperature sensor was installed at this Met mast. The RAW data, that were made available to Hatch, cover the periods from July 8, 2005 to September 18, 2009.

The Met station 0003 was located at 300m south of the Sachs Harbour Airport at the old wind turbine site. The station was equipped with one heated anemometer (NRG IceFreeII model), one heated wind vane (NRG IceFreeII model) and one temperature sensor (NRG 110S model). The heated instruments were installed at 4.2m above ground level on a U-boom at the top of pole attached to the side of a small concrete structure. Given that the free distance between the instruments and the top of the structure is only 2.2m, the wind data at this station would require an adjustment to account for the impact of the structure on the wind measurements. The available RAW data cover the period from July 8, 2005 to January 8, 2009.

The following table provides the Met stations' coordinates, dates of installation and the period of data collection used in the analysis.

Table 2-1 – Met Station Coordinates and Period of Relevant Data Used

Met Station ID	Installation Date	Top Anemometer Height (m)	Latitude / Longitude	Period of Relevant Data Used
0002	June 24, 2005	30.0	N 71° 59' 09.7" / W 125° 26' 14.9"	July 8, 2005 – July 7, 2008
0003	June 25, 2005	4.2	N 71° 59' 25.0" / W 125° 15' 01.6"	July 8, 2005 – July 7, 2008

2.2 Data Analysis

Three full years of RAW data were selected at both Met stations as listed in Table 2-1. A gap of missing data was found, within the dataset, from August 2008 to April 2009 at the Met mast 0002. As such, only three full years of data could be used for the analysis to limit seasonal wind speed bias. Details regarding instruments' monitoring, maintenance or malfunctions were not made available to Hatch.

The three years of data were screened out to detect icing events, missing data and erroneous measurements. A number of data were affected for short periods of time by usual effects such as icing and occasional unexplained spikes or drops and were removed. The following periods of missing data were found within the dataset:

- Met station 0002: 31/10/2006 to 01/12/2006 (31 days); 01/02/2007 to 09/03/2007 (36 days).
- Met station 0003: 31/10/2006 to 01/12/2006 (31 days); 31/10/2007 to 01/12/2007 (31 days); 29/02/2008 to 30/03/2008 (30 days).

The following table presents the data recovery rates calculated for all instruments. The data recovery rates are considered acceptable for all instruments except A3 at the Met mast 0002. A3 seemed to be malfunctioning from February 2007 to July 2008.

Table 2-2 – Instruments Data Recovery Rates (RR)

Met Station ID	Period of Data Used	Anemometer A1 RR (height)	Anemometer A2 RR (height)	Anemometer A3 RR (height)	Wind Vane V1 RR (height)	Temperature Sensor T1 RR (height)
0002	July 8, 2005 – July 7, 2008	90.6% (30m)	89.0% (20m)	55.6% (10m)	86.1% (30m)	n/a
0003	July 8, 2005 – July 7, 2008	89.6% (4.2m)	n/a	n/a	87.4% (4.2m)	91.3% (3.1m)

The wind speeds measured at the Met stations range from 5.9m/s to 6.0m/s on average. The winds are dominant from the south-southeast to east-southeast across the site.

The wind turbulence intensity observed at the site is generally low.

Given the land cover and topography at the Sachs Harbour site, the wind shear exponent was calculated at the Met mast 0002 to be 0.09 which is consistent with the expected value. The wind shear was assumed to be the same at the Met station 0003 location, thus it was used to extrapolate the data to hub height at both locations.

Since some missing data were found within the datasets of the 2 met stations, it was decided to synthesize these gaps in order to increase the data recovery rate at each location, thus correcting for the seasonal bias, before proceeding with the long term adjustments. The linear correlation between the Met stations was found to be acceptable with a coefficient of determination R^2 of 0.71 based on 10-minutes interval.

The *Sachs Harbour Climate* station located at the Sachs Harbour Airport, monitored by Environment Canada (EC), was selected as the reference station for the long term extrapolation of the data since it has a long-term historical record of 15 years. The wind speed data of each Met station were correlated to the concurrent wind speed data at the long term reference station. Excellent correlation results were obtained with hourly average values. The long-term average wind speed at the EC station is 5.4 m/s. It was estimated by averaging all annual averages over the period from January 2002 to December 2016 excluding the years 2009 and 2013 having low recovery rates.

The 10-minute measured data recorded at the Met mast were scaled down by the adjustment factor to reflect the long-term value. In terms of the wind direction data, the three-year dataset for the Met stations remained untouched. As a result, the station has a set of wind speeds and wind directions that are the best estimate of the long-term wind regime.

The long-term wind speeds at the Met station 0002 were reduced by 10% to account for the impact of the adjacent structure on the wind measurements as stated by Landberg (2000).

Extrapolation to a hub height of 38m was performed using the wind shear exponent of 0.09, calculated at the Met mast 0002. The results are presented in the following table.

Table 2-3 – Estimated Long-term Wind Speeds at 38m Hub Height

Met Station ID	Top Anemometer Height (m)	Annual Average Wind Speed (m/s)	Coefficient of Determination with Sachs Harbour Climate R^2	Adjustment Factor (%)	Long Term Wind Speed at Top Anemometer Height (m/s)	Long Term Wind Speed at Hub Height of 38m (m/s)
0002	A1 (30.0m)	5.9	0.79	-3.0	5.8	5.9
0003	A1 (4.2m)	6.0	0.82	-2.7	5.2*	6.3

* Including the reduction of 10%.

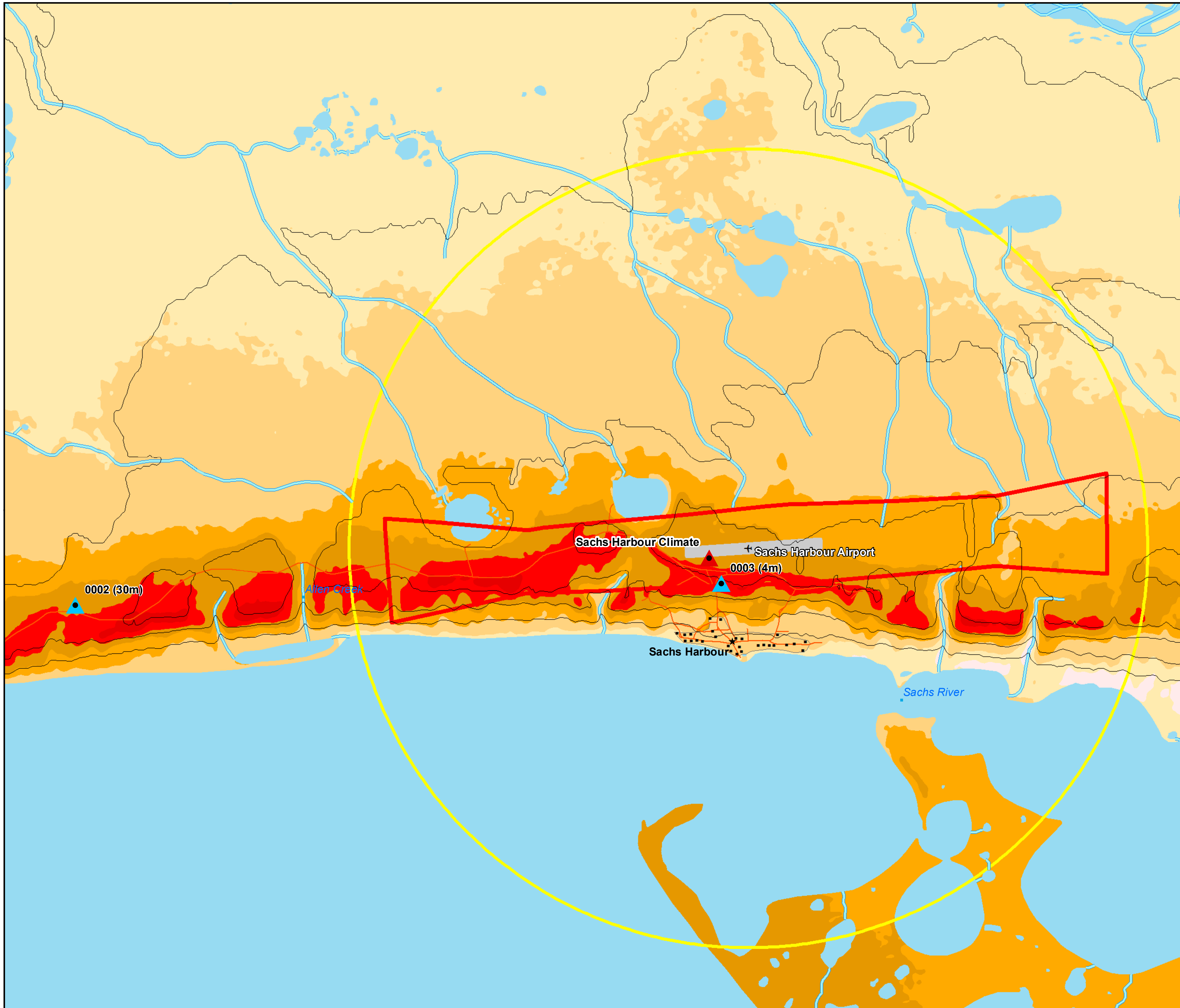
2.3 Wind Flow Map

The long-term wind resource estimated at each station was used to compute the wind flow across the project area. The wind flow was calculated with WAsP 11.04.0025 software, an appropriate model for the Sachs Harbour project area which exhibits low terrain complexity.

Two wind resource maps were computed over a project area covering all selected sites and then combined into a single wind resource map by a squared distance weighting process.

Cross prediction tests were made between the Met stations with each calculated wind flow before merging. The wind speed prediction errors were 2.0% on average. These wind speed prediction errors provide an estimate of the modelling error and the degree of confidence that can be given to the wind flow modelling.

The wind flow map used for energy production estimate is presented on the next page.



Sachs Harbour Project
Wind Flow 1

Legend

- Met Station
- Environment Canada Station
- Building
- Contour line (20m)
- Road
- Watercourse
- Runway
- Wetland
- Waterbody
- Village Area
- Airport Obstacle Restriction Area
- Airport Outer Surface Area (4km radius)

WindFlow

m/s

- 4.8 - 5
- 5 - 5.2
- 5.2 - 5.4
- 5.4 - 5.6
- 5.6 - 5.8
- 5.8 - 6
- 6 - 6.2
- 6.2 - 6.4

Wind resource map created by Hatch with WAsP 11.04.0025
Height of calculation: 38 m
Spatial resolution of wind resource grid: 50 m
Source file: SachsHarbour_BlendSqrd_38m_WF1.asc
Source of data used to create the wind flow:
Topographic data are provided by the Center for Topographic Information (NRCan). Meteorological data were collected from masts 0002 and 0003, located 4 km on average from the center of the map, between 08/07/2005 and 07/07/2008. Data were screened out by Hatch. Met data were adjusted for long term with reference to Environment Canada station Sachs Harbour Climate #2503648 (reference period 2002-2016).Wind flow merging method: Square distance weighted average.It is believed that the present map gives a reliable overall picture of the wind resource. However, it is advised to confirm any information obtained from this map at any location by on-site measurements.

Notes:
1. Spatial referencing NAD 83 UTM Zone 10N
2. Topogaphic Data - Canvec (CanVec is a digital cartographic reference product of Natural Resources Canada (NRCan).
3. Banks Island Migration Bird Sanctuary - Important Bird and Biodiversity Areas in Canada (IBA Canada)

0 0.5 1 2 km

NORTH

1:40,000

Prepared by: HATCH

Prepared for: Northwest Territories

March 27, 2017

3. Project Layout

3.1 Wind Turbine Sites

The wind turbine sites were optimized in a way to maximise energy production and reduce construction costs. The optimization was performed with the WindFarmer 4.2.20.0 software. Environmental restrictions and turbine visual impact also contributed to select the potential turbine locations. The proposed turbine sites may change depending on the consultation of the community and their preferences.

Two sites were selected within the Airport outer surface boundary and two outside the 4 km boundary. The following table presents the coordinates of the turbine sites, altitude and the distance to the Sachs Harbour power plant.

The NPS100 wind turbine model by Northern Power Systems was used as the base case turbine to determine the project layout. See Section 5 for details on the turbine selection process.

Table 3-1 – Wind Turbine Sites (Coordinate System: NAD83)

Site ID	Easting (m)	Northing (m)	Altitude (m)	Distance Between the Sites and Sachs Harbour Power Plant (km)
1	421400	7989146	59	1.2
2	418900	7989149	54	3.6
3	417799	7989000	60	4.7
4	416501	7988900	60	6.0

3.2 Interconnection

The electrical collection network is expected to be an overhead line routed along the turbine access roads. The interconnection point is expected to be the closest point on the existing distribution network. An interconnection study will be required to evaluate the saturation of the identified line and either confirm that it can accommodate the rated power output of the wind turbine or detail the line upgrades that would be necessary.

The wind turbines must be connected to a three-phase grid of 60 Hz that is regulated to within ± 15% of its nominal voltage with no more than 3% voltage imbalance, phase to phase. The Northern Power wind turbines have been design specifically for connection to low-voltage utility distribution networks with an integral isolation transformer mounted inside the base of the tower. Northern Power recommends that the connection system to the point of utility grid connection be designed to limit total line loss in the feeder to less than 3% voltage drop/rise. It is hence important to properly size the cabling and any other devices between the turbine and the point of utility connection.

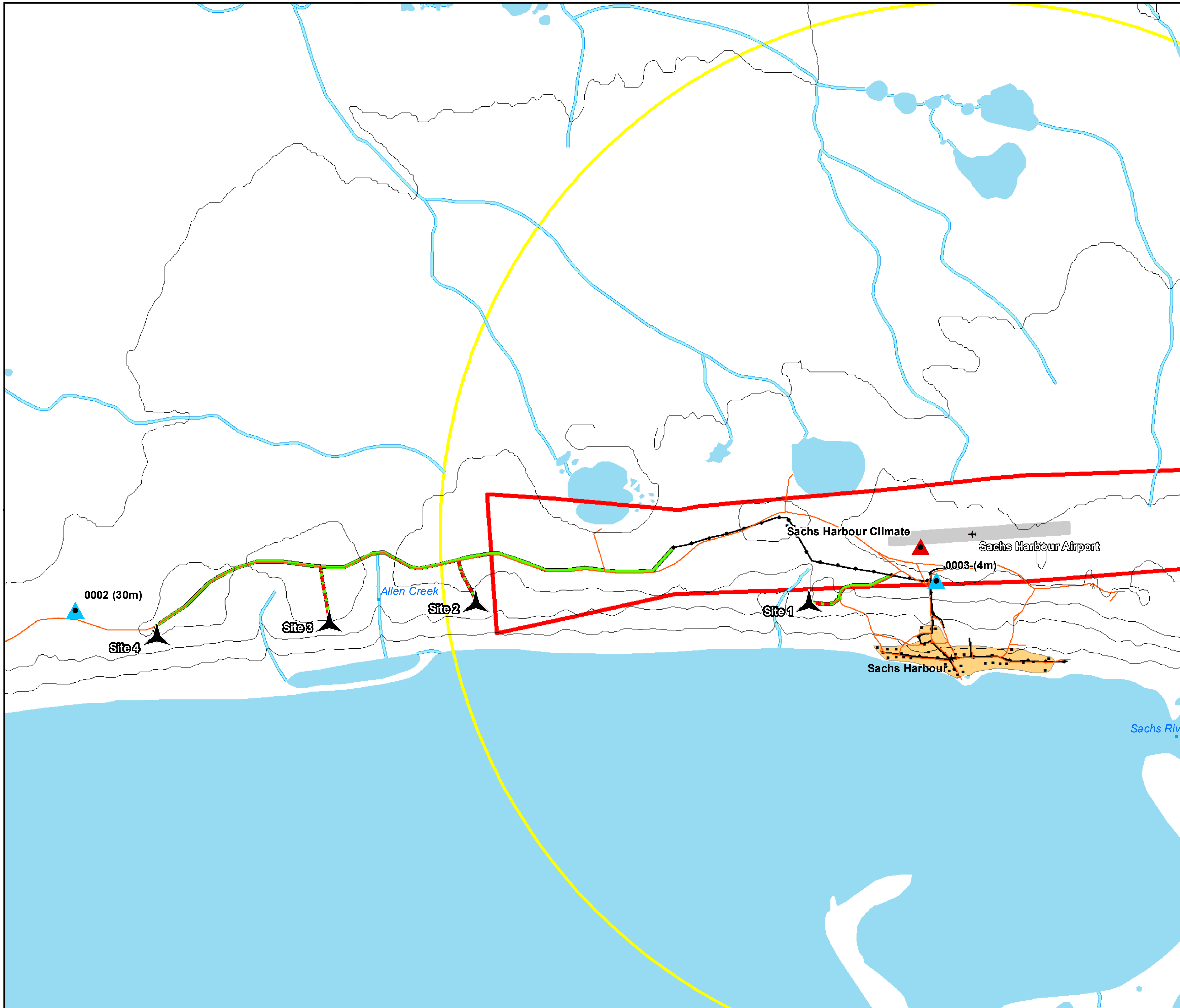
3.3 Road Access

The access road layout was designed in order to provide the shortest route from the existing road to each individual turbine site. Existing roads may require improvements to meet the crane and turbine component transportation specifications. Roads should meet the following constraints.

Table 3-2 – Access Road Constraints

Constraints	Values
Nominal width of carriageway	≥ 3 m
Unobstructed horizontal clearance	≥ 4 m
Unobstructed vertical clearance	≥ 4.5 m
Minimum curve radius outward	≥ 12.5 m
Minimum curve radius inward	≥ 5.5 m
Maximum slope (road)	~ 15%

The site layouts, access road and collector network extension are shown on the following map.



Sachs Harbour Wind Turbine Site Layouts

Legend

- Wind Turbine
- Met Station
- Environment Canada Station
- Building
- Contour line (20m)
- Road
- Watercourse
- Proposed Road
- Distribution Network
- Collector Network
- Runway
- Wetland
- Waterbody
- Village Area
- Airport Obstacle Restriction Area
- Airport Outer Surface Area (4km radius)

Turbine model: NPS100C-24 / Xant M-24
Number of turbines: 1 per site
Site capacity: 95 KW
Turbine rated power: 95 KW
Hub height: 38 m
File reference: SachsHarbour Wind Turbine Sites.txt

Notes:
1. Spatial referencing NAD 83 UTM Zone 10N
2. Topogaphic Data - Canvec (CanVec is a digital cartographic reference product of Natural Resources Canada (NRCan).
3. Banks Island Migration Bird Sanctuary - Important Bird and Biodiversity Areas in Canada (IBA Canada)

0 0.5 1 2 km

NORTH

1:30,000

Prepared by: HATCH

Prepared for: Northwest Territories

March 28, 2017

4. Turbine Selection

4.1 Qualification for Sachs Harbour

Operating a wind plant in Sachs Harbour implies meeting the stability and performance criteria required by utilities plus the specific requirements of the local wind regime, the severe arctic weather conditions and the remoteness of the site. These characteristics, which are evaluated in the turbine selection process, are detailed below.

First of all, the wind turbine manufacturer should present operational experience and wind turbine products that are adapted to isolated off-grid hybrid applications, so that they understand the context, constraints and specificities of operating in a remote environment.

Wind farms need regular maintenance and can be subject to equipment failures requiring intervention of specialized technicians and equipment. Given that accessing the project site is more difficult than at most wind farm locations, it becomes important to evaluate what turbine features will help mitigate the maintenance costs and lower the risk of long turbine shut downs. Displaying high reliability and availability rates will be even more critical in this type of remote project. Turbine reliability refers to low requirements for operation and maintenance (O&M) and lower probabilities of needing major repairs, crane mobilizations, spare parts and interventions of specialized technicians. In Sachs Harbour, unscheduled maintenance events can lead to major cost expenditures and prolonged down time periods. Turbine availability is the capacity to continue operating day-in and day-out through snow, ice, high wind gusts, grid faults and fluctuations.

Located well above the arctic circle, Sachs Harbour experiences severe arctic climate conditions. It is therefore essential to select a wind turbine well suited to this type of climate. Arctic climate requirements are:

- Ability to operate in temperatures as low as -40°C, because the temperature in Sachs Harbour is expected to remain below the -30°C mark for significant periods of time each year;
- Ability to resist blizzard conditions;
- Having a de-icing system to melt the ice off the wind turbine blades and avoid long stops during the windiest winter months is not required but is considered an advantageous feature at this site.

From the measurements recorded at the meteorological stations on site, the annual wind speed observed is in the lower part of the range for commercial wind farm conditions. Consequently, the wind turbine model selected must be suitable for this type of wind regime and be able to produce significant energy at these wind speeds.

The IEC standard defines as class III the wind turbines adapted to such a wind regime.

When operating on a small and closed grid network, a turbine must be able to operate through minor grid faults and cope with voltage and frequency fluctuations without damaging itself. It must also present a low fault current contribution to prevent damaging the electrical equipment at the diesel generator plant site in any event.

4.2 Turbine Selection Process

The previous section lists the particularities of the site with regards to wind turbine suitability, while the current section aims at identifying the best wind turbine model for the project.

Table 4-1 – List of Shortlisted Turbine Models

Model	Manufacturer	Capacity (kW)	Rotor Diameter (m)	Hub Height (m)	IEC Class
NPS100C-24	Northern Power	95	24	37	III
M-24	XANT	95	24	38	III
DW54	EWT	500	54	50	III
E-53	Enercon	800	53	50	III

4.3 Turbine Size

In order to determine the right turbine size, in terms of capacity, a balance has to be attained between avoiding to be too small, leading to negligible fuel savings, and too big, leading to large amounts of excess energy that would not be integrated and would reduce the value of the asset. Also, the physical size of wind turbine components impacts transportation, logistics, hoisting and of course project costs.

4.4 Comparison of Turbine Features

The following table lists the main features identified as important for the Sachs Harbour wind project, and presents which ones are achieved by the wind turbine manufacturers shortlisted.

Table 4-2 – List of Features

Features	NPS	XANT	EWT	Enercon
Experience in remote arctic applications	X		X	X
High energy yield from Class III winds	X	X	X	X
No gearbox (avoids major maintenance)		X	X	X

Features	NPS	XANT	EWT	Enercon
Grid stability features (fault ride through)	X	X	X	X
Operation down to -40ºC	X	X	X	X
Blade de-icing system		X		X
Easy installation (no crane needed)		X		

Northern Power Systems, Enercon and EWT all have extensive track records in Northern Canada and Alaska and can be labelled as “proven for operating in arctic conditions”. The XANT turbine is rated for the Arctic, offers a blade de-icing system and will commission a unit in southern Alaska in October 2017, but it does not offer operational experience in weather conditions that are comparable to Sachs Harbour’s at the moment.

The low penetration scenario is the one detailed in this report. The lower penetration scenario would allow to reduce diesel consumption while keeping investment cost and technological risk to a lower level. Hatch evaluates that turbines in the 100 kW range would be appropriate for this application, leaving the NPS and XANT turbines shortlisted. The NPS model was selected mainly because of its proven northern performance, but the XANT turbine also offers significant advantages.

The XANT turbine entirely fits in a standard container and is tilted up in place, thereby reducing logistics and turbine erection costs. Indeed, it avoids renting specialized blade trailers and a crane. Also, the turbine offers a blade de-icing feature and would produce the same amount of energy as the NPS model in this site’s wind regime.

The EWT model is recommended to take the project to a high level of wind penetration, because of its capacity, cold climate track record and low maintenance technology. It does not currently offer a blade de-icing system, but its cold weather package with black blades has proven reliable in arctic environments such as the Kotzebue, Alaska wind farm at 67º of latitude, commissioned in 2012. Note that a de-icing system is currently under development.

Enercon offers a product that is particularly well suited for this type of application, but it is considered oversized for Sachs Harbour at 800 kW.

For that scenario, battery storage would be required in order to store excess energy and be able to stop the diesel generator, which would allow to increase fuel savings and also save on O&M costs by delaying the date of major generator overhauls and replacements. Lithium-ion batteries in the 200-300 kWh range, coupled with a 200 kW inverter, would be a good starting point scenario. The exact system sizing would need to be optimized through simulation using detailed cost and technical inputs.

All manufacturers offer fault ride through and grid stability features, a more detailed electrical evaluation would have to be performed to quantify the differences or need for any additional compensation equipment.

5. Energy Production

5.1 Annual Energy Production Estimate

The energy production was estimated at each site using the selected two turbine models: the Northern Power NPS100C-24 and the Xant M-24. The calculation was executed with the power curve and thrust curve used for the optimisation and presented in Appendix A.

The air density was corrected by the Windfarmer software for each turbine site according to its elevation.

The following tables provide the estimated energy production for each selected site.

Table 5-1 – Energy Production Summary (NPS100C-24 Model)

Item	Site 1	Site 2	Site 3	Site 4
Wind Turbine Model	**NPS100C-24 Arctic**			
IEC Design Class	IIIA			
WTG Rated Power (KW)	95			
WTG Rotor Diameter (m)	24.4			
WTG Hub Height (m)	37.0			
Number of Wind Turbines	1	1	1	1
Site Capacity (KW)	95	95	95	95
Mean Free Wind Speed (m/s)	6.3	6.1	6.3	6.4
Wake Losses (%)	0.0	0.0	0.0	0.0
Gross Energy Production * (MWh/year)	335.0	323.0	339.0	342.0
Gross Capacity Factor * (%)	40.2	38.8	40.7	41.1
Additional Losses+ (%)	16.3	16.9	17.1	17.2
Net Energy Production (P50) (MWh/year)**	**280.3**	**268.5**	**281.2**	**283.1**
Net Capacity Factor (%)**	**33.7**	**32.2**	**33.8**	**34.0**

* Includes topographic effect

** Includes additional losses

+ Additional losses include all types of environmental and operational losses affecting the production of the wind turbine

Table 5-2 – Energy Production Summary (Xant M-24 Model)

Item	Site 1	Site 2	Site 3	Site 4
Wind Turbine Model	Xant M-24			
IEC Design Class	IIIA			
WTG Rated Power (KW)	95			
WTG Rotor Diameter (m)	24.0			
WTG Hub Height (m)	38.0			
Number of Wind Turbines	1	1	1	1
Site Capacity (KW)	95	95	95	95
Mean Free Wind Speed (m/s)	6.3	6.1	6.3	6.4
Wake Losses (%)	0.0	0.0	0.0	0.0
Gross Energy Production * (MWh/year)	329.0	317.0	334.0	337.0
Gross Capacity Factor * (%)	39.5	38.1	40.1	40.5
Additional Losses[+] (%)	15.3	15.8	16.0	16.2
Net Energy Production (P50) (MWh/year)**	**278.8**	**266.9**	**280.6**	**282.5**
Net Capacity Factor (%)**	**33.5**	**32.1**	**33.7**	**33.9**

* Includes topographic effect

** Includes additional losses

[+] Additional losses include all types of environmental and operational losses affecting the production of the wind turbine

The net energy numbers reported reflect the estimated output available from the wind turbine sites and do not account for the actual amount of energy integrated in the Sachs Harbour grid network.

5.2 Losses

This section provides a description of the estimated losses included in the P50 estimate. These losses include environmental, electrical, availability and turbine performance losses. The P50 is defined as the exceedance probability that denotes the level of annual wind-driven electricity generation that is forecasted to be exceeded 50% of the year. Half of the year's output is expected to surpass this level, and the other half is predicted to fall below it. Loss estimates should be reviewed as more detailed information becomes available.

The losses considered are presented in the following tables.

Table 5-3 – Sachs Harbour Sites Losses (NPS100C-24 Model)

Loss Category	Loss Type	Site 1	Site 2	Site 3	Site 4
Environmental	Blade Soiling and Degradation +	0.5%	0.5%	0.5%	0.5%
	High Wind Hysteresis	0.2%	0.2%	0.2%	0.2%
	Icing	4.1%	4.1%	4.1%	4.1%
	Lightning	0.0%	0.0%	0.0%	0.0%
	High Temperature Shutdown	1.3%	1.3%	1.3%	1.3%
Electrical	Collection Network +	1.3%	1.9%	2.2%	2.4%
	Auxiliary power	1.7%	1.7%	1.7%	1.7%
Availability	Wind Turbines Availability +	6.5%	6.5%	6.5%	6.5%
	Collection Network Outage +	0.7%	0.7%	0.7%	0.7%
	Grid Availability +	0.2%	0.2%	0.2%	0.2%
Turbine Performance	Out-of-range Operations	1.0%	1.0%	1.0%	1.0%
	Total* Losses	**16.3%**	**16.9%**	**17.1%**	**17.2%**

+ Estimated by Hatch according to past experience

* The total is the cumulated effect of the different losses and not their direct summation

Table 5-4 – Sachs Harbour Sites Losses (Xant M-24 Model)

Loss Category	Loss Type	Site 1	Site 2	Site 3	Site 4
Environmental	Blade Soiling and Degradation +	0.5%	0.5%	0.5%	0.5%
	High Wind Hysteresis	0.2%	0.2%	0.2%	0.2%
	Icing	2.9%	2.9%	2.9%	2.9%
	Lightning	0.0%	0.0%	0.0%	0.0%
	High Temperature Shutdown	1.3%	1.3%	1.3%	1.3%
Electrical	Collection Network +	1.3%	1.9%	2.2%	2.4%
	Auxiliary power	1.7%	1.7%	1.7%	1.7%
Availability	Wind Turbines Availability +	6.5%	6.5%	6.5%	6.5%
	Collection Network Outage +	0.7%	0.7%	0.7%	0.7%
	Grid Availability +	0.2%	0.2%	0.2%	0.2%
Turbine Performance	Out-of-range Operations	1.0%	1.0%	1.0%	1.0%
	Total* Losses	**15.3%**	**15.8%**	**16.0%**	**16.2%**

+ Estimated by Hatch according to past experience

* The total is the cumulated effect of the different losses and not their direct summation

5.3 Uncertainty

Sources of uncertainty arise at each step of the wind farm energy yield assessment process, from the location and instrumentation of the meteorology stations to the estimation of losses. Meteorological mast instrumentation does not meet the standards of the wind industry and thus imply higher uncertainty on the resource estimate. In the next project phase, an uncertainty assessment should be undertaken to quantify the project uncertainties.

6. Civil Overview

6.1 Geotechnical description

Only preliminary information is available at this point. A site visit and a geotechnical survey will be required in order to establish the best type of foundation to use and estimate the cost of foundations and of road base construction.

A report from French Arctic Consultants Limited[1] provided preliminary indications on the type of soil in the area. Ice infiltration (ice lens) in the bedrock cracks were reported, which tends to suggest that pile foundations would be required for wind turbine installation. A gravity base foundation would likely not be stable if the ice lens melt down over time and cause the bedrock to shift. This conclusion would of course need to be validated by on-site surveys.

6.2 Civil work

Civil work would include access road extensions, turbine platform with crane pad, overhead collection line with poles and substation. More detail will be provided once the site and turbine model are identified. Road base structure, optimal road geometry and drainage should be studied as the civil design is performed.

7. Logistics

Year-round personnel transportation and community supplies are only available through air transportation. Shipping large cargo items to Sachs Harbour is only possible via ocean freight (barge) during the summer season (July-September). There is no dock in Sachs Harbour and cargo will have to be rolled out from the barge directly to the beach. From there, a dirt road crosses the village and climbs to the top of the hill just north of the community. Depending on the selected site location, the dirt road will either lead directly to the project site or require an extension of no more than a few hundred meters.

Turbine components, interconnection components and project material and equipment will all be shipped to Inuvik by truck in May-June for consolidation. Then the earliest barge will take them to Sachs Harbour and they will return at the end of

[1] Sachs Harbour Granular Inventory, Final Report: March 1992, French Arctic Consultants Limited

the same summer once the project is built. Depending on the site work necessary and the type of foundation selected, the following equipment could be needed: a crane, a drill, trucks with flatbed trailers, a concrete truck with ready mix, accommodation modules. The NPS100 turbine would fit on two flatbed trailers.

According to what is available on site, there could also be a need to bring a truck, a loader, an excavator, a bulldozer, a forklift, a portable Genset and a portable crusher. The cost of renting, shipping and operating such pieces of equipment is high and the solution designed will have to take into account the equipment available and ensure to minimize the use of extra vehicles and machinery. Drilling equipment is listed since the current assumption is that pile foundations will be required, but this may be revised once geotechnical information is made available.

The location of laydown areas should be determined ahead of time, one next to the water and one next to the project site. Exact truck routing through the village should also be confirmed ahead of time with local authorities.

Planning logistics carefully when more detail is available will be a critical part of the project success with regards to meeting the budget and the schedule.

8. Project Schedule

At this stage, the project schedule is not to be used as a baseline schedule for project execution. It was developed in order to establish the overall timeframes of project execution and get an understanding of the critical path.

The schedule includes permitting, engineering, procurement, and the main construction activities needed to complete the wind power project at the Sachs Harbour site. It consists primarily of installing a 100-kW wind turbine, interconnecting it to the distribution network, and integrating the energy production and operations with the existing diesel generator plant.

The overall level of detail is as follows:

		Purpose
• Level 1	Overall Implementation Schedule	Presentation
• Level 2	Summary EPCM by area	Reporting
• Level 3	Detailed Schedule - Project Plan	Control
• Level 4	Vendor and Contractor Schedules	Execution

At the Scoping Study phase, the project schedule is developed at Level 1 detail, with the prime objective to identify main critical path items, schedule constraints and provide a general understanding of the project timeline and the sequence of events.

The Level 2 and 3 schedules will be developed during Pre-Feasibility/Feasibility phases, in line with procurement, engineering and cost estimate activities. The structure of the vendors and contractors plan (level 4) will be aligned with the structure of the overall project plan once orders have been placed.

The development of the current project schedule used several assumptions, including the following:

- Barging season will extend from July 1st to October 1st;
- Project permitting will follow typical timeline and will not require multiple re-submissions;
- Ground is frozen at the project site from October to mid-June. May to June is the thawing season and should be avoided for construction activities;
- The wind turbines will be installed on piled foundations;
- Reasonable time allowance for fabrication and delivery to site;
- Capabilities and productivities of the local firms and contractors;
- No base camp is required at proximity of the construction site.

Proper planning and execution of the logistical strategy will be essential to meet the schedule milestones. Specifically, timing equipment deliveries with the barge sea lifts heading to Sachs Harbour will be critical to meet the schedule. For that matter, the shipment of all equipment from suppliers to Inuvik should be made early to allow time for consolidation.

The general construction execution strategy consists of the following:

The project would be built in one summer season. Required aggregates and concrete to be prepared in June during thaw season, in time for road and foundation work to start in July. Depending on the type of foundation retained, the drilling of piles or concrete forms would be performed, followed by rebar and then concrete pouring when the temperature is warm enough for batch plant operations. After concrete has cured, the tower structure would be assembled with the crane and the rest of the turbine components will be installed in August. The crane and other heavy equipment will head back to Inuvik before the ice makes barging impossible in fall.

Electrical work is performed in parallel with the work conducted at the turbine site, but the critical path is usually associated with the sequence of activities at the turbine described above. The power line and substation are to be executed during the same summer season, at the same time as the roads, foundations and platforms are executed. The transformer, substation equipment and control equipment are all set up, installed, wired and tested in the July-September period, at the same time as the turbines are going up.

The turbine vendor will be responsible for the commissioning of the wind turbine unit after the completion of the installation and tests. Commissioning the substation and the process of integrating the project to the existing powerhouse operations, operator training and the run-in period will be managed by the EPCM firm or contractor and the owner. This commissioning process is to extend into the first quarter of 2019 before the project is deemed fully operational.

Other considerations with regards to the construction schedule:

- On-site construction labor requirements should be minimized by maximizing pre-assembling and pre-casting opportunities as much as possible.
- Use of local contractors should be maximized where capabilities and project requirements coincide.
- Winter productivity factors need to be applied when evaluating the duration and labor for any work performed in winter.

Table 8-1 – Preliminary Project Schedule

Activity	Time
Feasibility study completed	Sep-2017
Investment decision	Nov-2017
Order wind turbine (and other long lead time items)	Dec-2017
Project execution contract award	Feb-2018
Apply for Transport Canada and NAV Canada authorizations	Feb-2018
Detailed engineering completed	Apr-2018
Ship all equipment to Inuvik	May-2018
Freight consolidation in Inuvik	Jun-2018
Permitting completed	Jun-2018
Maritime transportation from Inuvik to Sachs Harbour	Jul-2018
Required staff flies to Sachs Harbour	Jul-2018
Site preparation (access road and work area)	Jul-2018
Foundation work (including curing)	Aug-2018
Collection network	Aug-2018
Turbine installation	Aug-2018
Substation completed	Sep-2018
Turbine interior finalization and communications	Sep-2018
Turbine testing, electrical testing	Sep-2018

Activity	Time
De-mobilize equipment to barge	Sep-2018
Commission substation	Oct-2018
Commission turbine	Oct-2018
Operator training	Nov-2018
Full integration to diesel plant operations	Jan-2019

This schedule is considered a best case scenario. Significant delays occurring in any phase of the project would push back construction to the summer of 2019.

9. Biological and Regulatory Overview

This section provides a review of the permits required to build a wind turbine in Sachs Harbour, on Banks Island in the Northwest Territories and to describe the main environmental constraints to consider at the planning, construction and operation phases.

9.1 Biological Overview

9.1.1 Protected Areas

There are two (2) Migratory Bird Sanctuaries (MBS) on Banks Island, both established by Environment Canada in 1961, to protect the seasonal nesting and moulting grounds of the Western Arctic's 500,000 Lesser Snow Geese :

1. Banks Island Migratory Bird Sanctuary No.1 (2,019,901 hectares) is the larger of the 2 and is located in the southwest quarter of the island and bordering the Beaufort Sea. Its boundaries surround the hamlet of Sachs Harbour.
2. Banks Island Migratory Bird Sanctuary No.2 (14,302 hectares) is in the Auvalik National Park, along the Thomsen River Valley and the adjacent wetlands.

These two bird sanctuaries are also listed as Important Bird Areas (IBA) by the IBA Program2. The IBA Program also identifies a third zone offshore called the Cape Bathurst Polynia (42, 722.35 km2). It is located in the southwestern part of the island and is selected for its significant waterfowl concentrations.

Finally, there is the Auvalik National Park, created in 1992 by Parks Canada, in the northern part of Banks Island.

The limits of the protected areas located on and around Banks Island are shown in Figures 9-1 and 9-2.

[2] The IBA Program is an international conservation initiative coordinated by BirdLife International. The Canadian co-partners for the IBA Program are Bird Studies Canada and Nature Canada.

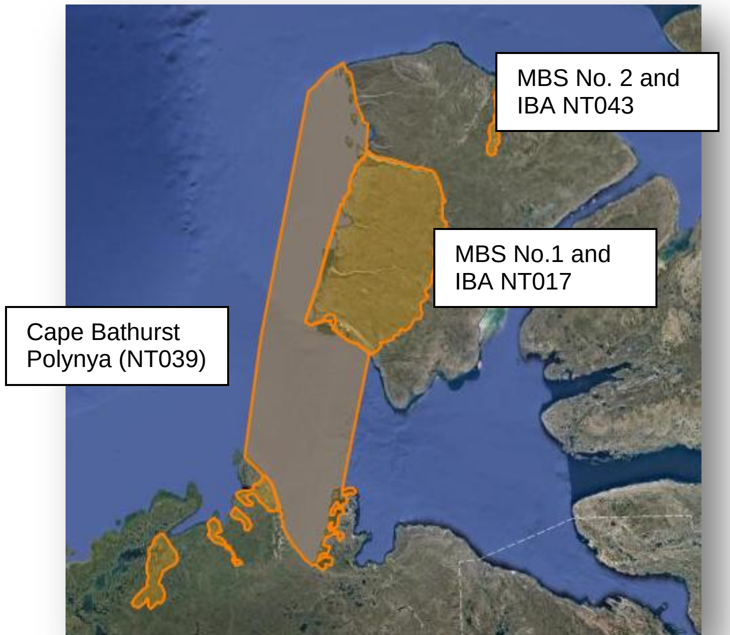


Figure 9-1 – Areas created on and around Banks Islands to protect significant bird concentrations

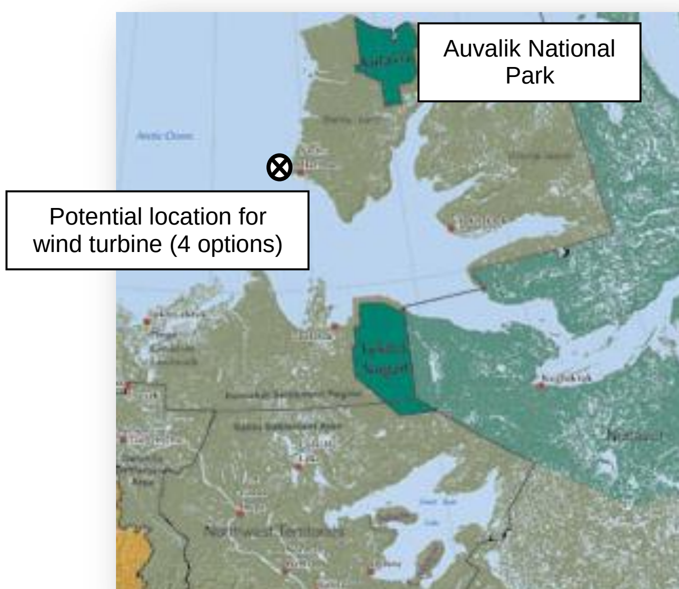


Figure 9-2 – Location of Auvalik National Park on Banks Island

9.1.2 *Vegetation*

Banks Island is treeless. The tallest plant is the arctic willow. In Auvalik National Park, on the northern part of the island, more than 150 flowering species have been documented. The growing season is very brief (from late May until late July with a peak in early July). By late July most of the herbs have gone to seed and the grasses have curved. Autumn in early August witnesses the low arctic willows turning orange. (*Parks Canada, Aulavik National Park of Canada, website consulted March, 28th 2017*)

In general, the vegetation on the southwestern part of Banks Island is characterized by polar desert and polar semi-desert with localized areas of lush plant cover. Low-lying, level areas along the river valleys are well vegetated with grasses and sedges. They grow in abundance in depressed areas where soil moisture is high. Plant cover diminishes upslope and the tops of hills are generally barren with scattered clumps of dwarf shrubs, cushion plants and lichens. *(ECCC, Banks Island MBS No. 1, website consulted March, 28th 2017)*

Given that all four sites proposed for the new wind turbine are located along a ridge exposed to winds, nearby an existing road, the plant cover is expected to be limited. If there is some vegetation, the typical habitat of lands impacted might be similar to what is described for hilltops in the last paragraph.

<u>*Species at risk*</u>

The Banks Island Alkali Grass (*Puccinellia bankasiensis*) has been found growing near the shores of inland freshwater lakes at the southern part of Banks Island. Globally, it is found in the NWT (3 sites), Alaska (1 site), and Nunvaut (4 sites). This species has been ranked “May be at Risk” by the NWT General Status Ranks process. This species has not gone through either national COSEWIC assessment or Species at Risk Act (SARA) processes, nor any processes under the Species at Risk (NWT) Act.

Considering its predilection habitat, the Banks Island Alkali Grass is not expected to be an issue.

The figure below shows the distribution of the Banks Island Alkali Grass on Banks Island.

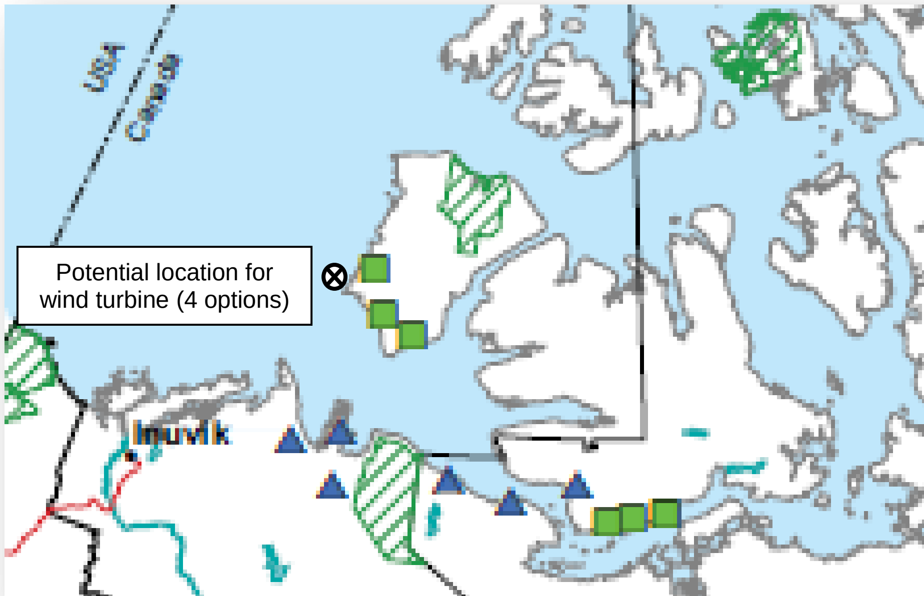


Figure 9-3 – Map showing the distribution of the Banks Island Alkali Grass in the NWT and Nunavut. A green square indicates a confirmed location – 3 sites on the southwestern part of Banks Island. (from GNTW-ENR, 2016)

9.1.3 Wildlife

<u>*Mammals*</u>

On Banks Island, there is a large Arctic Fox population, as well as Caribou, Polar Bears, Wolves, Muskoxen, Arctic Hare, Lemmings, Ermine, Seal and occasionally Grizzly Bears. White and bowhead whales are also common offshore*. (The Canadian Encyclopedia, Banks Island, website consulted March, 28th 2017)*

Polar Bear, Peary Caribou, Arctic Fox and Muskox are listed as major large mammals in the summary table describing the Banks Island MBS No. 1. (*ECCC, Network of Protected consulted on March, 21th 2017*)

However, Banks Island's most abundant large mammal is, by far, the muskox. This species has experienced a dramatic increase in numbers over the last fifty years. (*Parks Canada, Aulavik National Park of Canada, website consulted March, 28th 2017*)

The following figures show distribution of Muskox and Caribou on Banks Island. Given the proposed options for location of the new wind turbine, no major issue is expected regarding wildlife.

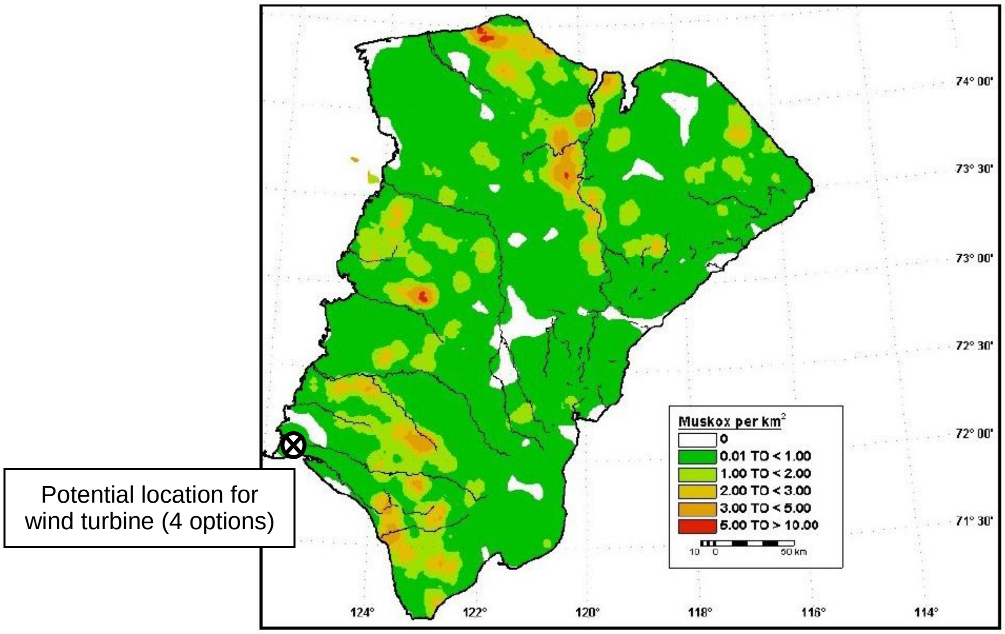


Figure 9-4 – Early July 1998 Distribution of Muskox on Banks Island (from the Sachs Harbour Community Conservation Plan, 2008)

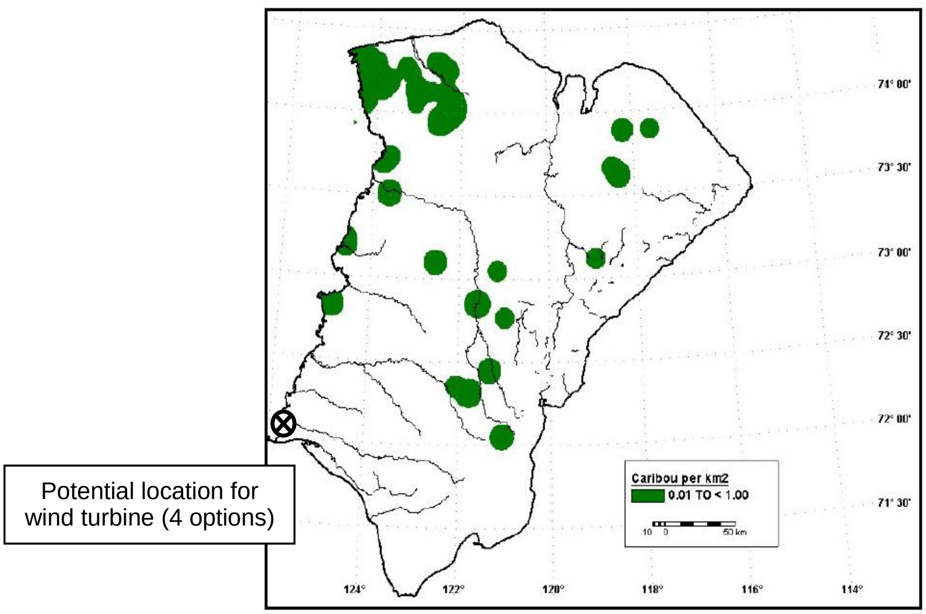


Figure 9-5 – Known Distribution of Caribou on Banks Island, July 1998 (from the Sachs Harbour Community Conservation Plan, 2008)

Birds

A great number of bird species may visit and nest on Banks Island. It is recognized in the Sachs Harbour Community Conservation Plan (July, 2008) that they may be important components of the ecosystem on which other species depend, and also, that they contribute to the quality of life in the area and are an attraction for tourists.

As mentioned in section 9.1.1, Banks Island is the home to the largest nesting population of snow geese in the western Arctic. Within the boundaries of the Banks Island MBS No. 1, this species is well represented, along with Black Brant, King Eider, Oldsquaw, Tundra Swan and Sandhill Crane which are considered as key species. Amongst other species observed are the following birds of prey : the Peregrine Falcon and Snowy Owl.

Wind energy projects could have the potential to adversely affect birds through direct fatalities, disturbance, and habitat loss. Given the proposed options for location of the new wind turbine sites, potential impact on migratory birds should be considered.

Species at risk

Peary Caribou (Endangered), Polar Bear (Special Concern) and Peregrine Falcon (Special Concern) are listed species under the Species at Risk Act (SARA). Peregrine Falcon uses coastal areas with suitable cliff nesting habitat and potential impact on this species should be considered.

9.1.4 Watercourses

There are many watercourses that can be found along the coast bordering the Sachs Harbour Community. The wind turbine should be located at least 100 m from any stream to avoid restrictions regarding excavating activities.

9.1.5 Summary of Biological Constraints

The following table summarizes the main biological constraints at this preliminary stage of the project for the construction of a new wind turbine in Sachs Harbour.

Table 9-1 – Summary of biological constraints for site location criteria

Parameter	Constraints	Location Criteria	Comments
Protected Areas	MBS No. 1 surrounding Sachs Harbour	Not trespass limits of MBS No. 1	Applicable at this stage
Watercourses	Excavation	When excavating Inuvialuit Land within 100m of any stream, excavate at a point that is below the normal high water mark of that stream, except for buried pipelines.	Applicable at this stage
Birds	Potential high bird concentrations around Sachs Harbour	Should not be located near bird colonies, along major bird migration routes, or in areas that could affect a Species at Risk.	Need more specific data

Parameter	Constraints	Location Criteria	Comments
Birds	Migratory Period	Avoid construction phase during migratory period (to be determined)	Need more specific data
Vegetation	Potential presence of Banks Island Alkali Grass (a “May be at Risk” species)	Avoid destruction	Need more specific data

9.2 Regulatory and Permitting Process

This section presents an overview of legal context related to the wind turbine project, and is a summary of the information obtained from the Sachs Harbour Conservation Plan – July 2008. Websites of the Government of Northwest Territories, Transport Canada, NAV Canada and Inuvialuit Regional Corporation were also consulted.

9.2.1 Legal Overview

9.2.1.1 Jurisdictions

The administration of rights on Territorial lands is largely the responsibility of various Federal and Territorial agencies (Government of Northwest Territories - GONT), with Inuvialuit typically providing comment on applications.

Information regarding the use of Territorial lands should be directed to the Government of Northwest Territories Department of Lands.

However, access to Inuvialuit private lands that is more than casual and individual in nature requires permission from Inuvialuit under the Inuvialuit Final Agreement.

9.2.1.2 Inuvialuit Final Agreement

To secure and protect the homeland of the Inuvialuit in the Beaufort Sea Region, known as the Inuvialuit Settlement Region (ISR), the Inuvialuit and the governments of Canada, the Northwest Territories, and the Yukon, negotiated The Inuvialuit Final Agreement (IFA).

Proclaimed on July 24, 1984, the IFA established several new management bodies to help ensure that the land and its living resources are conserved for the benefit of the Inuvialuit :

- Wildlife Management Advisory Councils (NWT and North Slope);
- Fisheries Joint Management Committee;
- Inuvialuit Game Council and Hunters and Trappers Committees : IGC is intended to represent the collective or entire Inuvialuit interest in wildlife and to advise government, often through the WMAC (NWT) and FJMC;
- Inuvialuit Land Administration (ILA) : responsible for managing and administrating *Inuvialuit-owned lands* in the ISR;

- Environmental Impact Screening Committee (EISC) : screens all development proposals on *Crown lands* within the ISR and offshore;
- Environmental Impact Review Board (EIRB) : Projects which may have significant negative impact are referred to the EIRB.

Review of development proposals within the ISR is carried out in a cooperative manner and primarily involves the ILA and/or EISC-EIRB.

Inuvialuit-owned lands

The ILA manages and administers access to Inuvialuit 7(1)(a) and 7(1)(b) lands (see Figure 9-6). Development proposals are screened by the ILA although they may also be referred to the Environmental Impact Screening Committee by the Inuvialuit.

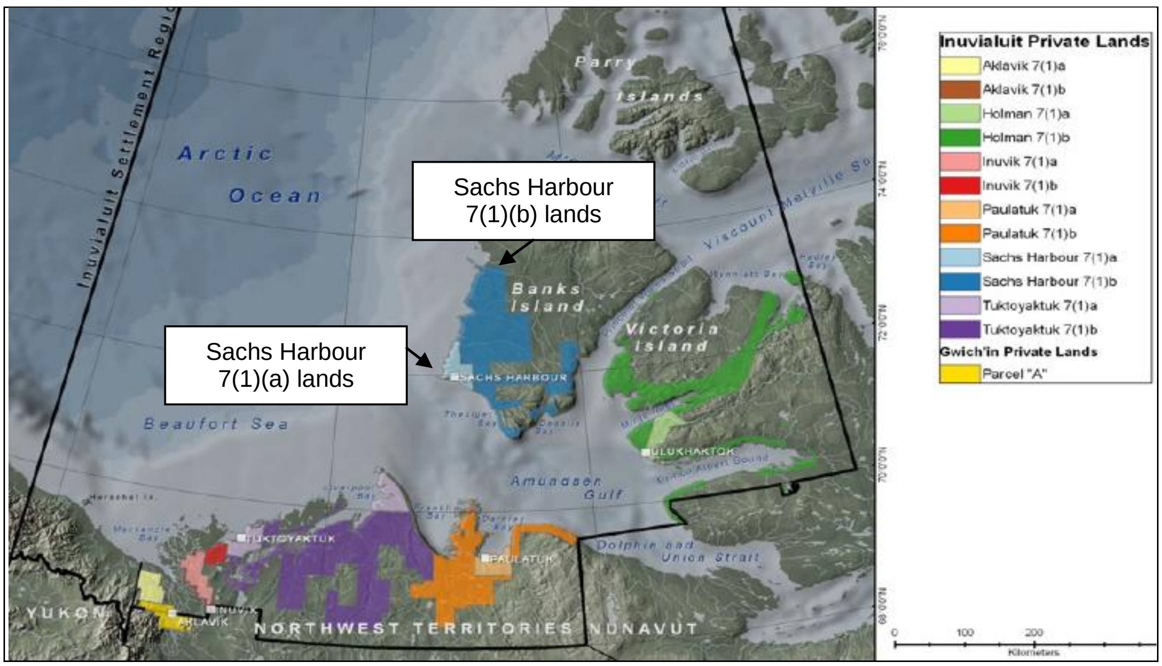


Figure 9-6 – Inuvialuit Settlement Region and Private Lands (from Sachs Harbour Community Conservation Plan, 2008)

All applications submitted to the ILA are distributed to the local HTC's and Community Corporations for review and comment. Final approval of applications is made by the ILAC (Inuvialuit Land Administration Commission) who generally will not grant permits without the support and approval of the HTC and Community Corporation. ILAC has the authority to specify enforceable conditions for attachment to ILA Land Use Permits on Inuvialuit 7(1)(a) and 7(1)(b) lands.

Crown lands

On Crown lands, within the ISR, non-Inuvialuit bodies, such as Department of Indian Affairs and Northern Development (DIAND), are responsible for attaching conditions to land use permits. GONT-Environment and Natural Resources (ENR) issues wildlife research permits and tourism licenses. The Prince of Wales Northern Heritage Centre issues permits for archaeological research. Within a National Park, Parks Canada issues permits.

Figures 9-7 and 9-8 present an overview of the application review and land use decision processes.

9.2.2 Permits / Environmental Impact Screening and Review

Inuvialuit

According to the previous regulatory review, and given that the new wind turbine (and measurement station) will be built on Inuvialuit 7(1)(a) lands, in the vicinity of Sachs Harbour, a permission is required from the Inuvialuit Land Administration (ILA). ILA utilizes an internet-based Land Use Application System (LUAS), which allows applicants to submit applications and to work with ILA online throughout the project cycle : http://irc.inuvialuit.com/apply-land-use

Also, as in the Inuvialuit Settlement Region, land use permitting is governed by the Northwest Territories Land Use Regulations and the GNTW should be advised using the application form shown in Appendix B.

No environmental impact screening/review is expected. If required though, the project should be entered in the official register of the Environmental Impact Screening Committee : http://www.screeningcommittee.ca/

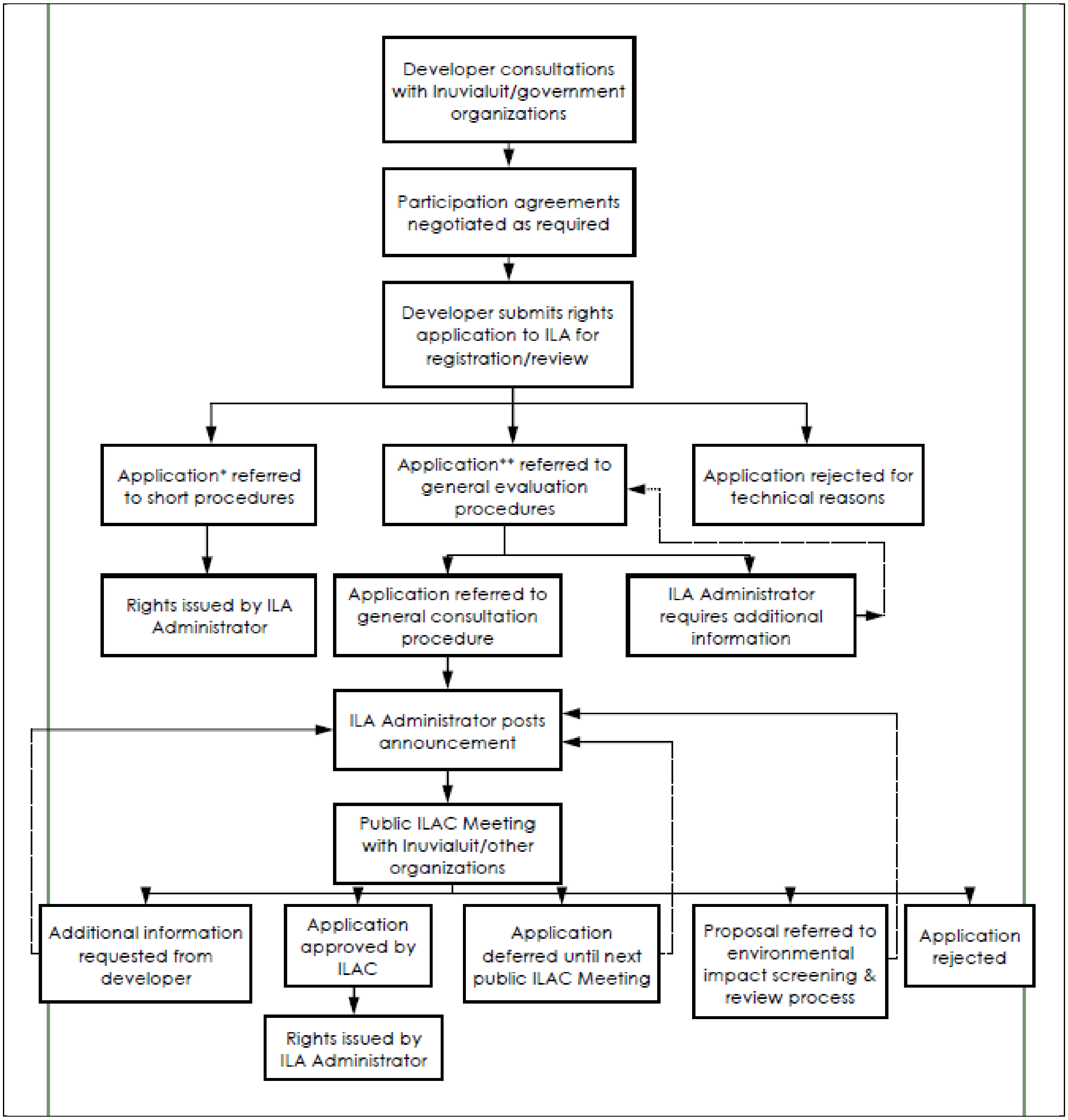


Figure 9-7 – Inuvialuit Land Administration Application Review Process (from Sachs Harbour Community Conservation Plan, 2008)

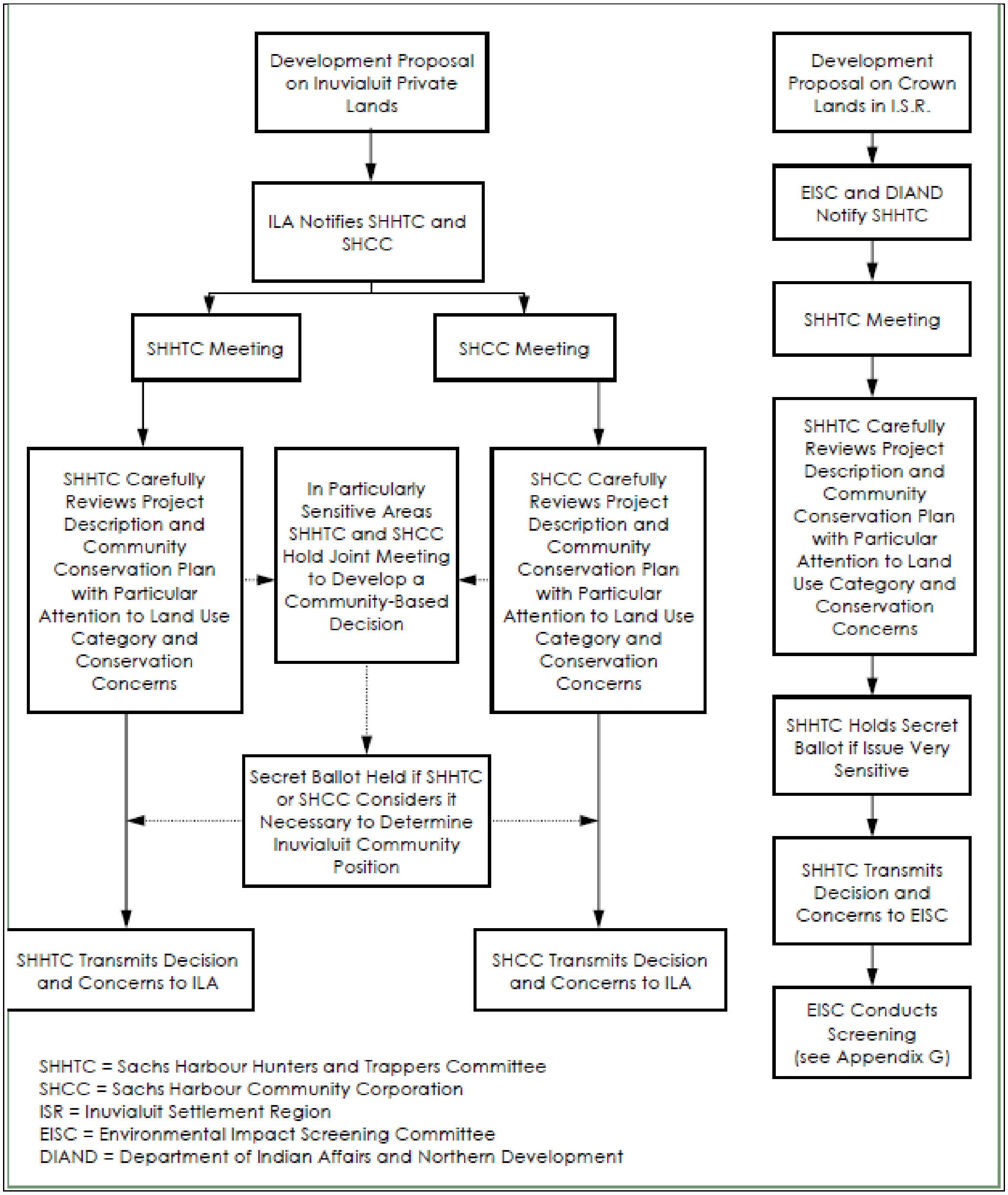


Figure 9-8 – Sachs Harbour Land Use Decision Process (from Sachs Harbour Community Conservation Plan, 2008)

Transport Canada

To be in compliance with the Canadian Aviation Regulations (CARs) 270-1 – Part VI: Standard 621 - Obstruction Marking and Lighting, a person planning to erect or modify an obstruction, namely a building, structure or object, including a moored balloon or kite, either permanently or temporarily, must contact the appropriate regional Transport Canada Civil Aviation office, at least 90 days prior to erection and provide the information on the planned obstruction, using the *Aeronautical assessment form for obstruction marking and lighting* as shown in Appendix B.

The application of the marking and lighting requirements specified in Standard 621 and the approval of equivalent requirements is to ensure that an obstruction to air navigation remains visible at a range sufficient to permit a pilot in visual meteorological conditions (VMC) to take appropriate action in order to avoid the obstruction, by not less than 300 m vertically within a horizontal radius of 600 m from the obstruction. The purpose of obstruction marking and lighting standards is to provide an effective means of indicating the presence of objects likely to present a hazard to aviation safety. Equivalent lighting and marking requirements may be approved depending on terrain features, weather patterns, geographic location, and in the case of wind turbines, depending on the number of structures and overall layout of design.

NAV Canada

Aviation safety may preclude certain land uses near airports or air navigation installations, regardless of whether other permits have been obtained.

NAV CANADA must assess and approve all proposals for land use near airports and air navigation infrastructure before construction begins to ensure that air navigation system safety and efficiency are not compromised by proposed land development.

The proposal must be submitted to NAV CANADA using the *Land Use Submission Form* as shown in Appendix B.

10. Project Costs

10.1 Capital expenditures

10.1.1 NPS 100C 95kW, 24.4m rotor, 37m tower

The selected turbine for this scenario is a Northern Power 95kW (NPS 100C-24m). Capital costs have been estimated with respect to each of the four sites identified in this study. Costs of power line extension and road construction were assessed according to the cost estimates given by GNWT. Other costs are based on supplier quotes or similar project costs carried out by Hatch in Northern Canada.

Table 10-1 provides a summary of the project cost for the design, supply, and construction of one NPS100C-24m associated with each of the four site options. Note that the foundation cost is based on a high level cost estimate. Furthermore, given the small diameter of the holes required for the foundations, it is assessed that the drilling equipment will be available at a reasonable cost in Inuvik. This estimate will be revised according to future geotechnical studies for the selected construction site at Sachs Harbour.

Table 10-1 – Summary of Total Project Costs - NPS 100

Item Cost	Site 1	Site 2	Site 3	Site 4
Site Preparation				
Power Line Extension (km)	0.77 km	2.07 km	3.25 km	4.31 km
Power Line Extension ($)	$ 154,000	$ 414,000	$ 650,000	$ 862,000
Road Construction & Clearing (km)	0.24 km	0.33 km	0.41 km	0.06 km
Road Construction & Clearing ($)	$ 180,000	$ 247,500	$ 307,500	$ 45,000
Foundations	$60,000	$60,000	$60,000	$60,000
Site & Crane Pad Construction	$15,000	$15,000	$15,000	$15,000
Subtotal	**$ 409,000**	**$ 736,500**	**$ 1,032,500**	**$ 982,000**
Engineering, Project Management, etc.	$ 544,000	$ 544,000	$ 544,000	$ 544,000
Wind Equipment Purchase	$ 578,770	$ 578,770	$ 578,770	$ 578,770
Installation	$ 331,000	$ 331,000	$ 331,000	$ 331,000
Contingency 10%	$ 186,277	$ 219,027	$ 248,627	$ 243,577
TOTAL	**$ 2,049,047**	**$ 2,409,297**	**$ 2,734,897**	**$ 2,679,347**

Based on this result, it is estimated that the total project cost will range between $2M and $2.7M depending on distance between the selected construction site and the interconnection point. Note that these costs are based on $200,000/km for line extension and $750,000/km for road extension. It is expected that the line extensions will be built alongside of the road in order to limit the cost of this item. Although it is recognized that road construction costs are extremely high at Sachs Harbour, several work-arounds might be considered for road extension during the project design phase in order to limit capital costs.

While the costs of line and road extensions are site-specific, several cost items for design studies and equipment rental are expected to be relatively identical for all sites. Table 10-2 provides the breakdown of these costs.

Table 10-2 – Cost breakdown for sites 1-4 – NPS 100 (without site preparation)

Item Cost	Site 1-4
Engineering, Project Management, etc.	
Owners Cost	$250,000
Environmental Assessment & Permitting	$30,000
Design and Management	$200,000
Geotechnical Investigation and Report	$20,000
Geotechnical Design and input to tendering process	$10,000
Geotechnical construction phase supervision	$10,000
Staff Training	$24,000
Subtotal	**$544,000**
Wind Equipment Purchase	
1x NPS100 Turbine, 24m Rotor, 37m Tower	$432,250
Cold weather package	$25,270
Shipping Vermont to Tuktoyaktuk	$33,250
Shipping Tuktoyaktuk to Sachs Harbour	$18,000
Transformer	$15,000
Control Building	$30,000
Radio / High Speed Communications	$20,000
Monitoring System (included)	$0
Initial Spare Parts	$5,000
Subtotal	**$578,770**
Installation	
Equipment Rental	$125,000
Utility Interconnection	$50,000
Labour- Assembly & Supervision	$80,000
Commissioning	$24,000
Travel and Accommodation	$52,000
Subtotal	**$331,000**

In terms of engineering and project management, the cost breakdown includes the owner's cost incurred by GNWT, the environmental assessment, the geotechnical study as well as the design and management of the project. Thirty man-days of staff training are also included in this cost category for training the local staff to operate the turbine and perform basic maintenance tasks.

In terms of wind equipment costs, the purchasing of the turbine is considered along with the shipping costs between Vermont and Sachs Harbour. Shipping costs include barging costs based on an estimate of $180/m³ for an approximate shipment size of

100m³. Transformer costs are based on a padmount transformer including shipping. Costs for the control building assumes a container-based control building delivered at Sachs Harbour. It is expected that $20,000 will be dedicated to build a nacelle modem on the turbine using either 3G or satellite communication as well as other communication costs for remote monitoring. High speed communication will be required to monitor and control the turbine using the resident control software that is provided with the turbine. Turbine costs include a 2-year manufacturer warranty that covers parts, labour, and freight. Finally, it was indicated by Northern Power that the initial spare parts for the NPS100 turbine represent a cost of approximately $5000 per turbine (to be procured locally if possible).

In terms of installation costs, the crane rental cost is based on the mobilization and demobilization of a 160T all-terrain crane at Sachs Harbour as well as 80 hours of on-site work with the crane (see Appendix C for quotation). This cost estimate assumes that the crane will be shipped separately from the turbine and the rest of the equipment for this project. Shipping is expected to take 7 days between Grande Prairie and Sachs Harbour (including 2/3 days on the barge). The cost estimate of the crane ($125,000 in Equipment Rental) does not include any on-site waiting time. Subsequently, it is assessed that “standby” time for the crane and its crew will cost an additional $3,000 per day. Turbine assembly and supervision costs are based on 100 man-days while commissioning costs include 30 man-days. Labour costs assumes $100 per hour while subsistence costs assumes a cost of $325 per man-day.

Note that integration costs are out of scope of this study (and not included in the cost breakdown). Based on Hatch’s experience, this item will represent an additional cost of approximately $80,000 to $100,000 for a resistive load bank and modest modifications on the PLC and Diesel plant. The full extent of this cost should be further assessed in the integration study.

10.1.2 XANT M-24 95kW, 24m rotor, 38m tower

In this scenario, the XANT M-24 turbine was considered instead of the NPS100. This turbine is using a tilt-up towers that is erected from the ground using an auxiliary mast and a pulling device (electrical winch). The foundations for the tower are based on one central foundation and four lateral foundations to connect the guy lines to the ground.

This turbine allows for lower installation costs (i.e. no crane is required) and lower shipping costs (i.e. one turbine fits into a 40ft container which can be used as control room) but encompass higher foundations costs (i.e. four lateral foundations). The price of the turbine and the cold weather package are relatively similar for both turbines.

Overall, a total cost reduction of approximately $155,000 can be achieved with the XANT turbine - as well as reducing the cost uncertainty associated with shipping costs for the crane and the turbine. Energy production estimates are almost identical for both turbines.

Total project costs for the XANT M-24 turbine are presented in table 10-3 with respect to the four selected sites.

Table 10-3 – Summary of Total Project Costs – Xant M-24

Item Cost	Site 1	Site 2	Site 3	Site 4
Site Preparation				
Power Line Extension (km)	0.77 km	2.07 km	3.25 km	4.31 km
Power Line Extension ($)	$ 154,000	$ 414,000	$ 650,000	$ 862,000
Road Construction & Clearing (km)	0.24 km	0.33 km	0.41 km	0.06 km
Road Construction & Clearing ($)	$ 180,000	$ 247,500	$ 307,500	$ 45,000
Foundations	$107,250	$107,250	$107,250	$107,250
Site Clearing	$15,000	$15,000	$15,000	$15,000
Site Preparation Subtotal	**$ 456,250**	**$ 783,750**	**$ 1,079,750**	**$ 1,029,250**
Engineering, Project Management, etc.	$ 544,000	$ 544,000	$ 544,000	$ 544,000
Wind Equipment Purchase	$ 516,972	$ 516,972	$ 516,972	$ 516,972
Installation	$ 206,000	$ 206,000	$ 206,000	$ 206,000
Contingency 10%	$ 172,322	$ 205,072	$ 234,672	$ 229,622
TOTAL	**$ 1,895,544**	**$ 2,255,794**	**$ 2,581,394**	**$ 2,525,844**

The above-presented costs include several cost items for design studies and equipment rental, which are expected to be relatively identical for all sites. Table 10-4 provides the breakdown of these costs.

Table 10-4 – Cost breakdown for sites 1-4 – Xant M-24 (without site preparation)

Item Cost	Site 1-4
Engineering, Project Management, etc.	
Owners Cost	$250,000
Environmental Assessment & Permitting	$30,000
Design and Management	$200,000
Geotechnical Investigation and Report	$20,000
Geotechnical Design and input to tendering process	$10,000
Geotechnical construction phase supervision	$10,000
Staff Training	$24,000
Subtotal	**$544,000**
Wind Equipment Purchase	
XANT M-24 100kW Turbine, 24m Rotor, 37m Tower	$408,980
Cold weather package	$25,740
Shipping to Vancouver	$15,052
Shipping Vancouver to Sachs Harbour	$17,200
Transformer	$15,000
Control Building	$10,000
Radio / High Speed Communications	$20,000
Monitoring System (included)	$0
Initial Spare Parts	$5,000
Subtotal	**$516,972**
Installation	
Erection System (included)	$0
Utility Interconnection	$50,000
Labour- Assembly & Supervision	$80,000
Commissioning	$24,000
Travel and Accommodation	$52,000
Subtotal	**$206,000**

10.2 Operation and Maintenance

With respect to the operating costs of both turbine options, is it assessed that the annual cost will represent $20,000 for one turbine.

Table 10-5 – Breakdown of Operation and Maintenance Costs

Item Cost	Site 1-4
Turbine O&M	$ 12,000
Land Lease Payments	$ 1,000
Site Operations	$ 5,000
Insurance	$ 2,000
TOTAL	**$ 20,000**

More specifically, the annual service contract from Northern Power represents $8000 per machine including $500 in consumables. This cost has been revised to $12,000 considering the remote location and travel costs to reach Sachs Harbour.

Land lease payment has been assessed based on similar lease costs in Northern Communities (but should be further assessed by GNWT). Site operations and insurance costs are based on similar project costs in Northern Canada for one 100kW turbine.

10.3 Cost of Energy

10.3.1 Levelized Cost of Energy (LCOE)

Cost of Energy estimates are based on capital and operation costs given in previous parts of this report. Energy production estimates used in the calculation of the cost of energy have been assessed on the basis of 100% of the net turbine output. A future integration study should further characterize the extent of wind curtailment for this turbine size with consideration for the expected electricity load of Sachs Harbour.

Table 10-6 and 10-7 present the levelized cost of energy (LCOE) for the NPS 100 and Xant M-24, respectively. This cost is presented for an investment period of 20 and 25 years. Note that a nominal discount rate of 4.91% and an inflation rate of 2% have been used to calculate the LCOE.

Table 10-6 – LCOE: NPS100

	Site 1	Site 2	Site 3	Site 4
Energy Production (GWh/yr)	0.280	0.269	0.281	0.283
CAPEX (M$)	2.05	2.41	2.73	2.68
OPEX (M$)	0.02	0.02	0.02	0.02
LCOE 20 years (¢/kWh)	**55.61**	**66.95**	**71.60**	**69.82**
LCOE 25 years (¢/kWh)	**48.43**	**58.14**	**62.05**	**60.53**

Table 10-7 – LCOE: Xant M-24

	Site 1	Site 2	Site 3	Site 4
Energy Production (GWh/yr)	0.279	0.267	0.281	0.283
CAPEX (M$)	1.90	2.26	2.58	2.53
OPEX (M$)	0.02	0.02	0.02	0.02
LCOE 20 years (¢/kWh)	**52.25**	**63.53**	**68.13**	**66.36**
LCOE 25 years (¢/kWh)	**45.58**	**55.24**	**59.10**	**57.59**

Based on these results, it can be observed that the LCOE is ranging between ¢45.6/kWh and ¢69.8/kWh depending on turbine type and site location. Further, a 5% LCOE reduction can be achieved by using the Xant turbine instead of the NPS alternative.

These LCOE results can be compared against the marginal cost of diesel generation in order to determine the economic feasibility of each options. This marginal cost has been evaluated at ¢46/kWh based on a diesel price of $1.42/litre and an efficiency of 3.08 kWh/litre (which represent the historical diesel cost and efficiency at Sachs Harbour). This marginal cost does not include O&M costs as it is expected that similar O&M costs for the Gensets will be incurred while integrating a 95kW turbine size. Carbon tax, which can contribute a significant additional fuel cost has not been considered here.

Using this marginal cost of diesel generation, it is assessed that the only option that presents economic benefits is site 1 with the XANT turbine (for a 25 years investment period). Other turbines and site options have energy costs situated above the marginal cost of diesel.

10.3.2 Sensitivity Analysis: Road Construction Costs

Based on the information received from GNWT, it was assessed that several work-arounds could be found to reduce the cost of road construction. Given the high cost of this item (i.e. $750,000/km), it is relevant to provide a sensitivity analysis that accounts for a lower road construction cost. Hence, in this scenario, it is assumed that significant work-arounds will be identified and that road construction costs will be reduced to $200,000/km.

Based on these new parameters, the revised LCOE values are given in the following tables.

Table 10-8 – LCOE Sensitivity: NPS100 (low road construction cost)

	Site 1	Site 2	Site 3	Site 4
Energy Production (GWh/yr)	0.280	0.269	0.281	0.283
CAPEX (M$)	1.90	2.21	2.49	2.64
OPEX (M$)	0.02	0.02	0.02	0.02
LCOE 20 years (¢/kWh)	**52.17**	**62.02**	**65.75**	**68.97**
LCOE 25 years (¢/kWh)	**45.50**	**53.94**	**57.07**	**59.81**

Table 10-9 – LCOE Sensitivity: Xant M-24 (low road construction cost)

	Site 1	Site 2	Site 3	Site 4
Energy Production (GWh/yr)	0.279	0.267	0.281	0.283
CAPEX (M$)	1.75	2.06	2.33	2.49
OPEX (M$)	0.02	0.02	0.02	0.02
LCOE 20 years (¢/kWh)	**48.80**	**58.57**	**62.26**	**65.51**
LCOE 25 years (¢/kWh)	**42.64**	**51.01**	**54.10**	**56.86**

Interestingly, it can be observed that, if the road construction cost can be lowered significantly, the NPS100 turbine now provides economic benefits for site 1 (over 25 years) – as the LCOE is below the marginal cost of diesel generation. Further, the LCOE of the XANT turbine is now ¢3/kWh below this marginal cost, hence increasing the return on investment of this project.

10.3.3 Sensitivity Analysis: Economies of Scale

Above-mentioned project costs are based on the design, supply, and installation of one 95kW turbine at Sachs Harbour (before integration costs). Those estimates include significant fixed costs that can be reduced if more than one turbine were to be installed, hence delivering economies of scale.

Specifically, it is assessed that the cost of installing a second turbine will be significantly reduced as no additional costs for line extension, road construction, engineering, and project management will be incurred. As a result, the total project cost for a second turbine is $930,000 and $850,000 for the NPS100 and the Xant M-24, respectively - as opposed to $2M+ for the first turbine.

Tables 11-10 and 11-11 provide the levelized cost of electricity for 1, 2, and 3 turbines. Note that scenarios with three 95kW turbines would definitely imply operating the project in high wind penetration and therefore require energy storage solutions.

Table 11-10 LCOE in ¢/kWh of the NPS 100 for 1, 2, and 3 turbines over an investment period of 20 and 25 years

	20 years			*25 years*		
	1 Turbine	2 Turbines	3 Turbines	1 Turbine	2 Turbines	3 Turbines
Site 1	55.6	42.4	37.9	48.4	37.1	33.4
Site 2	66.9	48.7	42.6	58.1	42.6	37.4
Site 3	71.6	50.3	43.2	62.1	43.9	37.9
Site 4	69.8	49.3	42.5	60.5	43.1	37.2

Table 11-11 LCOE in ¢/kWh of the XANT M-24 for 1, 2, and 3 turbines over an investment period of 20 and 25 years

	20 years			*25 years*		
	1 Turbine	2 Turbines	3 Turbines	1 Turbine	2 Turbines	3 Turbines
Site 1	52.3	39.9	35.8	45.6	35.1	31.6
Site 2	63.5	46.2	40.4	55.2	40.4	35.5
Site 3	68.1	47.8	41.0	59.1	41.8	36.0
Site 4	66.4	46.8	40.3	57.6	40.9	35.4

Interestingly, it can be observed that significant economies of scale can be obtained by installing more than one turbine at Sachs Harbour. It is assessed that, by installing three instead of one turbine, the LCOE of wind power generation is below the marginal cost of diesel generation for both turbine types at all sites over 20 years.

However, it should be noted that the above-mentioned LCOE values are based on the assumption that 100% of the wind power can be integrated in the local grid – and do not account for spacing-related losses.

An integration study is therefore required to determine the optimal number and size of turbines, and, the potential for high renewable penetration at Sachs Harbour. Based on Hatch's experience, a high renewable penetration project provides a number of additional benefits, including:

- Reduced O&M costs for the diesel plant (as gensets can be completely turned off during high wind period);
- Additional fuel and CO_2 savings – typically in the range of 50 to 70% of the annual consumption;
- Additional spinning reserves and backup capacities (i.e. battery)

These high penetration benefits can be quantified through an optimization model that accounts for supply and demand parameters in order to determine the solution that presents the most benefits for Sachs Harbour. Such detailed modelling is to be performed in the integration study.

11. Recommendations

- In order to reduce the wind project uncertainty regarding the wind resource, it's recommended to install a 30m Met mast in the vicinity of site 1 to better assess the wind regime at this selected site. The Met station 0003 presents high level of uncertainty due to the over-speeding issue. Alternatively, a four month wind monitoring Lidar campaign be performed at possibly reduced cost during the high wind season (s).
- Based on the energy production estimates and the capital expenditure associated with each site, it is assessed that economic benefits can be delivered to Sachs Harbour using site 1 with the XANT turbine. The NPS 100 turbine would also provide economic benefits if the cost of road construction could be lowered significantly.
- While the other sites than site 1 present interesting features in terms of distance from the community, the LCOE of these sites is consistently higher than the marginal cost of diesel generation – mostly due to the additional costs of transmission line extensions. It is assessed that these projects could be economically profitable if government subsidies could be raised to compensate for the cost of line extensions.
- The size of the selected turbines is based on a low/medium renewable penetration. Additional renewable capacities along with energy storage capacity would reduce the percentage of fixed project costs and consequently improve the economics of the project. Detailed modelling study should be performed in the future to model the high penetration potential for diesel power, wind turbines, and battery alternatives at Sachs Harbour as this option lead to significant fuel reduction, reduced O&M costs, extend lifetime of generators and lead to greater environmental benefits.
- In terms of cost uncertainty, installation costs should be reassessed once the geotechnical studies have been performed for the selected site. An integration study should be also carried out to assess the extent of the required modifications on the PLC and diesel plant.

12. References

Landberg, L. (1997). **The Mast on the House**. In R. Haunter (Ed.), Wind energy conversion 1997 (pp. 167-172).

Larter, N.C., Raillard, M. Epp. H. and J.A Nagy (2009). **Vegetation Mapping of Banks Island with particular reference to Auvavik National Park**. File Report No. 138, 32 p.

Community of Sachs Harbour, Wildlife Management Advisory Council (NWT) and Joint Secretariat (2008). **Sachs Harbour Community Conservation Plan.** 98 p. and Appendices.

Government of the NWT-Environment and Natural Resources (2016). **Species at risk in the Northwest Territories**. 96 p.

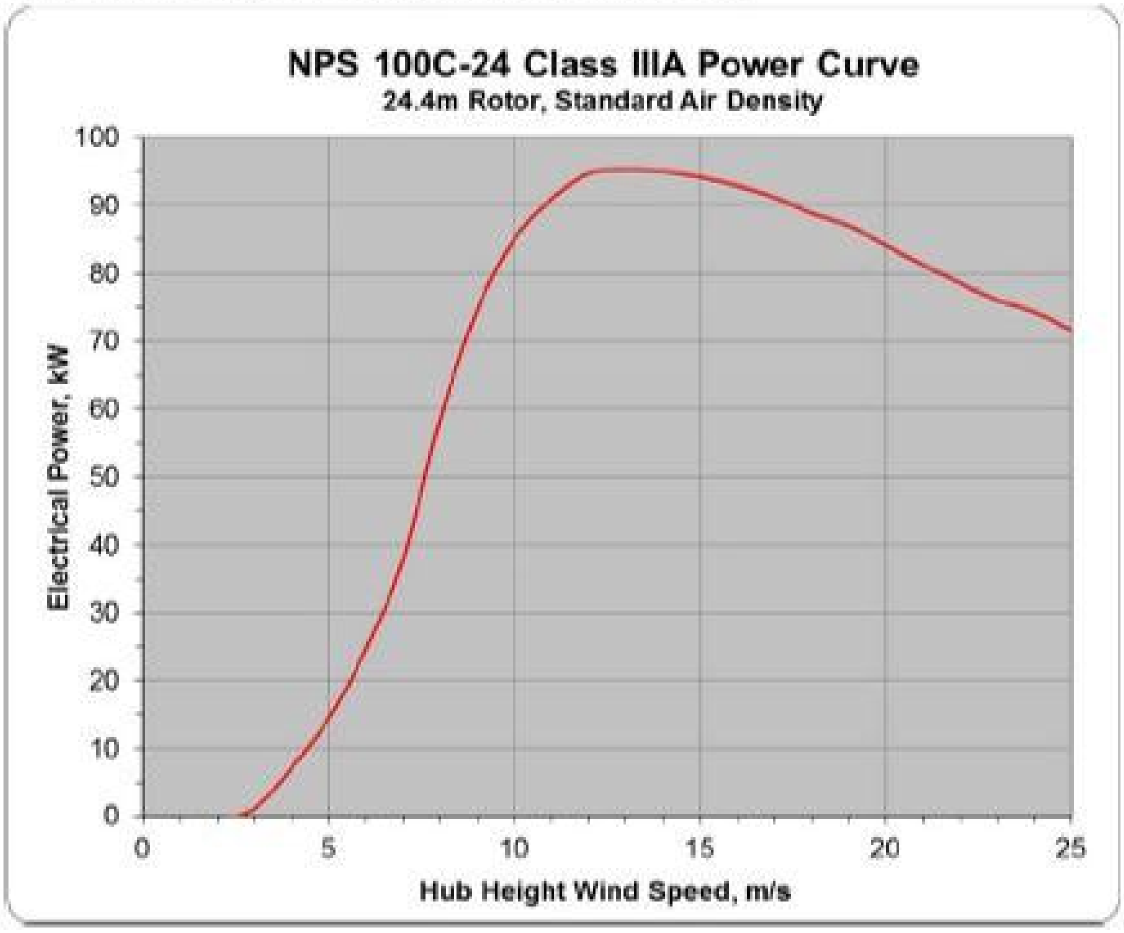
French Arctic Consultants Limited (1992). **Sachs Harbour Granular Inventory, Final Report: March 1992**. 53 p.

Appendix A

Wind Turbine Power And Thrust Curves

The following power curve is intended for use in estimating annual energy production. Power performance is based on standard conditions (air density of 1.225 kg/m^3). Annual energy calculations are based on Rayleigh wind speed distribution and 100% turbine availability.

Power curve is subject to change based on field testing.



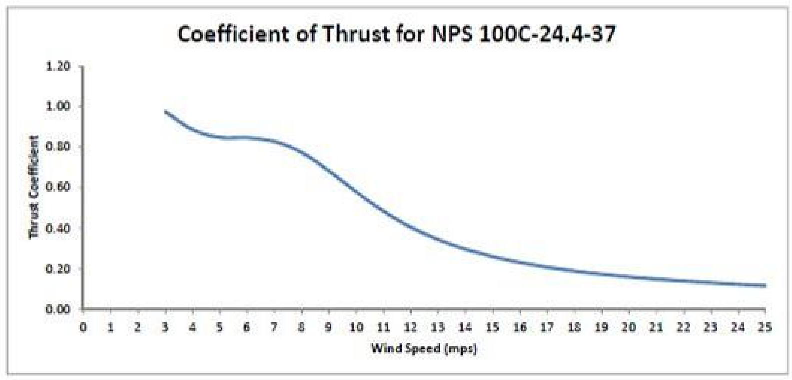
Power Curve Data	
Wind Speed (m/s)	Power (kW)
1	-0.5
2	-0.5
3	1.2
4	7.2
5	14.5
6	24.7
7	37.9
8	58.7
9	74.8
10	85.1
11	90.2
12	94.7
13	95.3
14	95.1
15	94.2
16	92.9
17	91.2
18	88.9
19	87.1
20	84.1
21	81.3
22	78.6
23	76.1
24	74.3
25	71.7

Annual Energy Production (AEP)	
Average Annual Wind Speed (m/s)	Annual Output (MWh)
5.0	196
5.5	240
6.0	284
6.5	325
7.0	364
7.5	400

AEP and Performance estimates based on Rayleigh distribution at standard conditions, 0.12 turbulence intensity at 15 m/s, and 100% availability.

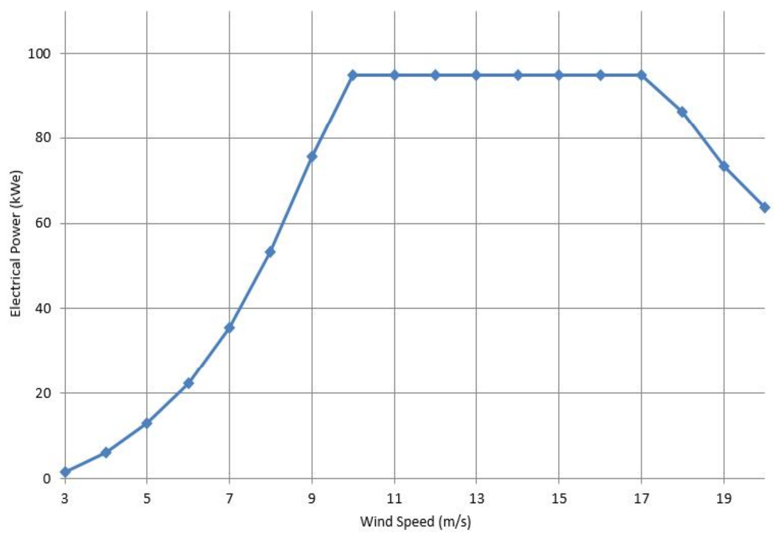
NPS 100C-24.4-37 Coefficient of Thrust Curve

Wind Speed mps	Thrust Coefficient	Rotor Speed RPM
3	0.975	26.3
4	0.886	28.9
5	0.847	33.9
6	0.846	40.6
7	0.827	46.0
8	0.774	48.8
9	0.682	49.4
10	0.579	49.6
11	0.483	49.6
12	0.405	49.6
13	0.344	49.6
14	0.297	49.6
15	0.260	49.6
16	0.231	49.6
17	0.207	49.6
18	0.188	49.6
19	0.173	49.6
20	0.160	49.6
21	0.148	49.6
22	0.139	49.6
23	0.130	49.6
24	0.123	49.6
25	0.116	49.6



3 POWER CURVE AND YIELD

The following power curve is intended for use in estimating annual energy production. Power performance is based on standard conditions (air density of 1.225 kg/m³).
Annual energy calculations are based on Rayleigh wind speed distribution and 100% turbine availability.



Wind Speed (m/s)	Power (kWe)
3	1.45
4	6.13
5	12.99
6	22.46
7	35.66
8	53.23
9	75.52
10	95.00
11	95.00
12	95.00
13	95.00
14	95.00
15	95.00
16	95.00
17	95.00
18	86.28
19	73.30
20	63.63

Figure 1: XANT M-24 Power Curve (Standard Conditions)

Table 3: XANT M-24 Gross Annual Energy Yield (AEY)

Average Wind Speed (m/s)	Gross Energy Yield (MWh)	Average Wind Speed (m/s)	Gross Energy Yield (MWh)
4.0	104.0	6.0	278.6
4.5	144.6	6.5	321.1
5.0	188.7	7.0	360.3
5.5	234.0	7.5	395.6

4 THRUST COEFFICIENT CURVE

The following thrust coefficient curve is usually intended for use in estimating the wake effect within a wind farm. The curve is based on standard conditions (air density of 1.225 kg/m³).

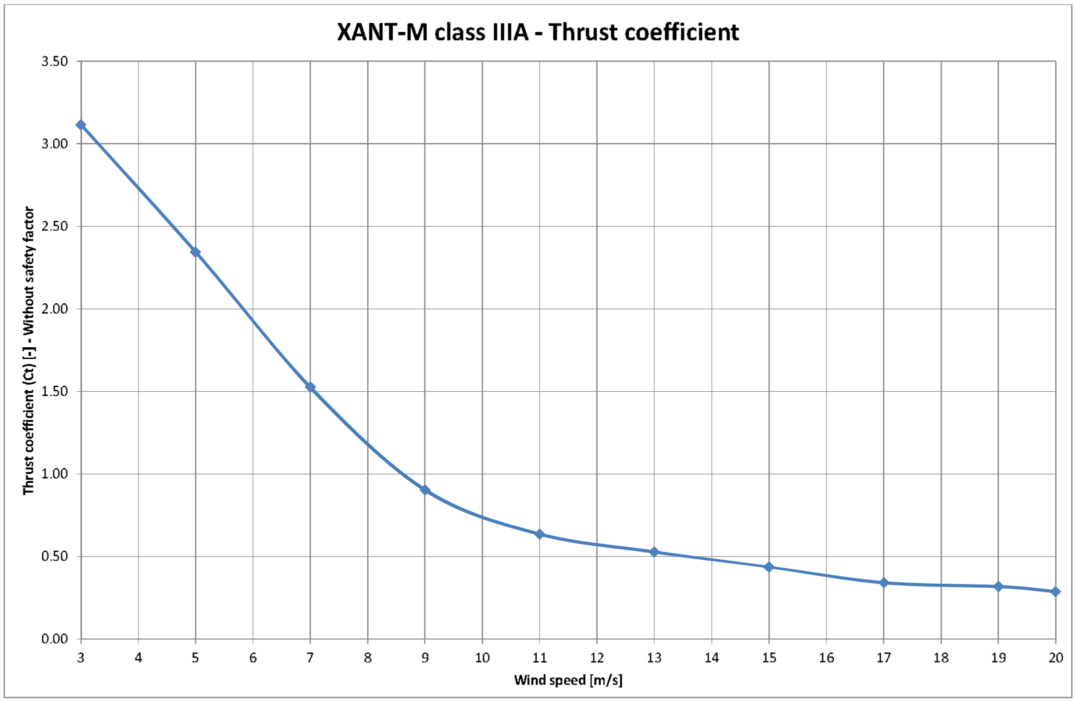


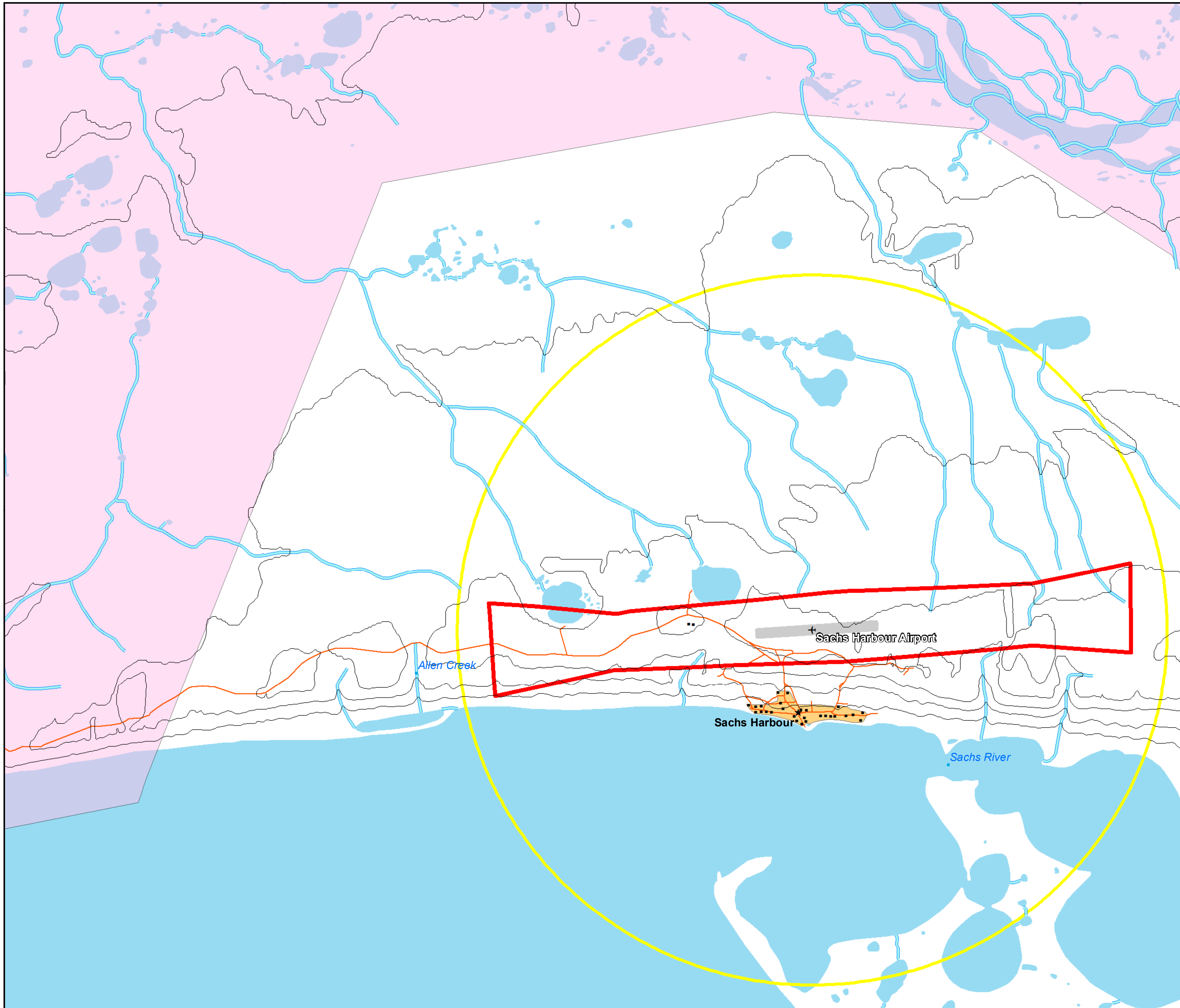
Figure 2 – XANT M-24 Thrust coefficient Curve (Standard Conditions)

Table 4 – XANT M-24 Thrust coefficient Curve (Standard Conditions)

Average Wind Speed (m/s)	Thrust coefficient (-)
3.0	3.12
5.0	2.34
7.0	1.53
9.0	0.90
11.0	0.64
13.0	0.53
15.0	0.44
17.0	0.34
19.0	0.32
20.0	0.29

Appendix B

Environmental Constraints and Permits



Sachs Harbour Project Environmental Constraints

Legend

- Building
- Contour line (20m)
- Road
- Watercourse
- Wetland
- Waterbody
- Village Area
- Runway
- Airport Obstacle Restriction Area
- Banks Island Migratory Bird Sanctuary No. 1 / Important Bird Area (IBA-NT017)
- Airport Outer Surface Area (4km radius)

Notes:
1. Spatial referencing NAD 83 UTM Zone 10N
2. Topogaphic Data - Canvec (CanVec is a digital cartographic reference product of Natural Resources Canada (NRCan).
3. Banks Island Migration Bird Sanctuary - Important Bird and Biodiversity Areas in Canada (IBA Canada)

0 0.5 1 2 km

NORTH

1:45,000

Prepared by: HATCH

Prepared for: Northwest Territories

March 30, 2017

CLEAR DATA

GOVERNMENT OF THE NORTHWEST TERRITORIES
DEPARTMENT OF LANDS

APPLICATION FOR LAND USE PERMIT
(FOR APPLICATIONS IN THE INUVIALUIT SETTLEMENT REGION ONLY)

Privacy Statement
The personal information you provide in this document is being collected under the authority of the *Northwest Territories Lands Act* for the purpose of assessing your application. Your personal information is subject to the protection and disclosure provisions of the Access to *Information and Protection of Privacy Act.* If you have any questions about the collection of your personal information contact Department of Lands, P.O. Box 1320, Yellowknife, NT, X1A 2L9, 867-767-9182 ext. 24452.

For Office Use Only

Application Fee	Land Use Fee	General Receipt No.	Date (YYYY-MM-DD)	Class	Permit Number

To be completed by all applicants ○ New Application ○ Amendment: Permit #

1. Applicant's Name and Mailing Address (Full name, no initials)		Facsimile Number (XXX) XXX-XXX Telephone Number (XXX) XXX-XXX
2. Head Office Address		Facsimile Number (XXX) XXX-XXX Telephone Number (XXX) XXX-XXX
Field Supervisor	E-Mail Address	Telephone Number (XXX) XXX-XXX

3. Other Personnel (Subcontractor, Contractors, Company Staff, etc.)

Total (number of persons on site)

4. Qualifications
Refer to Section 20 of the *Northwest Territories Land Use Regulations*

a(i) ☐ a(ii) ☐ a(iii) ☐ b ☐ c ☐

Number(s) exploration permit mineral claims (If applicable)

5. a) Summary of Operation (Describe purpose, nature and location of all activities.)
Refer to Section 21(2)(b) of the *Northwest Territories Land Use Regulations* (Use last page of form if necessary.)

b) Please indicate if a camp is to be set up (Use last page to provide details.)

6. Summary of potential environmental and resource impacts
(Describe the effects of the proposed program on land, water, flora and fauna and related socio-economic areas.)
(Use separate pages if necessary.)

7. Proposed Restoration Plans (Please use last page if required.)

8. Other rights, licences or permits related to this permit application (Mineral claims, timber permits, water licences, etc.) (Please use last page if required.)

Roads ▶ ◯ Is this to be a pioneered road? ◯ Has the route been laid out or ground truthed?

9. Proposed Disposal Methods (Please use last page if required.)

a) Garbage

b) Sewage (Sanitary and Grey Water)

c) Brush and Trees

d) Overburden (Organic soils, waste material, etc.)

10. Equipment (Includes drills, pumps, etc.) (Please use last page if required.)

Type and Number	Size	Proposed Use

11. Fuels	Number of Containers	Capacity of Containers	Location of Fuel Storage (Please provide co-ordinates.)
☐ Diesel			
☐ Gasoline			
☐ Aviation Fuel			
☐ Propane			
☐ Other: ____________			

12. Containment Fuel Spill Contingency Plans (A spill contingency plan for the proposed activities is to be developed in accordance with GNWT's Guide to *Spill Contingency Planning and Reporting Regulations*. The plan is to be submitted as an attachment to the application form.)

13. Methods of Fuel Transfer (To other tanks, vehicles, etc.)

14. Period of Operation (Includes time to cover all phases of project work applied for, including restoration.)

15. Period of Permit (Up to five years, with a maximum of two years of extension.)	Start Date	Completion Date
	(YYYY-MM-DD)	(YYYY-MM-DD)

16. Location of activities by map co-ordinates (Attach maps and sketches.) - NAD 83

	Degrees	Minutes	Seconds		Degrees	Minutes	Seconds
Minimum Latitude				Minimum Longitude			
Maximum Latitude				Maximum Longitude			

Map Sheet Number

17. Applicant (Print Full Name)	Signature	Date
	Please print and sign	(YYYY-MM-DD)

18. Fees

◯ Class **A** - $150.00 ◯ Class **B** - $150.00		$150.00
Land Use Fees: Less than or equal to 2 hectares	$50.00	$ 50.00
For each additional hectare over 2 hectares or portion of a hectare	X $50.00 =	0.00
Total application and land use fees payable to the Government of the Northwest Territories		0.00

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19. Calculation of area involved (Includes access, staging areas, airstrips, campsites, etc.)

Total Area (Ha)	Less than or equal to 2 hectares	Total (For Fee Calculation)

20. Application Checklist

- ☐ a) Application Signed and Dated
- ☐ b) Fees Attached
- ☐ c) Map Included
- ☐ d) Address and Telephone Number
- ☐ e) Screening Report
- ☐ f) Timber Permit Applied for - Yukon
- ☐ g) Fees Attached
- ☐ h) Lease Applied for

Remarks (Please use last page if additional space is required.)

Accepted by	Date
	(YYYY-MM-DD)

21. Additional Information (Attach additional pages if necessary.)

NAV CANADA

LAND USE PROPOSAL SUBMISSION FORM

Date Received by NAV CANADA		NC file N°./ Ref N°	TC File N° / Ref N°

GENERAL INFORMATION:

Company/Owner Name:	Contact Person:		
Address:	City:	Prov:	Postal Code:
Tel:	Fax:	Email:	24 Hour Emergency Number:
Applicant:	Contact Person:		
Address:	City:	Prov:	Postal Code:
Tel:	Fax:	Email:	24 Hour Emergency Number:
Airport Authority : (If within 6 km of a lighted aerodrome)	Airport Manager:		
Address:	City:	Prov:	
Postal Code:	Tel:	Fax:	Email:

DETAILS OF PROPOSAL:

- Please provide the data in the highest resolution as it was obtained.
- For geographic coordinates, provide up to four (4) decimal places of a second.
- For ground elevation and tower height, provide up to four (4) decimal places of a metre or foot.

Project #, Street Address, etc.:	Nearest Town, Province:		
Geographic Coordinates of Site in NAD 83:	Lat. N (Degrees / Minutes / Seconds) / /	Long. W (Degrees / Minutes / Seconds) / /	
Linear Structures: Indicate Starting Point on 1st line and End Point 2nd line:	Lat. N / /	Long. W / /	
Type of Structure:	New Structure? ☐Yes ☐No	Height Added (If Existing)	☐ft ☐m
Cranes to be used? ☐Yes ☐ No *If Yes*, see *instructions*	Ground Elevation (Above Sea Level)		☐ft ☐m
Dimensions:	Structure Height (Above Ground Level)		☐ft ☐m
Materials & Roof Shape (If Building):	Total Height (Above Sea Level) Structure Height + Ground Elevation		☐ft ☐m
Proposed Construction Start Date:	Approximate Duration of Construction:		
If Temporary Structure, indicate Removal Date:	From: hrs	To: hrs	
Comments:			

ELECTRONIC / TELECOMMUNICATION INTERFERENCE (Check off the items which may cause interference and provide details)

High Voltage Equipment	☐ Details
Arc Welding	☐ Details
Radar Emission	☐ Details
High Powered Transmissions	☐ Details
VHF Radio	☐ Details
Other	☐ Details

OBSTRUCTION TO VISION ON AIRPORT WITH NAV CANADA SERVICES/CONTROL TOWER, FSS, CARS:	
Check the items which may cause obstructions to vision to the installation:	
Line of Sight	☐ Details
Generation of Smoke/Vapour	☐ Details
Reflectivity	☐ Details
Aircraft Parking	☐ Details
Exterior Lighting	☐ Details

MAPS/DRAWINGS (Required for Supporting Documentation)

Proposals for structures not adjacent to an airport OR on airport without NAV CANADA Services

- 1:50,000 topographical map section with the location of the proposed structure clearly marked. The map must contain a legend indicating the map datum (NAD27 or 83) and the contour interval.
- Legal survey (if available)

Proposals adjacent within 2 km from an airport with FSS, Control Tower, Localizer or ILS navigational aids

- 1:50,000 topographical map section with the location of the proposed structure clearly marked. The map must contain a legend indicating the map datum (NAD27 or 83) and the contour interval.
- For localizer/ILS runways, site plan at 1:2000 scale, with distance bar, showing 90° distances to nearest runway centre line/centre line extension, and distance to nearest runway threshold. Note: reference TP 1247 to determine requirement when along an extended centerline of a localizer/ILS runway up to 6 km.
- For buildings, architectural drawings in both plan view (with north arrow indicator) detailing orientation of building and dimensions; and profile view detailing maximum height of building (including rooftop structures) and elevation at grade level.

Proposals on an airport with FSS or Control Tower Services, Weather Services, Localizer or ILS navigational aids

- 1:50,000 topographical map section with the location of the proposed structure clearly marked. The map must contain a legend indicating the map datum (NAD27 or 83) and the contour interval.
- Airport plan at 1:500 scale, with distance bar, showing orientation of structures including vehicle and aircraft entry/exit points.
- For sites with localizer/ILS runways site plan at 1:2000 scale, with distance bar, showing 90° distances to nearest runway centre line/centre line extension, taxiway, and distance to nearest runway threshold. Note: will require drawings for structures up to 6km along the extended centreline of the localizer/ILS runway.
- Site plan depicting entire airport and location of proposed structures and excavations/trenching include depth.
- Site plans at 1:2000 scale, with distance bar, showing line of sight to the mandatory viewing areas (runways and taxiways) identifying existing structures along the sightline in both cross section (profile) view and plan view format. Refer to NAV CANADA sightline requirements for criteria of mandatory viewing areas.
- For buildings, architectural drawings in both plan view (with north arrow indicator) detailing orientation of building and dimensions; and profile view detailing maximum height of building (including rooftop structures) and elevation at grade level.

Applicant/Representative Signature	**Print Name**	**Date**

For a detailed description on NAV CANADA's requirements and additional information, refer to the NAV CANADA website at www.navcanada.ca > PRODUCTS & SERVICES > Land Use Program.

NAV CANADA's evaluation of land use proposals and construction proposals neither constitutes nor replaces any approvals or permits required by Transport Canada, other Federal Government Departments, Provincial or Municipal land use authorities, or any agency from which any approval is required.

Please Submit by email to landuse@navcanada.ca

Processing Times

NAV CANADA will endeavour to provide a response within 8 to 12 weeks of receipt of the proposal. The accuracy and completeness of the initial documentation provided to NAV CANADA, and consequently the cooperation of the proponent to quickly rectify any deficiencies/inaccuracies will go far to expedite the process and ensure a timely response. Electronic submissions will also decrease the time required to properly assess a submission.

Obstruction Marking and Lighting

Transport Canada is required to perform an assessment on the requirement for obstruction marking and lighting of man-made structures per Canadian Aviation Regulations (CAR). Obstructions are assessed by Transport Canada through the Aeronautical Obstruction Clearance Form Process. *Note: outages in obstruction lighting deemed a requirement by Transport Canada are to be reported to Transport Canada as per CAR 601.28.*

Contact Us

NAV CANADA
Aeronautical Information Services
Data Collection Unit / Land Use Office
1601 Tom Roberts
P.O. Box 9824, Station T
Ottawa, ON
K1G 6R2

Website: www.navcanada.ca > PRODUCTS & SERVICES > Land Use Program

Toll Free: (866) 577-0247
Fax: (613) 248-4094
Email: landuse@navcanada.ca *****Preferred method for submission***

Land Use Proposal Submission Form Instructions

This section provides additional instructions for each section of the Land Use Submission Form.

24 Hour Emergency Number: This number may be required for aviation safety purposes.

Airport Authority: If site location is within 6 km of a lighted aerodrome provide the name of the airport and contact information.

Applicant: If not the same as owner, the name of consultant, contractor, or other who is applying on behalf of the owner. Note: all correspondence will be forwarded to the applicant.

Approximate Duration of Construction: Specify time of operation for temporary structures of short duration. This may be required for NOTAMing purposes.

Arc Welding: If any construction taking place on your site requires arc welding, please complete this field. Specify the anticipated duration of arc welding. Welders can potentially interfere with the reliability of the ILS systems of an airport and must therefore be brought to our attention.

Blasting Operations: The following additional information will be required for blasting activities for a Land Use Assessment and possible NOTAM / publication action:

> *Blast Area:* Geographic coordinates (latitude & longitude in NAD83) of the blasting area corners or centre coordinates with a blasting radius.
>
> *Blasting Times:* specify period during the day (for example, daylight hours or 0800 to 1600 local time Monday to Friday, one-time event, etc.).
>
> *Duration of Operation:* estimated amount of time (months/years) expected to operate at specified location.
>
> *Elevations:* Highest ground elevation (above sea level) within blasting zone, maximum height of fly rock or debris (above ground level), and shockwave/overpressure height (above ground level, if applicable). Indicate use of blast mats (if applicable).
>
> *Topographical map:* (1:50 000 scale) depicting the blasting area.

Company/Owner Name: Owner of the proposed structure or development.

Cranes: For construction projects (such as a new building, placement of roof top structures, flare stack, etc.) where a crane will be required and where the maximum operating height will be higher than the overall height of the proposed structure, the applicant is to provide details for both mobile and temporary cranes on a separate submission form **at least 30 working days in advance**. We ask that crane application(s) be cross referenced to the associated construction project and provide detailed crane specifications such as maximum height, boom length and swing radius. A drawing detailing the crane specifications and type would be beneficial, please reference the NAV CANADA Land Use Program web page for more details. *Note: A drawing showing the required specifications indicated below will be beneficial.*

> *Maximum Swing Radius:* In a manner similar to a large structure, a crane with a large swing radius can create a severe horizontal angle with respect to Navigation/Communication/Surveillance equipment, thereby compromising coverage. The maximum swing radius shall be provided so we can properly assess the situation and determine whether or not the swing radius is within an acceptable level. Note: maximum swing radius refers to the maximum that will be achieved during construction and not the maximum achievable swing of the crane (unless that specific setting is being used in the construction).
>
> *Boom Length:* This information is needed to determine the vertical angle of the crane with respect to any nearby NAV CANADA facilities.
>
> *Max Height Achieved During Construction:* This information is needed to determine the worst case scenario for vertical angles between the crane and nearby NAV CANADA facilities.

Date Received: Represents the date the application was received by NAV CANADA Land Use.

Details of Proposal: Project Number, Street address, etc.: A project name, number or street address that can be traced should the owner/applicant require follow-up status on a project.

Dimensions: Indicate structure design specifications. Certain equipment used by NAV CANADA (the radar equipment in particular) can potentially be disrupted by those structures which possess large horizontal dimensions. Such scenarios are assessed by determining the structure's horizontal angle with respect to the NAV CANADA site. For Cranes, include maximum height to which the crane will be raised, boom length and swing radius. A drawing with the specs is desired.

From / To:
Indicate the time of the day when the structure will be raised. For example: 08:00, 13:00
Indicate the time of the day when the structure will be lowered. For example: 11:00, 17:00

Geographic Coordinates: The geographic location in latitude and longitude of the proposed structure/development. Coordinates must be provided in degrees, minutes, and seconds for NOTAM and database updating purposes. It is an ICAO (International Civil Aviation Organization) requirement to provide accuracy to within 1/100th of a second.
For example, N46° 06' 44.67" W064° 40' 43.25".

Geodetic Datum: Coordinates are to be provided in NAD83 only. NAD 27 or UTM coordinates must be converted into the required format; the following are Natural Resources Canada online transformation links (these may change without notice):

NAD 27/83 and Geographic/UTM conversions: http://webapp.geod.nrcan.gc.ca/geod/tools-outils/ntv2.php?locale=en

NAD 27/83 and Geographic/UTM conversions: http://webapp.geod.nrcan.gc.ca/geod/tools-outils/trx.php

Reference the Natural Resources Canada webpage for information on this topic.

Ground Elevation: Should be consistent with the contour interval details shown on the 1:50,000 topographical chart. *Note: GPS readings (when not surveyed) or Google Earth readings are not considered reliable information. Please refer to topographical maps containing contour information or surveyed data. Where ground elevation has been surveyed, the finished grade is to be provided.*

Height Added: The structure currently exists. Specify any increase in height due to an addition.

High Powered Transmission: Such transmissions include AM, FM, or television broadcast signals. Such equipment should typically be located at least 8 km from NAV CANADA facilities. However, any equipment at the proposed site which falls under this category must be mentioned here.

High Voltage Equipment: Any equipment which carries a voltage of at least 2 kV must be mentioned here as such equipment can create electrical interference with NAV CANADA's radar systems. Voltages over 100 kV are especially worthy of mention, as they will potentially interfere with, not only the radar systems, but the ILS systems as well.

Linear Group of Structures: Cable crossing, telephone or power line, should have a beginning and end point of the line. Should there be intersection points along the route, applicant to provide a spreadsheet containing the geographic coordinates and ground elevation.

Note: Groups of Structures (Linear or Non-Linear): Groups of structures that are sufficiently close together can disrupt line of sight radio frequency (RF) coverage in a manner similar to a single, large structure. Therefore, a drawing of the group's layout is required in order to determine its bearing with respect to a NAV CANADA facility. From here, a horizontal angle between the site and the group of structures can be determined in order to assess the risk of coverage shadowing. Note: this requirement will be in addition to the map requirements listed on page 2 of the Land Use Proposal Submission Form.

MAPS/DRAWINGS

<u>1:50,000 topographical map 8.5"x11" sectional with the location of the proposed structure clearly marked.</u> The map submission must contain a legend indicating the map datum (NAD27 or 83) and the contour interval: NAV CANADA will accept the equivalent to the topographical maps produced by Natural Resources Canada which can be obtained digitally (by various mapping software companies) or in paper copy at most map supply stores. This will allow the Land Use Office to confirm possible discrepancies between the location shown on the map and the ground and geographic coordinates provided on the form. It will assist us in referencing where the proposed structure is with respect to the nearest airport, as well as any nearby NAV CANADA sites, and to reference the structures location within an instrument procedure design to determine possible penetration of the obstacle limitation surface on published instrument flight procedures.

<u>Site Plan Depicting Entire Airport and Location of proposed structures:</u> In cases where the proposed structure is close to an airport, within 6 km, or on an airport with a localizer/ILS (Instrument Landing System) runway, it is important to determine where the structure is with respect to any ILS at the airport. For this reason, site plans should include the *entire airport* and have the airport zoomed in as close as possible while still showing the proposed site in its entirety.

<u>Proposals adjacent within 2 km from an airport with FSS or Control Tower:</u> Certain equipment used by NAV CANADA (the radar equipment in particular) can potentially be disrupted by structures that possess large horizontal dimensions. Such scenarios are assessed by determining the structure's horizontal angle with respect to the site in question. This angle cannot be determined unless all horizontal dimensions and orientation of the structure are provided as well as the structure's bearing (that is, the map should include a north arrow).

For localizer/ILS runways, site plan with distance bar at 1:2,000 scale measure distances based at 90° to nearest runway centerline/extended runway centerline, and distance to nearest runway threshold. *Note: reference TP1247 to determine requirement when along an extended centerline of a localizer runway up to 6 km.*

Materials and Roof Shape: Indicate only the <u>dominant</u> materials of the structure, along with any metal which may exist. Indicate whether or not the roof (if applicable) of the structure is flat or sloped. *Note: Certain materials (such as metal) can cause undesirable reflections if they are sufficiently close to NAV CANADA equipment. Mentioning every material being used in the development is unnecessary, but metal in particular is worthy of mention, regardless of whether or not it is the dominant component of the structure. For example: A windmill made entirely of fibreglass with metal strips outlining the blades.*

Metres/Feet: Please identify whether heights provided are in feet or metres. All values will be converted into feet in the Land Use assessment and Notice of Construction as this is the required format for aeronautical publications and database purposes.

All metric/imperial conversions will be calculated as follows:

- Feet to Metres: To obtain metres, multiply the value (in feet) by 0.3048.
- Metres to Feet: To obtain feet, divide the value (in metres) by 0.3048.

NC File Number: If this submission is an amendment or is associated to a previous submission, applicant to indicate NAV CANADA file number assigned to the associated land use submission. For example, Revision to 07-0001 or Reference 07-0001 (building application).

Nearest Town: Closest town to where the development/project will take place.

New Structure: Replacement of a structure is considered a new structure; however, details on the old location and original owner are to be provided in the comments section for NAV CANADA database management. If submitting for an existing structure, NAV CANADA will consider the structure as 'new' if it is not currently recorded in our obstacle database.

OBSTRUCTION TO VISION ON OR ADJACENT TO AN AIRPORT WITH NAV CANADA SERVICES / CONTROL TOWER, FSS CARS: Controller/Specialist visibility requirements are based on dimensions defined in TP312, Aerodrome Standards & Recommended Practices and TP308, Criteria for the Development of Instrument Procedures. These Transport Canada publications define the airspace around aerodromes that has to be maintained free from obstacles to protect aircraft during either "an entirely visual approach or during the visual segment of an instrument approach". An aircraft on approach should be somewhere within this defined airspace, thus, controllers and specialists require line-of-sight to the areas overlying (above) these obstacle limitation surfaces. It is important to note that structures which meet these obstacle limitation surfaces could still interfere with controller/specialist line-of-sight.

<u>Line of Sight:</u> All aerodrome manoeuvring surfaces, unobstructed line-of-sight from the Tower Cab to the mandatory viewing area shall be provided. Line-of-sight is defined as a straight line from the 'ideal' controller/specialist eye-level position, established at 122 cm (48 in or 4 ft) above the floor and 91 cm (36 in) back from the perpendicular glass line, to any object in the mandatory viewing area. Line-of-sight shall not be obstructed by structures, parked aircraft, large vehicles and surrounding terrain/landscaping. Line-of-sight over buildings or other structures shall have a suitable margin of clearance to allow for snow build-up.

<u>Generation of Smoke/Vapour:</u> Line-of-sight can be impaired by visible contaminants such as steam, or heat distortion patterns. Consideration shall also be given to local weather phenomena that would restrict visibility due to fog or industrial haze from off airport sources.

<u>Reflectivity:</u> Line-of-sight can be impaired by direct or indirect sun glare and external light sources such as apron lights, parking area lights, street lights, or reflective surfaces (water pooling).

<u>Aircraft Parking:</u> Line-of-sight can be obstructed by structures such as parked aircraft, large vehicles and surrounding terrain/landscaping.

<u>Exterior Lighting:</u> Line-of-sight can be impaired by external light sources such as apron lights, parking area lights, street lights.

Other: Any high-powered electronic or telecommunications equipment which does not fall under the preceding categories should be brought to our attention if they can potentially interfere with equipment.

Radar Emission: High powered radio frequencies (in the GHz range) will potentially interfere with NAV CANADA radar performance. Any high powered frequencies originating from your proposed structure must be brought to the attention of NAV CANADA.

Reference: TP1247 Land Use in the Vicinity of Airports

Runway Certification Changes: To ensure Instrument Procedures meet design criteria requirements, NAV CANADA must be informed of any changes to runway certification (for example, precision to non-precision, non-precision to non-instrument, etc.). This includes temporary certification changes or changes occurring during a runway closure (the instrument procedure serving a closed runway may still be used for circling or other purposes).

Structure Height: This is the overall height of the structure above ground level.

> *Buildings:* Include roof top structures such as, antennas, advertising boards, architectural features or mechanical rooms above the building height.
>
> *Communication Towers:* Include the tower structure itself plus all appurtenances such as antennas, lightning rods, equipment, and obstruction lights.
>
> *Wind turbines:* Overall height of the structure including blade radius (blade in the 12 o'clock position); and to include height at the hub and blade length.
>
> *Cranes:* Maximum heights to which the crane will be raised when on site include height of mobile crane if used to install a tower crane.

TC Number: Applicant to provide the Transport Canada file number if known.

Temporary Structure: For structures with a planned removal date such as drilling rigs, cranes, meteorological towers, etc., please indicate the estimated removal date.

Total Height: Ground elevation plus the structure height at its highest point.

Type of Structure: The type of structure; for example, Hotel, Drilling Rig, Cranes, Hangar, Development, Wind Turbine, Communication Tower, Meteorological Tower, Flare Stack, Telephone/Transmission line, Cable Crossing, etc. *Note, where the structure is a flag pole, dimensions of maximum flag size is to be stipulated.* Should cranes be required during building construction, please refer to the Cranes section.

> *Tower or Support Structures:* Applicant to indicate whether they are guyed or self-support structures
>
> *Guyed Towers:* Applicant may be required to provide drawing with specifications on number of guyed lines, orientation of the structure (with north arrow) in both plan and profile view if available. Drawings may be required if the proposed structure is in close proximity to a NAV CANADA facility.
>
> *Self-Support Towers:* Applicant to provide a profile view detailing the dimensions of the structure if available. *Note: may be required if the proposed structure is located within 2 km of a NAV CANADA facility.*
>
> *Buildings:* Require architectural drawings in both plan view (with a north arrow indicator detailing the orientation of the building) and a profile (elevation) view (detailing maximum height of building including rooftop structures such as mechanical room, air conditioners, elevator shaft, etc. with the ground elevation at grade level). The North arrow indicator is particularly important in order to identify how the structure is oriented for azimuth calculations. *Note: should cranes be required during construction an additional land use submission will be required for assessment*.

VHF Radio: Frequency and Transmitter Power

VHF consists of all frequencies between 30 MHz and 300 MHz. Such frequencies will potentially cause interference with NAV CANADA's communications equipment. Any frequencies originating from the proposed site which fall within this range must be mentioned here, in order to rule out the possibility of interference.

For situations in which VHF radio will exist at a proposed site, NAV CANADA engineers must perform intermodulation studies in order to ensure that the performance of NAV CANADA communication sites is not compromised. These studies cannot be performed unless the proponent indicates the *specific* VHF frequencies being used onsite. Specify the transmitter power, as this is required to determine whether or not an overlap in coverage will take place.

Wind Farm: For clusters consisting of more than one turbine, the applicant can use one land use proposal submission form with a spreadsheet listing all turbines including turbine number, geographic coordinates (latitude/longitude) in NAD83, ground elevation and structure height. The 'Multiple Obstacle Template' spreadsheet sample is provided on the 'Proposal Submission Procedures' portion of the web site.

Transport Canada / Transports Canada

Transport Canada number
Applicant number

AERONAUTICAL ASSESSMENT FORM FOR OBSTACLE EVALUATION

SECTION 1

Owner's Name		Contact Person
Address		
City	Province	Postal Code
Telephone number (999-999-9999)	Fax number (999-999-9999)	Email Address

SECTION 2

Applicant's Name		Contact Person
Address		
City	Province	Postal Code
Telephone number (999-999-9999)	Fax number (999-999-9999)	Email Address

SECTION 3

Description of Proposal (or as attached)

SECTION 4

Nearest Community	Province

SECTION 5	**SECTION 6**
Nearest Aerodrome	Have you contacted the aerodrome? ◯ Yes ◯ No

SECTION 7	**SECTION 8**
Notice of ◯ New Construction ◯ Change to existing structure	Duration ◯ Permanent ◯ Temporary

SECTION 9

Proposed Construction Date Beginning (yyyy-mm-dd)

SECTION 10

Temporary Structure

From date (yyyy-mm-dd) ______________________ To date (yyyy-mm-dd) ______________________

Transport Canada number

SECTION 11

Geographic Coordinates ☐ NAD83 ☐ NAD27 ☐ WGS84

For multiple structures in a grouping, submit geographical coordinates on a seperate spreadsheet (e.g. windfarms, transmission lines)

N Latitude deg ________ min ________ sec ________

W Longitude deg ________ min ________ sec ________

SECTION 12

Marking and Lighting Proposed (refer to Standard 621)

- ☐ Red lights and paint
- ☐ Red and M.I. white lights
- ☐ White M.I. lights
- ☐ Red and H.I. white lights
- ☐ White H.I. lights
- ☐ No painting
- ☐ No lighting
- ☐ Paint marking only
- ☐ Other (provide description): ________

SECTION 13

Monitoring to Standard 621, article 4.7

- ☐ Visual inspection – 24 hrs
- ☐ * Remote indicator – failure alarm
- ☐ Remote indicator – with self-diagnostic
- ☐ * No monitoring

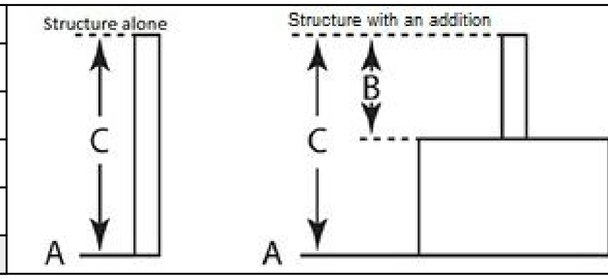
* Mitigation to be detailed in Section 3 – Description

SECTION 14

Catenary/Cable Crossing

- ☐ Paint supporting structures
- ☐ Cable marker spheres
- ☐ Shore markers
- ☐ Support structure lighting
- ☐ Cable marker lights

SECTION 15	Feet	Metres
A Ground Elevation (AMSL)		
B Height of an addition to a structure		
C Total structure height including **B** (AGL)		
Overall height (**A** plus **C**) (AMSL)		



SECTION 16

Does the proposal comply with ***Airport Zoning Regulations***?

◯ Yes ◯ No ◯ N/A

Where the location of the object is on lands affected by ***Airport Zoning Regulations***, a legal survey is required with the submital.

I hereby certify that all the above statements made by me are true, complete and correct to the best of my knowledge. Also, I agree to mark and/or light and maintain the structure with established marking and lighting standards as necessary.

____
Name of person filing notice

____ ____________________
Signature Date (yyyy-mm-dd)

TRANSPORT CANADA ASSESSMENT (Transport Canada use only)

Marking and lighting required (as per Standard 621)

☐ Lighting Required ☐ Marking Required ☐ Temporary Lighting Required ☐ No Lighting or marking required

Completion of this form does not constitute authorization for construction nor replace other approvals or permits. See instruction E and F.

Civil Aviation Inspector	Signature	Date (yyyy-mm-dd

Note 1: This assessment expires 18 months from the date of assessment unless extended, revised, or terminated by the issuing office.

Note 2: If there is a change to the intended installation, a new submittal is required.

USE AND INSTRUCTIONS FOR COMPLETING FORM

A. Purpose of Form: The purpose of this form is to assess the need and application of marking and lighting for objects that may pose a hazard to aviation and to determine conformance to ***Airport Zoning Regulations***.

B. When to Complete the Form: Completed forms, electronic or paper, are submitted at least 90 days prior to all alterations which increase the structure's height; or for proposed new structures if:

- (i) of such a height as to penetrate an airport obstacle limitation surface specified in the *Aerodrome Standards and Recommended Practices Manual* – TP312;
- (ii) within 6 km of the centre of an aerodrome;
- (iii) higher than 90 m AGL within 3.7 km of the centreline of a recognized VFR route such as, but not limited to, a valley, a railroad, a transmission line, a pipeline, a river or a highway;
- (iv) higher than 150 m AGL at any other location; or
- (v) a component of a catenary wire crossing where any portion of the wires or supporting structures exceed 90 m AGL;

C. Proponents are encouraged to make submittal for other objects such as skeletal and solid structures, MET (meteorological) towers, power lines and bridges, in order for the Minister to determine if they constitute a hazard to air navigation in accordance with CAR 601.25.

D. Supporting Data and Documents

- (i) a 1:50,000 scale map, or the most detailed map available showing ground contour elevations to allow determination of the structure's latitude and longitude.
- (ii) sketches, plans or blueprints for structures other than radio or TV antennae.

E. This form does not constitute authority for construction.

F. This form neither constitutes nor replaces any approvals, permits or assessments required by NAV CANADA, Industry Canada, other Federal Government departments, Provincial or Municipal land use authorities or any other agency from which approval/assessment is required.

G. Completed applications are to be forwarded to the applicable Transport Canada Regional office listed in Standard 621, Appendix A.

H. A separate application is to be submitted to NAV CANADA. For a detailed description on NAV CANADA's requirements and additional information, refer to the NAV CANADA Land Use Proposal website at www.navcanada.ca

I. If the proposed construction does not take place, notification is sent to Transport Canada.

Abbreviations

AMSL	Above Mean Sea Level
AGL	Above Ground Level
M.I.	Medium Intensity
H.I.	High Intensity
VFR	Visual Flight Rule

Canada

USE AND INSTRUCTIONS FOR COMPLETING FORM (continued)

Section 1 – The Owner of the structure who is responsible for installation of marking and lighting. Include name, address and phone number of a personal contact point as well as the company name.

Section 2 – The Owner's representative who is making application, if other than Section 1 Include name, address and phone number of a personal contact point as well as the company name.

Section 3 – Provide a narrative description of the proposal

- (a) – MANDATORY - Indicate the type of structure. (e.g. antenna, crane, building, power line, landfill, water tank, wind farm, moored balloon, kite, catenary/cable crossing, etc.)
- (b) – For overhead wires or transmission lines, include size and configuration of wires and their supporting structures (Attach depiction).
- (c) – For each pole/support, include coordinates, site elevation, and structure height above ground level or water. For buildings, include site orientation, coordinates of each corner, dimensions, and construction materials. For alterations, explain the alteration thoroughly.
- (d) – For a proposed wind farm, include a spreadsheet with Turbine ID, geographic coordinates (in minutes, degrees and seconds), height above ground, and ground elevation.
- (e) – For existing structures, thoroughly explain the reason for notifying Transport Canada (e.g. corrections, no record on file with Transport Canada or previous study, etc.).
- (f) – For Catenary crossings, the geographic coordinates for all pertinent support structures are provided along with heights AMSL and AGL including the height of wires above ground or water level.
- (g) – If available, attach a copy of a documented site survey with the surveyor's certification stating the amount of vertical and horizontal accuracy in feet.
- (h) - Description of surrounding environment and structures. Provide photographs of the area of intended installation.

Section 4 – Enter the name of the nearest community, city or town to the site. If the structure is or will be in a community, enter the name of that community.

Section 5 – Enter the name of the nearest aerodrome.

Section 6 – It is recommended that the nearest aerodrome be contacted to resolve any difficulties that the installation may pose to aerodrome operations.

Section 7 – (a) – New Construction would be a structure that has not yet been built.

(b) – Alteration is a change to an existing structure such as the addition of a top mounted antenna, a change to the marking and lighting, a change to power and/or frequency, or a change to the height. The nature of the alteration is included in Section 3 "Description of Proposal".

(c) – Existing would be a correction to the latitude and/or longitude, a correction to the height, or if filing on an existing structure which has not been assessed. The reason for the notice is included in Section 3 "Description of Proposal".

Section 8 – A temporary structure would be such as a crane or drilling derrick.

Section 9 – Enter the date for the start of construction.

Section 10 – Enter the time period during which the temporary structure will be in place.

Section 11 – Latitude and longitude must be geographic coordinates, to within the nearest second or to the nearest hundredth of a second if known. For accuracy of the measurement refer to the International Civil Aviation Organization (ICAO) Annex 15 *Aeronautical Information Services*. For multiple structures in a grouping, submit geographical coordinates on a seperate spreadsheet (e.g. windfarms, transmission lines)

Section 12 – Refer to Standard 621 for requirements of marking and various lighting systems.

Section 13 – Indicate the means that will be used to monitor the status of the lighting and identify the occurrence of a failure.

– Where electronic monitoring with "failure alarm" is provided or there is no monitoring, describe in Section 3 what mitigation will be applied (e.g. long life lamps and annual inspection).

Section 14 – Indicate the form of marking and lighting that is proposed for the catenary crossing.

Section 15 – A – Enter the ground elevation AMSL expressed in metres and feet. This data should match the ground contour elevations for site depiction submitted under Section 3.

B – Enter the height of the object if it is an addition to an existing structure. The height will determine the need for lighting of this object and may affect the heights of intermediate levels of lighting on the structure.

C – Enter the total structure height AGL in metres and feet. The total structure height includes anything mounted on top of the structure, such as antennae, obstruction lights, lightning rods, etc, in addition to the structure itself.

Enter the overall height AMSL. This will be the total of **A** plus **C**.

Section 16 – The survey done by a licensed surveyor attests the conformance of the object height to airport zoning surfaces for the given location.

Appendix C

Crane Quote

March 28, 2017
Quote #2017-105

HATCH
2800 Speakman Drive,
Sheridan Science and Technology Place
Mississauga, Ontario L5K 2R7

Email: joel.guilbaud@hatch.ca
Office: (514) 861-0583

Attention: Mr. Patrick Haak

As per our recent communication I am pleased to submit the following proposal to supply a 160 Ton All Terrain Crane (equipped with 14,600 lbs of counterweight and 197' of live main boom) to erect a 100KW Wind Turbine near Sachs Harbour, NT in 2017.

Arctic Crane to supply:

(1) One 160 Ton Liebherr LTM 1130 5.2 All Terrain Crane
(2) One Crane & Rigging Supervisor c/w pickup
(3) Pilot Car (from Yukon border to Inuvik & return)
(4) Barge Crossing to and from Sachs Harbour
(5) Flights for Operator & Supervisor from Inuvik to Sachs Harbour & return.

Price:

Equipment	Mobilization	Demobilization	Hourly Rate on site
160 Ton All Terrain Crane	$40,100.00	$40,100.00	$480.00
Supervisor c/w pickup	Included above	Included above	$100.00

Notes:

1) Customer to supply adequate access, room, and ground conditions free of charge for equipment transportation and set up.
2) If your schedule requires that work be performed outside normal business hours, Mon – Fri 8:00am – 4:30pm, operator overtime would be charged at $50/man hour.
3) This proposal is based on size and weight information provided at the time of quotation and is subject to change after our review of technical details.
4) Subsistence would be charged at $325.00 per day per person while in Sachs Harbour and $290.00/person/day in Inuvik.
5) Our mob/demob is based on full transport weights (100 % axle weights)
6) Engineering & Rigging Studies available upon request.
7) Permits at extra cost to customer.
8) Quotation is valid for 90 days.

March 28, 2017
Quote #2017-105

9) Arctic Crane Service Ltd. will not be responsible for any possible damages that may occur in parking lots, sidewalks, roadways, grass/landscaping, curbs or pedestrian/traffic control.
10) Purchase order number is required before mobilization is initiated.
11) All applicable Federal and provincial taxes are additional to quoted price (if applicable, provide documentation for PST exemption).

Thank you for the opportunity to quote your project. If you have any questions please feel free to contact me at your convenience.

Regards,

Shane Fraser
General Manager
Arctic Crane Service Ltd.
Cell: (780) 897-6996