Howse Minerals Limited

Howse Mine Property – Environmental Assessment – Noise and Vibration Report

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
0	Brian Bulnes	January 20, 2015	Original document
1	Brian Bulnes	October 29, 2015	Updated to include new mining plan, noise sources, receptors, and address CEAA/Community comments.

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Executive Summary

In accordance with the Canadian Environmental Assessment Agency (CEAA) document *Guidelines for the Preparation of an Environmental Impact Statement – Howse Property Iron Mine,* a noise and vibration assessment is required for the operation of the proposed Howse mining site. This report documents the impact of noise, ground vibration, and blasting overpressure on sensitive receptors surrounding the Howse Mining Site.

The proposed Howse mining site is located in Newfoundland and Labrador, approximately twenty three kilometres northwest of Schefferville, Quebec, near the provincial border of Newfoundland and Labrador, and Quebec. The site will be located in close proximity to the Direct Shipping Ore 3 (DSO3) project. DSO3 consists of Timmins 3, Timmins 4, Timmins 7, and Fleming 7 mining sites, in addition to production plants.

Results of the environmental noise assessment (see Section 4.1.3) indicate that the operation of the new Howse mining site will have an impact of 5dB at receptor R13 (Naskapi-Uashat People's Camp), located northwest of the Howse Mine. The largest contributors to this exceedance are the Howse Mine track drill (used for drilling of holes for blasting at the Howse Mine) and nearby First Nations crusher (located next to the east side of the Howse mining site). It is likely that this impact will result in negative community response. Howse Minerals Limited has committed to preparing a mitigation plan for the Howse mine track drill (the highest source of noise impact), should complaints occur (discussed in Section 4.1.4). Note that the First Nation's crusher contributes to the project noise levels (2^{nd} highest noise impact) causing an exceedance. Addressing noise levels from the First nation's crusher will reduce the likelihood of potential complaints.

The blast impact analysis addresses blasting feasibility based on Quebec's "DIRECTIVE 019-SUR L'INDUSTRIE MINIÈRE, MARS 2012" and the Ministry of the Environment (MOE) Model Municipal Noise Control By-law (NPC 119). Given that mining operations have not been undertaken in the past on this specific property, site-specific blast data is not available. Vibration and overpressure levels from the blasting are predicted using MOE 1985 "Guidelines on Information Required for Assessment of Blasting Noise and Vibration" models. It is a recommendation of this report that a vibration and overpressure monitoring program be initiated onsite upon the commencement of blasting operations to further develop blasting plans. Details on blasting program and monitoring recommendations are provided in Section 4.2.4.

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1. Introduction

In accordance with the Canadian Environmental Assessment Agency (CEAA) document *Guidelines for the Preparation of an Environmental Impact Statement – Howse Property Iron Mine,* an environmental assessment is required for the operation of the proposed Howse Mine site. The proposed Howse Mine is located in close proximity to the Direct Shipping Ore 3 (DSO3) project site. As part of the environmental assessment, this report documents the impact of noise, ground vibration, and overpressure on sensitive receptors surrounding the Howse Mine site.

Noise and Vibration sensitive areas were identified using land use maps, and a DSO3 project site map. These areas include a nearby workers' camp, towns, and Innu, Uashat-Mani-Utenam, and Naskapi camps. Worst case (typically the closest to mining operations) receptors were assessed. Areas further removed from mining operations will receive lower noise and vibration impacts. Receptors are presented in Appendix A and are further discussed in Section 3.

2. Background

The proposed Howse Mine site is located in Newfoundland and Labrador, approximately twenty-three kilometres northwest of Schefferville, Quebec, near the provincial border of Quebec and Newfoundland and Labrador. The site will be located in the vicinity of the DSO3 project. The DSO3 operations include the Timmins 3, Timmins 4, Timmins 7, and Fleming 7 mine sites, in addition to the Main Processing Plant and Plant 2 complexes. Noise sources associated with DSO3 include excavation, drilling, grading, trucking activities, and ore processing (crushing, screening, drying).

The addition of the Howse Mine will result in the following operational changes:

- Additional crushing/screening/drying area near the rail loop (this area is referred to as Howse Mini-Plant)
- Operation of new Howse Mine site
- Increased haul truck and train operations
- Mining plan changes for Timmins and Fleming mine sites
- First Nations crushing plant near Howse Mine

3. Receptors

A number of locations in Newfoundland and Labrador and Quebec were identified as noise and vibration sensitive areas surrounding the production plants and mining sites. These locations included:

- Innu Camps
- Innu-Uashat-Mani-Utenam Camps
- Naskapi Camps
- Workers' Camp
- Towns (Schefferville, Kawawachikamach, Lac John and Matimekush[1])

The study area boundaries were within available land use mapping limits, and include worst case receptors in every direction surrounding the Howse Mine. Fourteen receptors were modelled representing the worst case location (typically the closest to mining operations) of each noise sensitive area. Areas further removed from mining operations will receive lower noise and vibration impacts. Assessment criteria differs between Newfoundland and

[1] *Schefferville was assessed instead of Kawawachikamach, Lac John, and Matimekush as Schefferville is in closer proximity to the mining operations.*

Labrador, and Quebec, therefore criteria for each receptor varied based upon their location. Assessment criteria for both provinces are further discussed in Section 4.1.1.

Table 1 details each modelled receptor and the noise sensitive area(s) it represents. Locations and impact results (further discussed in Section 4.1.3) are presented in Appendix A.

Table 1: Modelled Receptors

Receptor Name	Receptor ID	Province	Description
TSMC Workers' Camp	R40	Newfoundland and Labrador	Workers' camp, located approximately 700 metres south of Timmins 3 Mine site, 5.2 kilometres southeast of Howse Mine.
Innu Tent 1	R7	Newfoundland and Labrador	Innu tent site, located approximately 4.7 kilometres south of Howse Mine site, north of Elross Lake.
Innu Cabin 3	R25	Quebec	Innu cabin site, located approximately 12.8 kilometres east of Howse Mine site, near Lac La Cosa.
Young Naskapi Camp 7 (Pinette Lake)	R9	Newfoundland and Labrador	Young Naskapi camp site on east edge of Pinette Lake, located approximately 950 metres southeast of Howse Mine.
Young Naskapi Camp 3	R10	Newfoundland and Labrador	Young Naskapi camp site, located approximately 1000 metres north west of Howse Mine site, across the river from Irony Mountain.
Young Naskapi Trailer Tent (Triangle Lake)	R11	Newfoundland and Labrador	Young Naskapi trailer site, located approximately 1.6 kilometres northwest of Howse Mine site, southeast of Triangle Lake.
Young Naskapi Camp 5 (Elross Creek)	R12	Newfoundland and Labrador	Young Naskapi camp site on the east side of Elross Creek, located approximately 3.9 kilometres southeast of Howse Mine site.
Naskapi – Uashat People's Camp	R13	Newfoundland and Labrador	Naskapi-Uashat people's camp site on northwest corner of Irony Mountain, located approximately 950 metres northwest of Howse Mine site.
Innu-Uashat-Mani-Utenam Camp 1	R16	Quebec	Innu-Uashat-Mani-Utenam camp site, located approximately 3.2 kilometres north of Timmins 4 Mine site, 3.0 kilometres northeast of Howse Mine.
Innu-Uashat-Mani-Utenam Camp 2	R17	Newfoundland and Labrador	Innu-Uashat-Mani-Utenam camp site located on west side of Irony Mountain, located approximately 2.2 kilometres west of Howse Mine site.
Innu-Uashat-Mani-Utenam Camp 3 (Inukshuk Lake)	R18	Quebec	Innu-Uashat-Mani-Utenam camp site, located approximately 500 metres north of Timmins 7 Mine site, 3.9 kilometres east of Howse Mine.
Innu Cabin 2	R20	Quebec	Innu cabin site, located near Lac Star, approximately 12.5 kilometres southeast of Howse Mine site.
Irony Mountain	R24	Newfoundland and Labrador	Irony mountain, located approximately 1.2 kilometres southwest of Howse Mine site.
Schefferville (Town)	R39	Quebec	Town in Quebec located approximately 15.5 kilometres south east of Fleming 7 Mine site, 22.5 kilometres southeast of Howse Mine.

4. Assessment

4.1 Operations

4.1.1 Criteria

A review of Newfoundland and Labrador Department of Environment and Conservation information has revealed that there are no available noise and vibration guidelines. A review of Canadian Environmental Assessment Agency (CEAA) sources has also revealed no specific guidelines or limits. Health Canada states: "Health Canada does not have noise guidelines or enforceable noise thresholds or standards." [2] However, Health Canada does utilize a formula for determining health impacts created by noise, further explained in this section below.

To determine the environmental noise effects as required by the CEAA[3], this assessment has been completed with respect to the anticipated community response to changes in noise level due to the project. Guidance on this relationship is provided in *ISO/R 1996: Assessment of the Noise with Respect to Community Response*. Table 2 below describes the estimated community response with respect to change in noise level above pre-existing background levels. Similar to traffic noise impact assessments and other projects with criteria based upon noise level difference, a 5dB exceedance of criteria has been adopted as the threshold for noise mitigation investigation.

Table 2: Estimated Community Response to Noise – ISO/R 1996

Amount in dB(A) by which the rating sound level exceeds the noise criterion.	Estimated Community Response	
	Category	Description
0	None	No observed reaction
5	Little	Sporadic complaints
10	Medium	Widespread complaints
15	Strong	Threats of community action
20	Very Strong	Vigorous community action

Per discussions between Howse Minerals Limited and CEAA, the DSO3 operations shall be considered as part of the background noise. Therefore, the basis of assessment, at each Newfoundland and Labrador receptor, will be the higher of either the base DSO3 operation noise levels, or the existing outdoor ambient noise level. Measurements of the existing ambient noise levels were taken by Tecsult in 2006 can be found in Howse project description documentation[4]. The Tecsult report defined the ambient background noise as the L_{95} measurement. The relevant results of the ambient background measurements are presented in Table 3.

Table 3: Ambient Background Measurements - Tecsult, 2006

Location ID (Decimal Degrees)	Description	Period	L_{95} Ambient Noise (dBA)
Station 1: -67,21595 54,89924	Located 4.5 kilometres southwest of Howse Mine. Background noise from natural environment includes presence of birds, wind, etc.	Day	33.0
		Night	35.5
Station 2: -67,23445 54,89814	Located 5.7 kilometres southwest of Howse Mine. Background noise from natural environment includes presence of birds, wind, etc.	Day	33.5
		Night	34.9

2 *Health Canada, Useful Information for Environmental Assessments, 2010.*

3 *Guidelines for the Preparation of an Environmental Impact Statement, Pursuant to the Canadian Environmental Assessment Act, 2012 – Howse Property Iron Mine, July 14, 2014.*

4 *Howse Minerals Limited, Project Registration/Project Desciption for the DSO – Howse Property Project, April 2014.*

Receptors in Quebec have been assessed against the Quebec guidelines for stationary noise sources[5], as the mine site is located in close proximity to the Quebec – Newfoundland and Labrador border. Guidelines state the greater of current residual noise levels, or maximum L_{eq} per "zoning" area be used as the basis of assessment. Table 4 presents maximum L_{eq} levels for receptors in Quebec, sorted by "zoning" area.

Table 4: Maximum L_{eq} per Zoning Area – Quebec Guidelines for Stationary Noise Sources

Zoning Area	Day L_{eq} (dBA)	Night L_{eq} (dBA)
I	45	40
II	50	45
III	55	50
IV	70	70

"Zoning" areas for receptors in Quebec are sorted into 4 different types:

Type I: Territory for single-family, detached or attached dwellings
Type II: Territory for multiple dwelling units, parks, mobile homes, institutions or campsites.
Type III: Lands for parks or recreational commercial uses.
Type IV: Land zoned for industrial or agricultural purposes.

The nearby camp receptors and town of Schefferville in Quebec can be classified as Type I areas per the above description. Therefore, basis of assessment for day time noise levels was either the greater of the predicted base DSO3 noise level or 45 dBA. The basis of assessment for night-time noise levels was either the greater of the predicted base DSO3 noise level or 40 dBA.

Health Canada uses a change in highly annoyed percentage (%HA_n) as a measure for determining health impacts of noise generated by wind turbine, road traffic, and industrial noise sources. For industrial noise sources, this relationship is given by the formula[6]:

$$HA_n = \frac{100}{[1+\exp(10.4-0.132(L_{dn})]} \qquad (1)$$

where
%HA_n = Highly annoyed percentage
L_{dn} = Day-night sound level

Day-night sound level (L_{dn}) is the average noise level over a 24 hour period, where a 10dB penalty is applied to night time noise hours. L_{dn} (using 15 hour day and 9 hour night periods) can be calculated using the following formula:

$$L_{dn} = 10log[\frac{\left(15*10^{0.1L_{eq,day}}\right)+\left(90*10^{0.1L_{eq,night}}\right)}{24}] \qquad (2)$$

where $L_{eq,day}$ and $L_{eq,night}$ are hourly equivalent sound levels for day and night hours, respectively.

Health Canada has recommended that noise mitigation be recommended when a project related increase in %HA_n is greater than 6.5%. Highly Annoyed percentage assessments for each receptor can be found in section 4.1.3.

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5 *Ministere du Developpement durable, Environnement et Lutte contre les changements climatique, Traitement des plaintes sur le bruit et exigences aux entreprises qui le génèrent, June 2006.- Referenced in Quebec's "DIRECTIVE 019-SUR L'INDUSTRIE MINIÈRE, MARS 2012".*

6 *A justification for using a 45 dBA sound level criterion for wind turbine projects, Stephen E. Keith, David S. Michaud, Stephen H.P. Bly, 2008.*

4.1.2 Noise Sources

The project will consist of three phases: Preparation and Construction, Operations, and Decommissioning. All three phases use similar equipment. The Operations phase has the highest amount of equipment and greatest operational areas (thus having the highest noise impact), and therefore was the only phase assessed. Operations phase noise modelling requires two scenarios for this assessment: Base DSO3, and Future Case. The base DSO3 case scenario contains noise sources at the following areas:

- Main Processing Plant
- Production Plant 2 (currently operating east of the Main Processing Plant)
- Timmins 3,4,7 Mining Sites
- Fleming 7 Mining Site
- Roads connecting production plants and Timmins and Fleming mining sites
- Road connecting DSO3 to Kivivic mine site (eg. DSO4)

Trains are not currently in daily operation during the Base DSO3 operations, and therefore were excluded from the base DSO3 noise modelling. The future worst case scenario with the highest amount of mine production contains noise sources at the same areas listed above, (with the exceptions of Timmins mine sites which will no longer be active during the worst case scenario), in addition to the following:

- Howse Mining Site
- Howse Mini-plant (processing plant for Howse ore) located near the rail loop
- Roads between Plants and Howse Mining Site
- Daily train operations east of Plant 1
- First Nations crushing site (located next to the Howse Mine site, on the east side)

Future locations of the new Howse Mini Plant and the First Nations crusher can be found in Appendix A.

All equipment types included in the noise modelling is listed below. A full detailed equipment list (including make, model number, serial number [as applicable], negligible sources, and number at each location) for all locations is provided in Appendix B.

- Vibration Screen
- Apron Feeder
- Feed Hopper
- Hydraulic Rock Breaker
- Primary Sizer
- Secondary Sizer
- Roof Fans
- Wall fans
- HVAC Ventilation Unit
- Vacuum Pump Blowers
- 2MW Generators
- Generator Rad Fans
- Hydraulic Excavators
- Production Drill
- Track Dozer
- Road Grader
- Haul Trucks
- Train (Idling and Travelling)
- Diesel-fired Burners
- Induced draft fans

Equipment noise data was gathered from manufacturer data, previous equipment measurements, BSI British Standards, and Roadway Construction Noise Model (RCNM) data. It should be noted that RCNM data is typical of conservative worst case situations. Train data was provided by Howse Minerals Limited. A typical train consists of 2 locomotives, 212 cars, travelling between 25-50 km/h. As is typical in noise assessments, noise generated by receptors is not part of the project, and therefore have not been included in this assessment.

4.1.3 Impact Assessment

Noise levels for the Base (pre-Howse DSO3 mining) and Future scenarios were modelled with the ISO 9613 standard implemented in the CadnaA modelling package. Noise levels for the train were modelled using Federal Transit Administration (FTA) railroad methodology, also implemented in CadnaA. Ground topography for the area was obtained from publicly available resources using digital elevation data from the Geobase Initiative[7]. The digital elevation data was used to generate ground elevation contour lines in the noise model. Noise level contours are provided in Appendix A.

Predicted day-time and night-time noise level impacts at each nearby Newfoundland and Labrador receptor are presented in Table 5 and Table 6. Each receptor is representative of noise sensitive areas surrounding the two production plants and each mining site. Results for each receptor are also presented in Appendix A.

Table 5: Day-Time Base and Future Scenario Noise Levels - Newfoundland and Labrador

Receptor	Receptor ID	Base DSO3 Noise Level (dBA)	Basis of Assessment (dBA)[8]	Future Scenario Noise Level (dBA)	Impact (dBA)
TSMC Workers' Camp	R40	52.1	52.1	52.7	0.6
Innu Tent 1 (Elross Lake)	R7	31.1	33.0	32.2	-
Young Naskapi Camp 7 (Pinette Lake)	R9	40.9	40.9	45.4	4.5
Young Naskapi Camp 3	R10	29.1	33.0	37.4	4.4
Young Naskapi Trailer Tent (Triangle Lake)	R11	27.9	33.0	32.1	-
Young Naskapi Camp 5 (Elross Creek)	R12	40.9	40.9	41.6	0.7
Naskapi – Uashat People's Camp	R13	29.3	33.0	38.0	5.0
Innu - Uashat - Mani-Utenam Camp 2	R17	26.2	33.0	28.5	-
Irony Mountain	R24	33.2	33.2	37.9	4.7

Table 6: Night-Time Base and Future Scenario Noise Levels - Newfoundland and Labrador

Receptor	Receptor ID	Base DSO3 Noise Level (dBA)	Basis of Assessment (dBA)[9]	Future Scenario Noise Level (dBA)	Impact (dBA)
TSMC Workers' Camp	R40	52.1	52.1	52.7	0.6
Innu Tent 1 (Elross Lake)	R7	31.1	34.9	32.1	-
Young Naskapi Camp 7 (Pinette Lake)	R9	40.9	40.9	45.4	4.5
Young Naskapi Camp 3	R10	29.1	34.9	37.4	2.5
Young Naskapi Trailer Tent (Triangle Lake)	R11	27.9	34.9	32.1	-
Young Naskapi Camp 5 (Elross Creek)	R12	40.9	40.9	41.6	0.7
Naskapi – Uashat People's Camp	R13	29.3	34.9	38.0	3.1
Innu - Uashat - Mani-Utenam Camp 2	R17	26.2	34.9	28.4	-
Irony Mountain	R24	33.2	34.9	37.7	2.8

The predicted noise impact (≥ 5dB) at the Naskapi – Uashat People's Camp (R13) camp site (west of Howse Mine) triggers mitigation investigation. The noise sources creating the greatest noise impact on the camp site were the drill

[7] *Geobase Initiative– Canadian Digital Elevation Data. 2011. Retrieved from http://www.geobase.ca/geobase/en/find.do?produit=cded. Date accessed 15 September 2014.*

[8] *Ambient background measurements indicate an existing noise level without mining of 33-35 dBA.*

[9] *Ambient background measurements indicate an existing noise level without mining of 33-35 dBA.*

operating at the Howse mining site, and the First Nations crusher operation near Howse mine. Sporadic noise complaints are expected if no mitigation is implemented. Noise impact at Irony Mountain is close to exceeding criteria. Moving the First Nations crusher further north behind an existing berm or overburden pile may reduce likelihood of noise complaints.

Predicted day-time and night-time noise level impacts at each nearby Quebec receptor are presented in Table 7 and Table 8. For receptors in Quebec, sound levels were assessed against the greater of predicted base level ambient noise or maximum L_{eq} levels set for Zone I areas.

Table 7: Day-Time Base and Future Scenario Sound Levels - Quebec

Receptor	Receptor ID	Base DSO3 Noise Level (dBA)	Basis of Assessment (dBA)	Future Scenario Noise Level (dBA)	Impact (dBA)
Innu Cabin 3	R25	23.5	45.0	26.1	-
Innu - Uashat - Mani-Utenam Camp 1	R16	30.8	45.0	32.9	-
Innu - Uashat - Mani-Utenam Camp 3	R18	46.8	46.8	48.2	1.4
Innu Cabin 2	R20	24.0	45.0	38.7	-
Schefferville (town)	R39	12.6	45.0	24.3	-

Table 8: Night-Time Base and Future Scenario Sound Levels - Quebec

Receptor	Receptor ID	Base DSO3 Noise Level (dBA)	Basis of Assessment (dBA)	Future Scenario Noise Level (dBA)	Impact (dBA)
Innu Cabin 3	R25	23.5	40.0	24.3	-
Innu - Uashat - Mani-Utenam Camp 1	R16	30.8	40.0	32.8	-
Innu - Uashat - Mani-Utenam Camp 3	R18	46.8	46.8	48.2	1.4
Innu Cabin 2	R20	24.0	40.0	24.5	-
Schefferville (town)	R39	12.6	40.0	13.1	-

There were no predicted noise impact exceedances for any receptors in Quebec.

The following table presents the Day-Night noise levels and change in Highly Annoyed percentage for each receptor.

Table 9: Day-Night Noise Levels and Change in Highly Annoyed Percentage

Receptor Name and ID	Receptor ID	Base DSO3 Day-Night Level (dBA)	Future Scenario Day-Night (dBA)	Base DSO3 Highly Annoyed Percentage (%)	Base DSO3 Highly Annoyed Percentage (%)	Change in Highly Annoyed Percentage (%)
Innu Tent 1	R7	37.5	38.5	0.43	0.49	0.06
Young Naskapi Camp 7	R9	47.3	51.8	1.54	2.76	1.22
Young Naskapi Camp 3	R10	35.5	43.8	0.33	0.98	0.65
Young Naskapi Trailer Tent	R11	34.3	38.5	0.28	0.49	0.21
Young Naskapi Camp 5	R12	47.4	48.0	1.56	1.69	0.13
Naskapi – Uashat People's Camp	R13	35.7	44.4	0.34	1.06	0.72
Innu - Uashat - Mani-Utenam Camp 1	R16	37.2	39.3	0.41	0.54	0.13
Innu - Uashat - Mani-Utenam Camp 2	R17	32.6	34.8	0.22	0.30	0.08
Innu - Uashat - Mani-Utenam Camp 3	R18	53.2	54.6	3.30	3.94	0.64
Innu Cabin 2	R20	30.4	37.6	0.17	0.43	0.27
Irony mountain	R24	39.6	44.2	0.56	1.03	0.47
Innu Cabin 3	R25	29.9	31.0	0.16	0.18	0.02
Schefferville (town)	R39	19.0	23.9	0.04	0.07	0.03
TSMC Worker's Camp	R40	58.5	59.1	6.43	6.92	0.49

No receptors have a Highly Annoyed percentage change of 6.5% or greater. Therefore, Highly Annoyed percentage will not trigger mitigation per Health Canada criteria at any receptors. However, the Naskapi-Uashat People's Camp receptor (R13) will still undergo mitigation investigation due to the ≥5dB noise impact at that location.

4.1.4 Recommendations

Receptor R13 (Naskapi-Uashat people's camp) located northwest of the Howse mine was predicted to have a noise impact of 5 dBA, triggering noise mitigation investigation. The Howse Mine track drill and First Nations crushing equipment is expected to have the highest contribution to this exceedance.

Drill noise was modelled using RCNM noise data. As previously noted, RCNM data is conservative, which does not account for localized conditions (ground composition) and additional factors (drill speed, drilling time, equipment used). Actual noise emissions can be significantly lower than modelled; as such noise mitigation for the drill may not be required. Howse Minerals Limited has committed to preparing a mitigation plan for the drill to be implemented should complaints occur. Example methods of reducing drill noise include:

- Reducing drilling speed
- Reducing drilling time
- Using a noise shroud around the drill
- Use of a mobile noise screen

Moving the First Nations crusher further north behind an existing berm or overburden pile may avoid noise complaints, as the Irony Mountain receptor noise impact was close to (but below) the noise criteria.

4.2 Blasting

There are two main impacts from blasting – ground vibration and overpressure. When explosives detonate in a borehole, shock waves (energy from the detonation) radiate outward and crush the material adjacent to the borehole. Energy not used in the fracturing and displacement of bedrock dissipates in the form of ground vibration and air overpressure. Some of the factors and parameters that affect the proper fragmentation of the rock and the impacts of blasting include:

- The explosive type, loading densities and weights;
- The detonator delays and firing sequence;
- The decking lengths;
- The spacing of holes;
- The distance between the holes and the free or open face;
- The geology (type and condition) of the bedrock and
- The depth and composition of the earth covering deposit (soil).

Vibrations transmitted through the ground, and pressure waves through the air (overpressure) can disturb buildings and people. This may cause nuisance, or damage (in extreme cases). The propagation of ground vibration and overpressure differs between the front and back of the blast.

Ground vibration transmission is affected by the geology of the terrain and the distance to the receptor source. The transmission of ground vibration will typically move faster and at a higher frequency in rock than soil. Ground vibration is measured in peak particle velocity (PPV) in mm/s.

Air overpressure in its simplest form is the compression of air molecules in a wave travelling away from the source at a rapid rate. The overpressure propagates at the speed of sound and has an audible noise level. Thus, air blasts are measured in decibels. The transmission of air blast pressure away from the explosive source is affected by the topography and the atmospheric conditions that occur during the event. The direction and strength of the wind, the humidity and the density and ground height of the cloud cover will all affect the transmission of air blast from a source.

4.2.1 Criteria

A review of Newfoundland and Labrador Department of Environment and Conservation information, and federal sources has revealed that there are no available noise and vibration guidelines. Therefore, the ground vibration and overpressure from blasting operations are assessed per Quebec's "DIRECTIVE 019-SUR L'INDUSTRIE MINIÈRE, MARS 2012", and Ontario's Ministry of the Environment (MOE) NPC-119 Guideline.

Quebec's "DIRECTIVE 019-SUR L'INDUSTRIE MINIÈRE, MARS 2012", is similar to the MOE NPC-119 Guideline. However, the MOE Guideline is slightly more conservative, and also provides general guidance for vibration and overpressure where no site specific data is readily available. Therefore, MOE criteria have been adopted for this assessment.

Quebec's DIRECTIVE 019 has two criteria based on the distance between the blasting location and nearest receptor. Where there is no point of impact within a perimeter of 1 km around the mine site:

- Maximum speeds of vibration permitted ground due to operations blasting are indicated in Table 10
- Maximum level of air pressure permitted at any dwelling is 128 decibels.

Table 10: Maximum allowable ground speeds as a function of vibration frequency (Source: “Directive 019-sur l’industrie minière, mars 2012”)

Frequency of vibration	Maximum Permissible Vibration Velocity (mm/sec)
frequency ≤ 15	12.7
15 < frequency ≤ 20	19.0
20 < frequency ≤ 25	23.0
25 < frequency ≤ 30	30.0
30 < frequency ≤ 35	33.0
35 < frequency ≤ 40	38.0
frequency > 40	50.0

For cases where mining activities are carried out within 1 km of a point impact, the maximum speed permitted ground vibrations due to operations blasting and recorded at the impact point is 12.7 mm/sec. The maximum threshold air pressure at any dwelling is 128 decibels. In addition, blasting is not permitted between 7:00 pm and 7:00 am if there are dwellings within 1 km from the mine. Directive 019 also indicates that the operator must install a monitoring program for ground vibration and air pressures at the nearest dwellings to the mine.

NPC-119 provides two sets of limits: (1) standard limits and (2) cautionary limits. The standard limits are used where regular monitoring is being conducted during blasting operations. Cautionary limits are slightly lower and apply when blasts are not monitored on a routine basis. Table 11 depicts these limits for both blast vibration and overpressure.

Table 11: Blast Vibration and Overpressure Limits (Source: NPC-119)

Type of Limits	Vibration (mm/sec)	Overpressure (dBL)
Standard limit	12.5	128
Cautionary limit	10.0	120

4.2.2 Blasting ground vibration and overpressure prediction models

The most commonly used formula for predicting PPV is known as the USA Bureau of Mines (BOM) prediction formula or Propagation Law. Ground vibration is estimated for a specific location using the following equation:

$$PPV = \beta(SD)^{\alpha} \quad (3)$$

where
PPV = Peak Particle Velocity (mm/s);
SD = Scaled Distance ($m/kg^{1/2}$); and
α and β are site-specific constants based on the geology of the terrain.

Scaled Distance is defined as:

$$SD = D/w^{1/2} \quad (4)$$

Where:
D = Distance between the closet blast hole to the receptor (m); and
w = maximum weight of explosive detonated per delay (kg).

The constants, α and β, are site-specific and must be determined by conducting a blast study at the site. A blast study includes multiple test blasts conducted on-site while measuring particle velocities at varying distances and charge weights for each blast. The resulting data can then be used to create a log-log plot of peak particle velocity versus scaled distance where the slope of the line-of-best-fit through the data is equal to the constant α and the value of the y-intercept is equal to β.

Blast overpressure is estimated for a specific location using the following equation:

$$P = \beta(SD)^{\alpha} \qquad (5)$$

Where:
P = Air Pressure;
SD = Scaled Distance (m/kg1/3); and
α and β are site-specific constants based on the geology of the terrain.

Scaled distance is defined as:

$$SD = D/w^{1/3} \qquad (6)$$

Where:
D = Distance between the closet blast hole to the monitoring receptor (m); and
w = maximum weight of explosive detonated per delay period (kg).

the Air Pressure Level (dBL) is calculated using the following equation:

$$APL = 10*\log(P/P_{ref})^2 \qquad (7)$$

Where:
APL = Air Pressure Level (dBL);
P_{ref} = reference pressure which is $20x10^{-6}$ Pa

Scaled distances for air blasts are generally calculated by dividing the separation distance with the cube root of the maximum charge weight, as opposed to dividing by the square root of the maximum charge weight when determining the scaled distance for peak particle velocity. Similar to the procedure for determining the propagation constants for ground vibrations, a blast study measuring overpressure (dBL) with varying distances and charge weights for each blast will provide the required information to generate a log-log plot of maximum overpressure versus scaled distance. The slope of the line-of-best-fit through the data is equal to α and the value of the y-intercept is equal to β.

Since test blasts have not been conducted at the site and no seismograph information is available, it is not possible to obtain the site-specific propagation constants, α and β. Therefore, the maximum allowable charge weight per delay was estimated using the prediction model as presented in Ontario Ministry of the Environment "Guidelines on Information Required for Assessment of Blasting Noise and Vibration – December 1985" (Appendix C). Parameters are obtained from fitting USA BOM equations to figures presented in the guidelines relating vibration and overpressure to scale distance. PPV can be estimated from the following equation:

$$PPV = 1033\ (SD)^{-1.59} \qquad (8)$$

The overpressure varies based on the location of the receptor with respect to the blast. The overpressure of a receptor in front of the blast can be estimated from:

$$P = 3873\ (SD)^{-0.97} \qquad (9)$$

While the overpressure of a receptor to the back of the blast can be estimated from:

$$P = 229\ (SD)^{-0.51} \qquad (10)$$

Equations 6 to 8 are typically used to calculate vibration and overpressure levels at specific locations from a given blast (charge). This equation can be reconfigured to calculate the approximate maximum blast size for a given location and level limit. These equations are therefore a useful blast design tool in establishing maximum explosive charge weights per delay for various distances from a blast site, using maximum ground vibration level and overpressure limits.

4.2.3 Blast Vibration and Overpressure estimates

Since the blasting plan is still in development, vibration and overpressure levels from the blasting were predicted using MOE 1985 “Guidelines on Information Required for Assessment of Blasting Noise and Vibration” models. Using charge size per delay (i.e., explosive weight is in kg), and separation distance between the blast location and assessment receptor, the absolute ground vibration and overpressure levels expected at the point of reception can be determined. Since insufficient detail on topographical and soil conditions was available, the predictions are based on generic environmental and topographical conditions, and no adjustments have been made to suit site specific conditions. The maximum suggested explosive loads for various distances from the blast site are based on the provincial guideline limits of 12.5 mm/s and 128 dBL discussed previously. According to MOE model, the maximum allowable charge per delay is listed in Table 12 and Table 13 for various receptor distances from the blast.

For the purpose of this assessment, the entire site is considered as a potential blasting location and the distance from the outer perimeter of the open pit to the receptor is considered as the distance to receptors in the assessment. Based on the information provided to date, the closest sensitive receptor (R13) is determined to be approximately 900 metres from the site perimeter. The maximum allowable charge per delay for the closest receptor (using generic conditions) is summarized in Table 14.

Table 12: Preliminary maximum allowable charge per delay versus distance to meet Blast vibration limit – 12.5 mm/sec

Distance to Receptor (m)	Allowable Explosive per Period - kg
100	39
200	154
300	348
400	618
500	965
600	1390
700	1892
800	2471
900	3128
1000	3862

Table 13: Preliminary maximum allowable charge per delay versus distance to meet Blast overpressure limit (128 dB)

Distance to Receptor (m)	Allowable Explosive per Period - kg	
	Front of Blast	Back of Blast
100	1	135
200	12	1082
300	40	3652
400	96	8656
500	187	16907
565	270	24394
600	324	29214
700	514	46391
800	768	69249
900	1093	98599
1000	1499	135252

Table 14: Generic maximum allowable charge per delay for the closest point of reception located at 900m from the site

Charge per delay (kg)	Criteria
3128	Blast Vibration Limit – 12.5 mm/sec
1092	Blast Overpressure Limit – 128 dBL

The impact is controlled by the overpressure limit, so charge per delay should be restricted to below 1092 kg. However, blasting vibration and overpressure is complex in nature, and variability in ground type and meteorological conditions makes it difficult to accurately predict ground vibration and overpressure without site specific measurement data. Test blasting using a lower charge should first be conducted. Furthermore, no details of the blast configuration and design have been supplied at this stage. Therefore a lower charge test blast should be conducted prior to the start of production blasting. Any blast on site should be designed by a qualified contractor and include consideration of the blasting vibration and overpressure limits outlined in this report. Upon commencement of blasting on site, these parameters will require revisions based on site specific data and attenuation equations developed. Although meeting overpressure criteria may satisfy regulatory requirements, the short duration, high noise level may cause complaints.

4.2.4 Recommendations

It is recommended that:

1. An initial four blasts as a minimum shall be monitored by a specialist in blast monitoring to obtain the site specific data needed to develop attenuation formulae, confirm the applicability of the initial guideline parameters, and assist in developing future blast designs.

2. It is recommended that the four initial test blasts be conducted with charge per delay restricted to below 700 kg per delay. Vibration and overpressure should be monitored to provide an update to the Prediction model parameters.

3. Directive 019 recommends blasts shall be monitored for both vibration and overpressure, at the closest sensitive receptor adjacent to the site. It is recommended that a minimum of one digital seismograph be used in subsequent years. Subsequent routine monitoring should be utilized to update blast designs as required.

4. Blast designs shall be continually reviewed with respect to ground vibration and overpressure. Blast designs shall be modified as required to ensure compliance with applicable guidelines and regulations. Decking, reduced hole diameters, and sequential blasting techniques will be used to ensure minimal explosives per initiated delay period.

5. Detailed blast records shall be maintained. The MOE (1985) recommends that the body of blast reports should include the following information:
   a) Location, date and time of the blast.
   b) Dimensional sketch including photographs, if necessary, of the location of the blasting operation, and the nearest point of reception.
   c) Physical and topographical description of the ground between the source and the receptor location.
   d) Type of material being blasted.
   e) Sub-soil conditions, if known.
   f) Prevailing meteorological conditions including wind speed in m/s, wind direction, air temperature in ^{o}C, relative humidity, degree of cloud cover and ground moisture content.
   g) Number of drill holes.
   h) Pattern and pitch of drill holes.
   i) Size of holes.
   j) Depth of drilling.
   k) Depth of collar (or stemming).
   l) Depth of toe-load.
   m) Weight of charge per delay.
   n) Number and time of delays.
   o) The result and calculated value of Peak Pressure Level in dB and Peak Particle Velocity in mm/s.
   p) Applicable limits.
   q) The excess, if any, over the prescribed limit.

6. A community engagement program and noise complaint process should be implemented, to advise the community of upcoming blasts and address community concerns.

The blast parameters described within this report will provide a good basis for the initial blasting operations at this location. However, it may be possible to refine these parameters once site-specific data from the blasting operations becomes available.

5. Conclusions

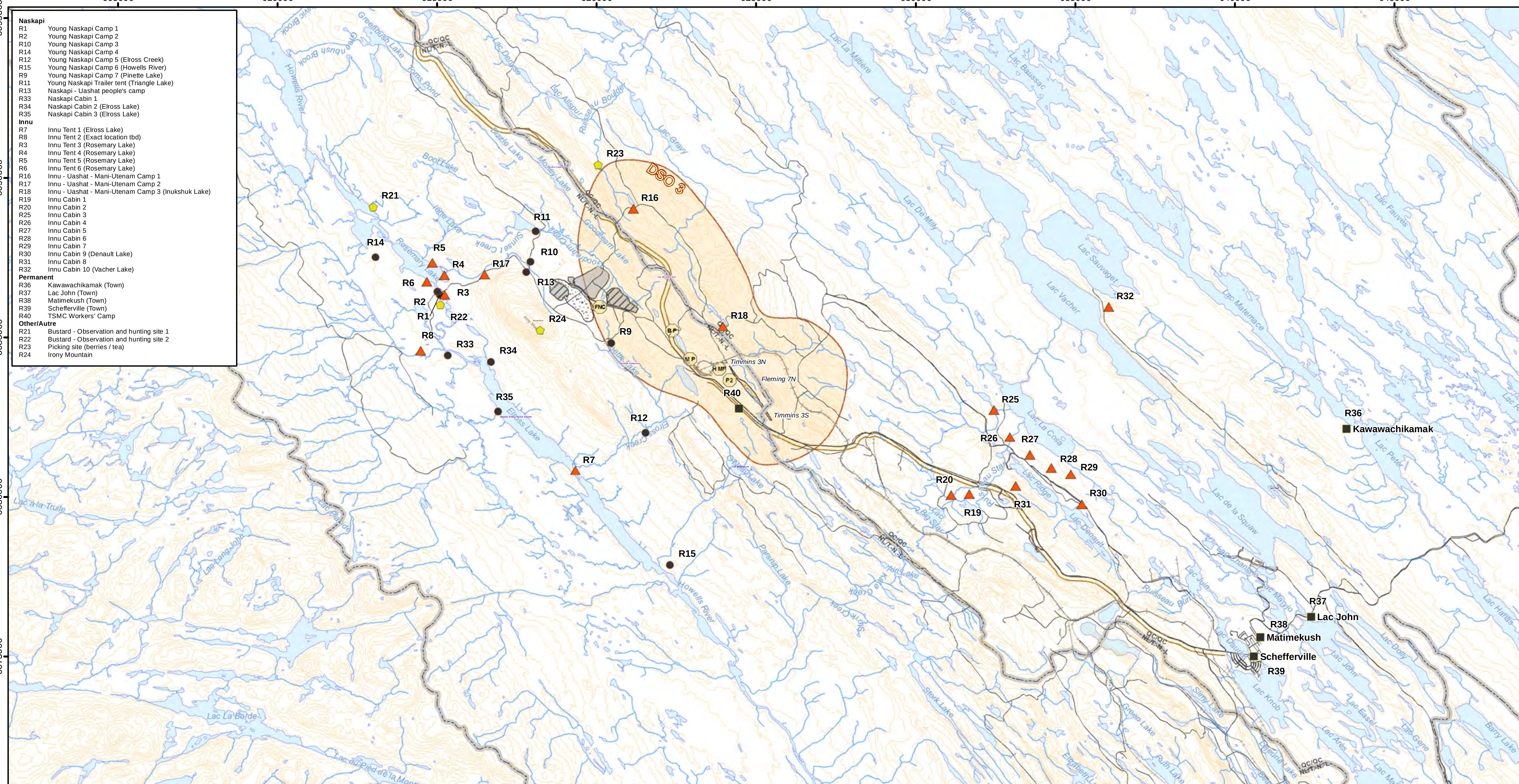
In accordance with the Canadian Environmental Assessment Agency (CEAA) document *Guidelines for the Preparation of an Environmental Impact Statement – Howse Property Iron Mine,* an environmental assessment was completed for the operation of the Howse mining site. Results of the noise assessment indicate that the operation of the new Howse mining site and addition of the First Nations crushing area will have an impact of 5dB at one Naskapi Uashat People's Camp site (R13), west of the Howse Mine. This impact is predicted to result in sporadic community complaints. If complaints occur, Howse Minerals Limited has committed to implementing a mitigation plan (discussed in Section 4.1.4) for the Howse Mine track drill. In addition, moving the First Nations crusher further north behind an existing berm or overburden pile may reduce complaints.

Since there is no blast vibration and overpressure data available for the site, generic empirical formulas were used to estimate the impact of blast vibration and overpressure at the closest point of reception. A preliminary maximum charge per delay of 1092 kg was estimated for the blast vibration and overpressure to conform to the applicable limits. An initial blast test with a charge per delay below 700 kg should be first conducted. Vibration and overpressure should be monitored during the blast test and explosive weight adjusted accordingly.

Even with overpressure levels below acceptable limits, the instantaneous noise level will be much higher than the ambient noise levels at the closest sensitive locations and may trigger negative community response. Therefore efforts to liaise with the community and advice on future blasting may improve the community response to the blasting.

Appendix A

Appendix A: Area Layout, Receptor Locations and Noise Level Contour Figures



LEGEND

Sensitive Receptors
- Naskapi
- Innu
- Permanent
- Other

Infrastructure and Mining Components
- P2 Plant 2
- MP Main processing Plant
- HMP Howse Mini-Plant
- BP Batch Plant
- FNC First Nations crusher/screener
- Road to DSO Area 4
- Existing Railroad
- Deposit
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Waste Dump/ In-Pit Dump
- Proposed Sedimentation Pond
- Proposed Mine Haul Road

Basemap
- Existing road
- Contour Line (50 ft)
- Provincial Border
- Watercourse
- Water Body

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0672 , PR185-19-14, 2015-10-15, edickoum

N

0 2 4
Kilometers
SCALE: 1:120 000

UTM 19N NAD 83

SOURCES:

Basemap and Land Use Components
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and government of Quebec,

Mining Components
TATA Steel Minerals Canada Limited/
MET-CHEM Howse Deposit Design
for General Layout., 2013
Groupe Hémisphères, Hydrology and update, 2013

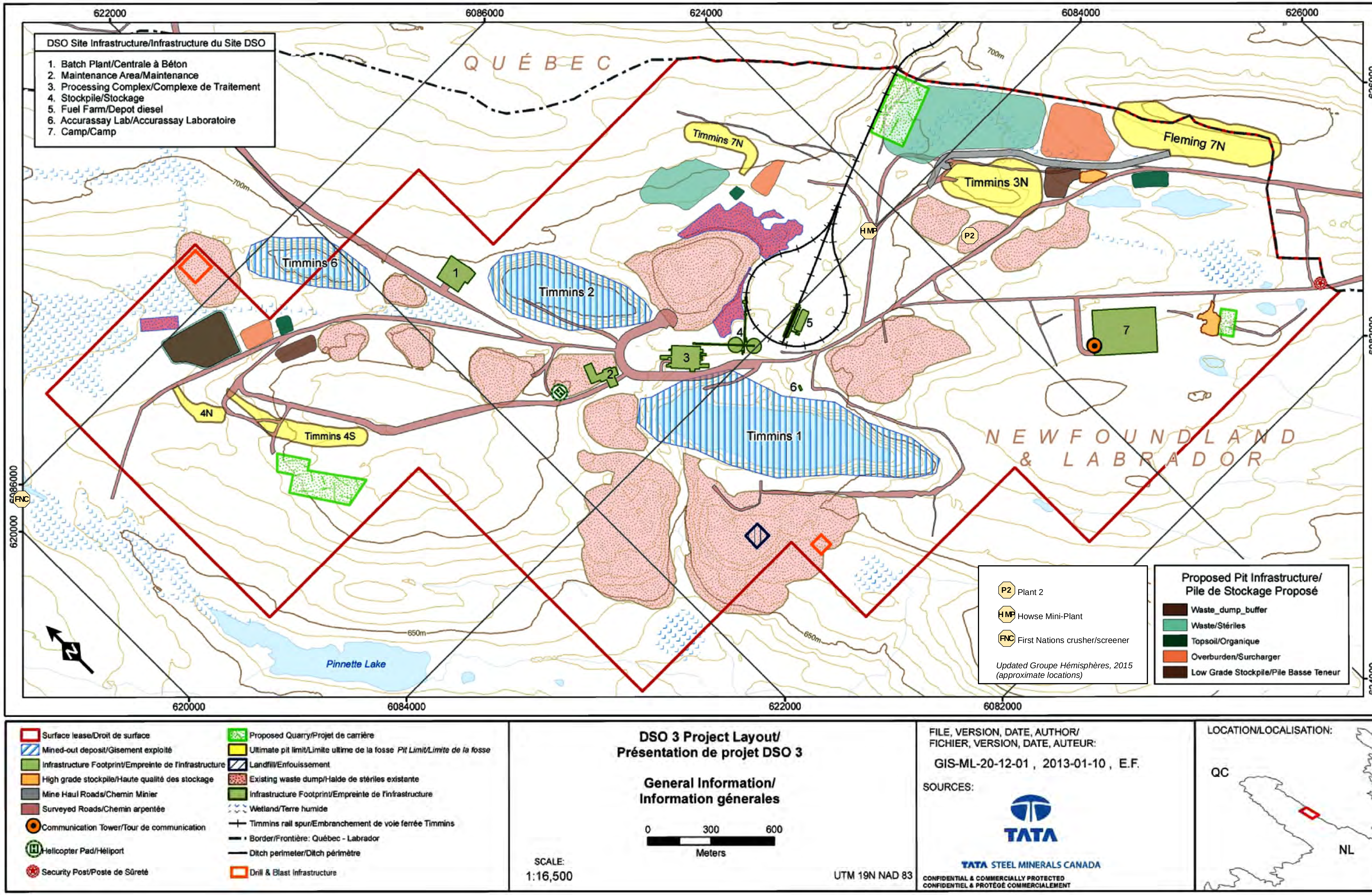
ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Sensitive Receptors

Howse Minerals Limited

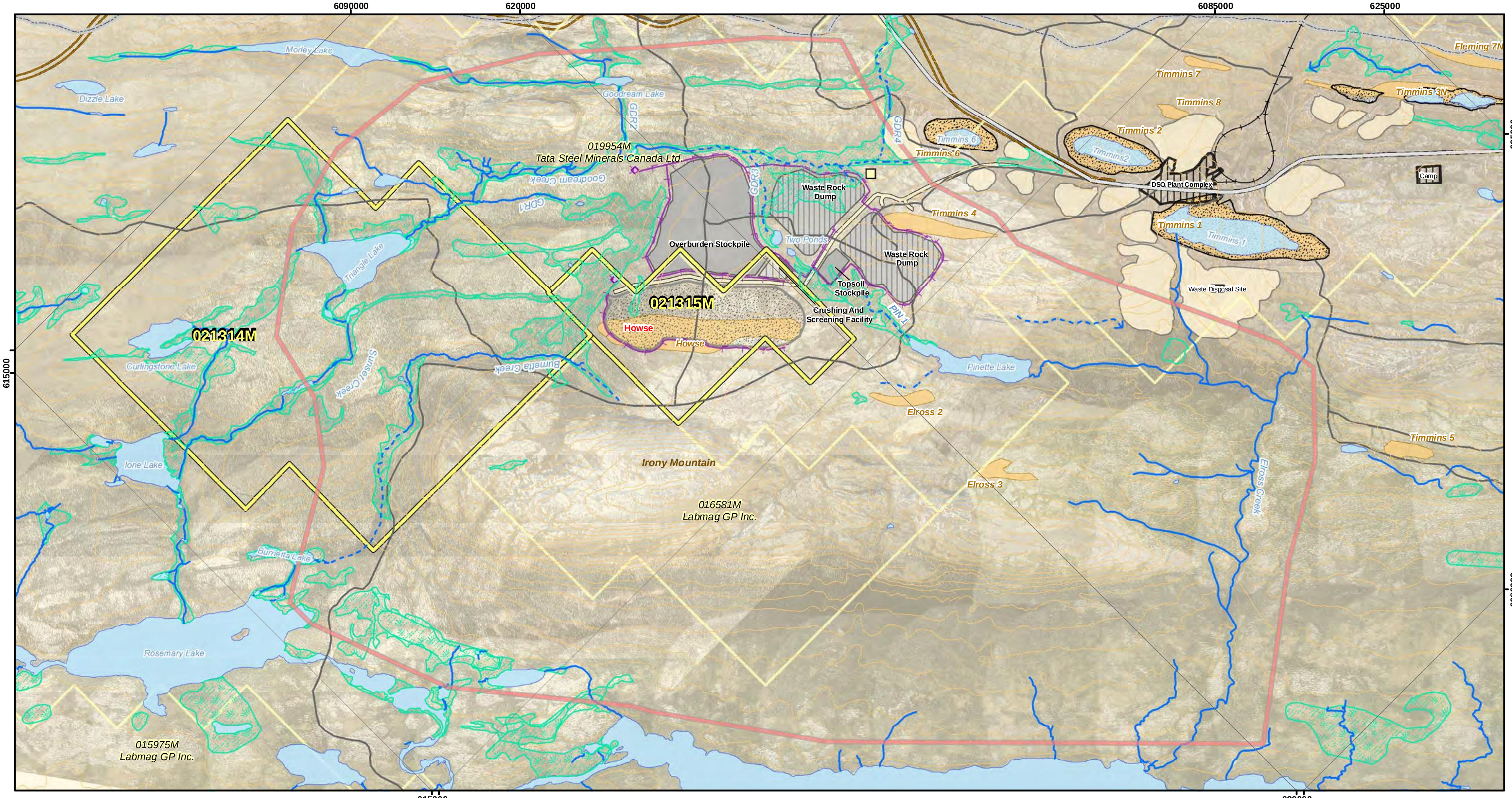
GroupeHemispheres
5731, rue Saint-Louis, Bureau 201, Lévis (QC) Canada, G6V 4E2
1453, rue Beaubien est, Bureau 301, Montréal (QC) Canada, H2G 3C6

Figure 2.1



DSO Site Infrastructure/Infrastructure du Site DSO
1. Batch Plant/Centrale à Béton
2. Maintenance Area/Maintenance
3. Processing Complex/Complexe de Traitement
4. Stockpile/Stockage
5. Fuel Farm/Depot diesel
6. Accurassay Lab/Accurassay Laboratoire
7. Camp/Camp
QUÉBEC
NEWFOUNDLAND & LABRADOR
Timmins 7N
Fleming 7N
Timmins 3N
Timmins 6
Timmins 2
Timmins 1
Timmins 4S
4N
Pinnette Lake
700m
650m
HMP
P2
FNC
Plant 2
Howse Mini-Plant
First Nations crusher/screener
Updated Groupe Hémisphères, 2015 (approximate locations)
Proposed Pit Infrastructure/ Pile de Stockage Proposé
Waste_dump_buffer
Waste/Stériles
Topsoil/Organique
Overburden/Surcharger
Low Grade Stockpile/Pile Basse Teneur
622000
6086000
624000
6084000
626000
620000
6082000
Surface lease/Droit de surface
Mined-out deposit/Gisement exploité
Infrastructure Footprint/Empreinte de l'infrastructure
High grade stockpile/Haute qualité des stockage
Mine Haul Roads/Chemin Minier
Surveyed Roads/Chemin arpentée
Communication Tower/Tour de communication
Helicopter Pad/Héliport
Security Post/Poste de Sûreté
Proposed Quarry/Projet de carrière
Ultimate pit limit/Limite ultime de la fosse Pit Limit/Limite de la fosse
Landfill/Enfouissement
Existing waste dump/Halde de stériles existante
Infrastructure Footprint/Empreinte de l'infrastructure
Wetland/Terre humide
Timmins rail spur/Embranchement de voie ferrée Timmins
Border/Frontière: Québec - Labrador
Ditch perimeter/Ditch périmètre
Drill & Blast Infrastructure
DSO 3 Project Layout/ Présentation de projet DSO 3
General Information/ Information génerales
0 300 600
Meters
SCALE:
1:16,500
UTM 19N NAD 83
FILE, VERSION, DATE, AUTHOR/ FICHIER, VERSION, DATE, AUTEUR:
GIS-ML-20-12-01 , 2013-01-10 , E.F.
SOURCES:
TATA STEEL MINERALS CANADA
CONFIDENTIAL & COMMERCIALLY PROTECTED
CONFIDENTIEL & PROTÉGÉ COMMERCIALEMENT
LOCATION/LOCALISATION:
QC
NL

Figure 2.2



LEGEND

Basemap

- Permanent Watercourse
- Intermittent Watercourse
- Storm Run-off
- Disappearing Stream
- Artesian Spring
- Waterbody
- Contour Line (50 ft)
- Provincial Border
- Existing Road
- Main Access Road
- Wetland
- Local Study Area

Infrastructure And Mining Components

- Proposed Howse Pit
- Proposed Low Grade/ Overburden Stockpile
- Proposed Crushing/ Screening Facility
- Proposed Waste Rock Dump
- Proposed Sedimentation Pond
- Proposed Mine Haul Road
- Proposed Ditch
- Potential Road To DSO Area 4
- Proposed Railroad
- Timmins 4 Sedimentation Pond-3
- DSO Howse - Claims Labrador Iron Mines Limited(49%)/ Howse Minerals Ltd.(51%)
- Other Claim
- Elross Lake Area Iron Ore Mine (ELAIOM) Plant Infrastructure footprint
- Existing Dump
- Existing Pit
- Deposit

*Hydronyms are oriented along the direction of water flow

FILE, VERSION, DATE, AUTHOR:
GH-0467-05, 2014-03-26, E.D., J.T.

SCALE: 1:30 000

UTM 19N NAD 83

0 500 1 000 2 000

Meters

SOURCES:
Basemap
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and government of Quebec, Boundary used for claims
SNC Lavalin, Groupe Hémisphères, Hydrology update, 2013

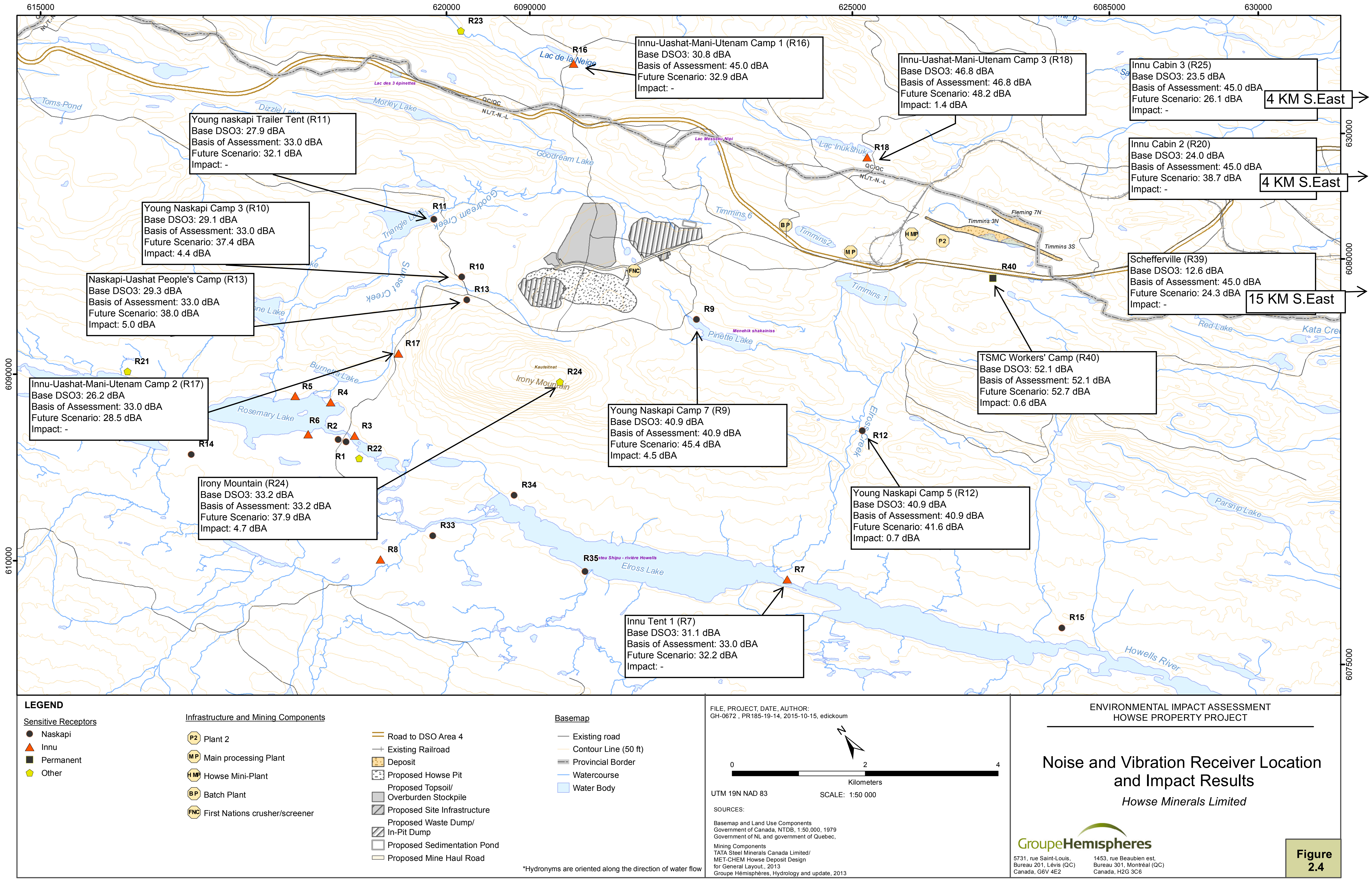
Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
TATA Steel Minerals Canada Limited/ MET-CHEM Howse
Deposit Design for General Layout, 2013

Howse Property And TSMC DSO Project Infrastructure

DSO Howse Property

Figure 2.3

GroupeHemispheres



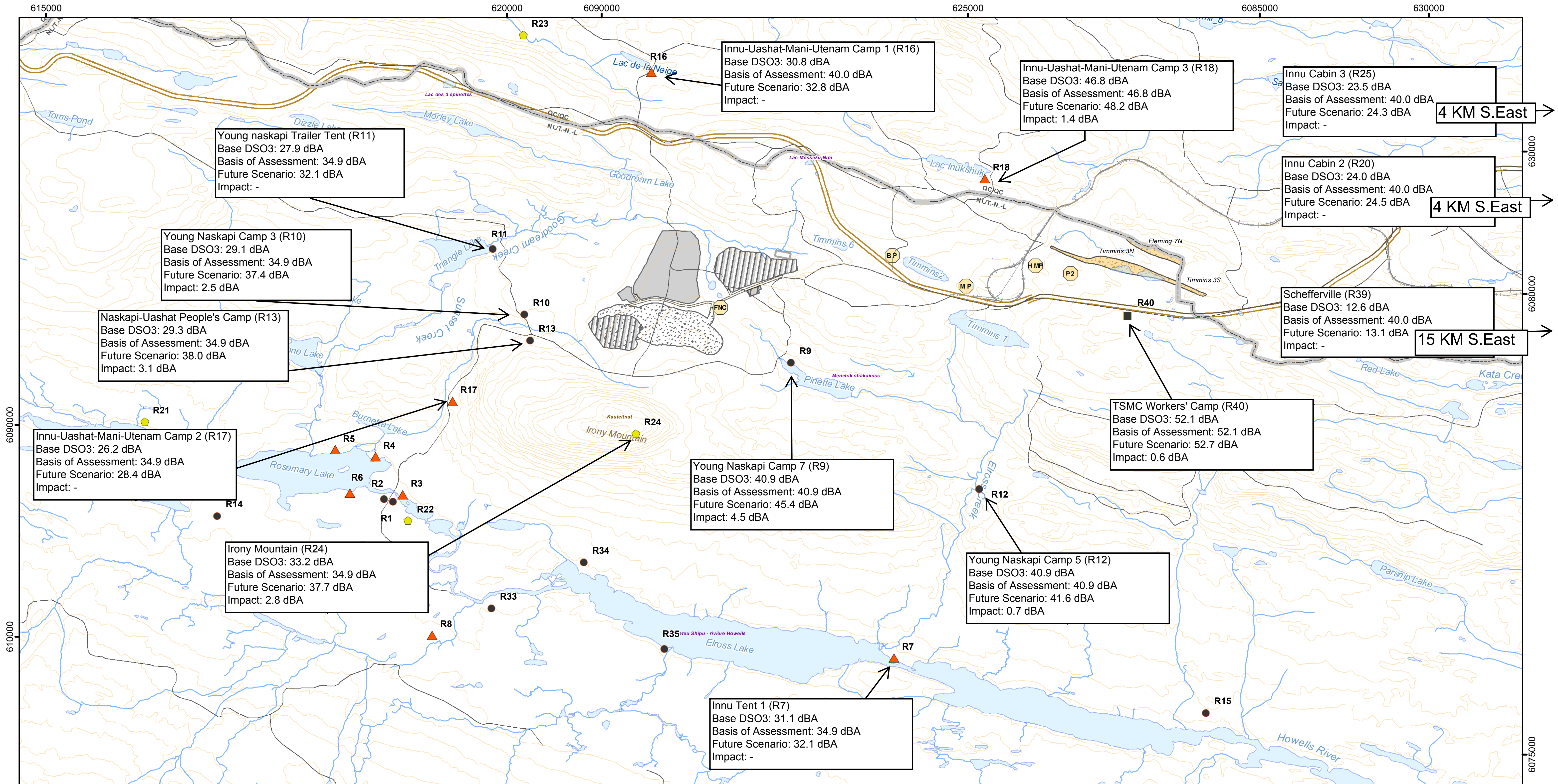
ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Noise and Vibration Receiver Location and Impact Results

Howse Minerals Limited

GroupeHemispheres
5731, rue Saint-Louis, Bureau 201, Lévis (QC) Canada, G6V 4E2
1453, rue Beaubien est, Bureau 301, Montréal (QC) Canada, H2G 3C6

Figure 2.4



LEGEND

Sensitive Receptors
- Naskapi
- Innu
- Permanent
- Other

Infrastructure and Mining Components
- P2 Plant 2
- MP Main processing Plant
- HMP Howse Mini-Plant
- BP Batch Plant
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- Existing Railroad
- Deposit
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Site Infrastructure
- Proposed Waste Dump/ In-Pit Dump
- Proposed Sedimentation Pond
- Proposed Mine Haul Road

Basemap
- Existing road
- Contour Line (50 ft)
- Provincial Border
- Watercourse
- Water Body

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0672 , PR185-19-14, 2015-10-15, edickoum

0 2 4
Kilometers

UTM 19N NAD 83
SCALE: 1:50 000

SOURCES:

Basemap and Land Use Components
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and government of Quebec,

Mining Components
TATA Steel Minerals Canada Limited/
MET-CHEM Howse Deposit Design
for General Layout., 2013
Groupe Hémisphères, Hydrology and update, 2013

ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

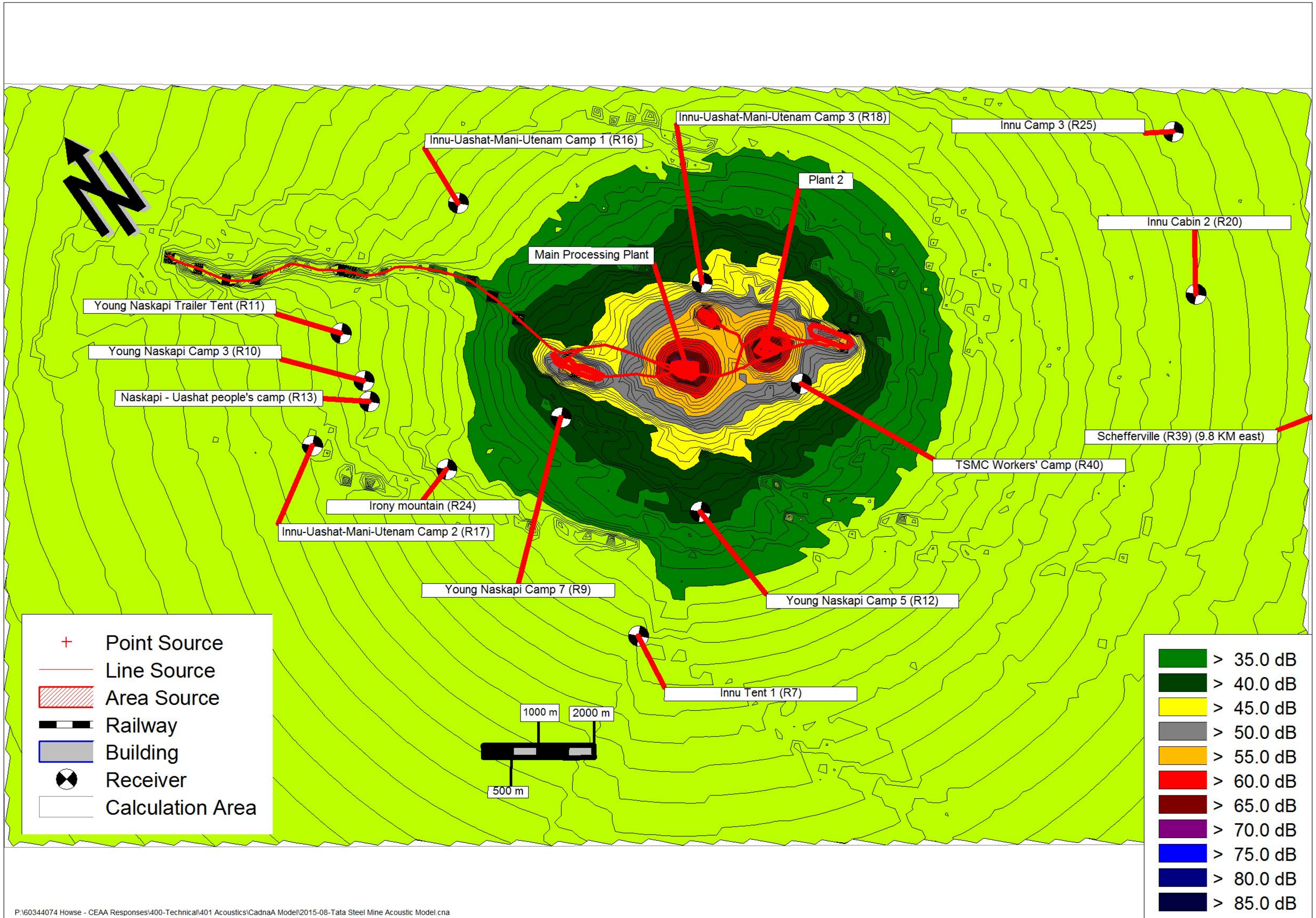
Noise and Vibration Receiver Location and Night-time Noise Impact Results

Howse Minerals Limited

GroupeHemispheres
5731, rue Saint-Louis, Bureau 201, Lévis (QC) Canada, G6V 4E2
1453, rue Beaubien est, Bureau 301, Montréal (QC) Canada, H2G 3C6

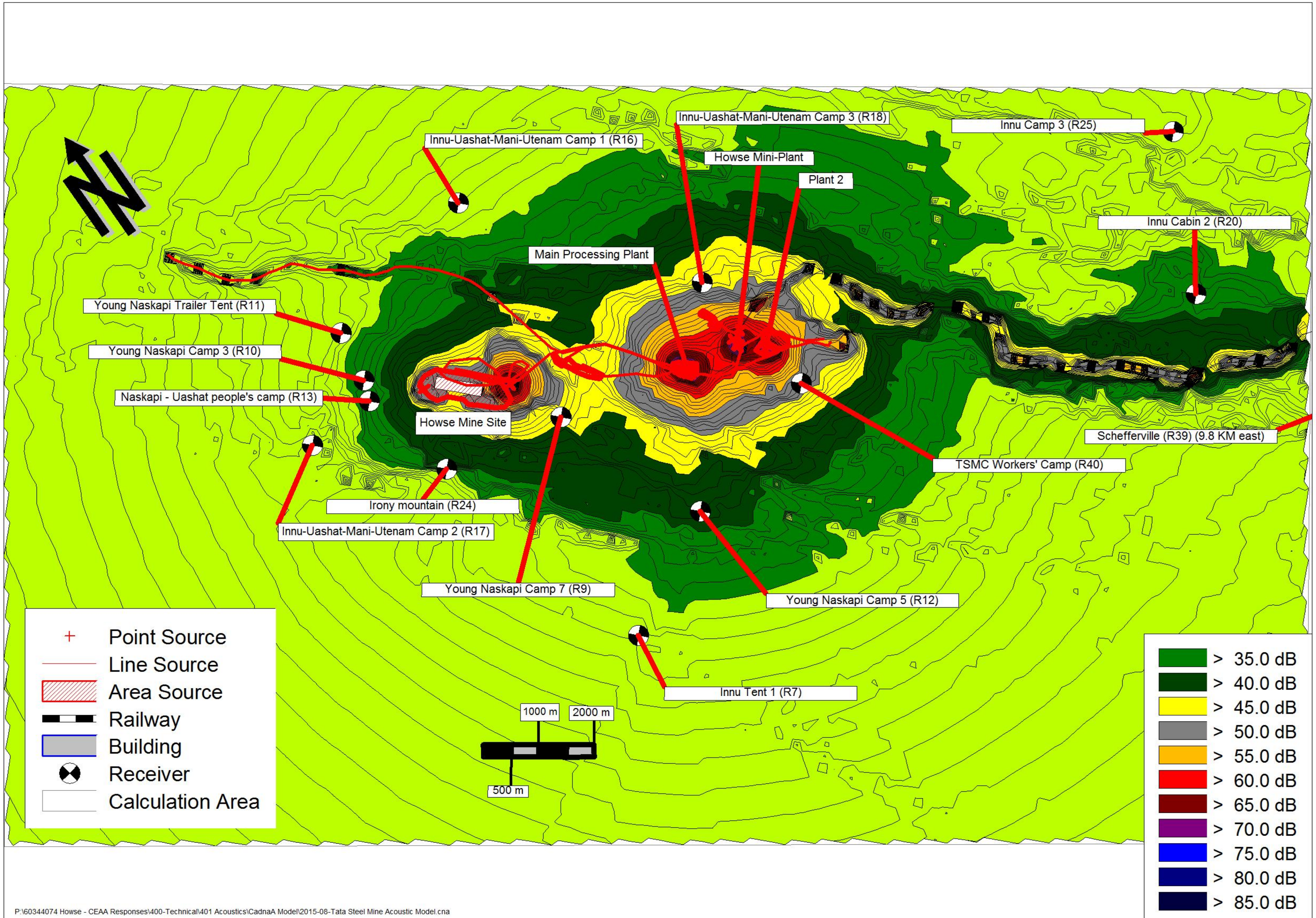
Figure 2.5

Base DSO3 Scenario -Noise Contours



P:\60344074 Howse - CEAA Responses\400-Technical\401 Acoustics\CadnaA Model\2015-08-Tata Steel Mine Acoustic Model.cna

Future Scenario - Noise Contours



Appendix B

Appendix B: Noise Source Information

Full Equipment List

Location	Equipment Description	Make	Model Number	Serial Number	Negligible?	Number
Plant 1	DIVERTER GATE-MAIN PLANT BYPASS				YES	1
	CONVEYOR-SCREEN FEED	MODULAR			YES	1
	VIBRATION SCREEN	METSO		SNSM2129	NO	1
	CONVEYOR-UNDER SCREEN	MODULAR			YES	1
	CONVEYOR-FINES TRANSFER #1	THOR	TC115-15	2126	YES	1
	CONVEYOR-FINES TRANSFER #2	THOR	TC115-15	2127	YES	1
	CONVEYOR-FINES STOCKPILER	THOR	T170-15	2123	YES	1
	CROSS CONVEYOR-LUMP	MODULAR			YES	1
	CONVEYOR-LUMP TRANSFER	THOR	TC150-4	2176	YES	1
	CONVEYOR-LUMP STOCKPILER	THOR	T170-15	2124	YES	1
	CONVEYOR-OVERSIZE STOCKPILER	THOR	RS70-2	2175	YES	1
	HOPPER-FEED HOPPER	SANDVIK	PX200-1200		NO	1
	APRON FEEDER-MINERAL SIZER	SANDVIK	PX200-1200		NO	1
	HYDRAULIC ROCK BREAKER	ALLIED	1505HD	02227	NO	1
	SIZER-PRIMARY HYBRID	SANDVIK	CR810/12-20		NO	1
	OVERHEAD CRANE-PRIMARY SIZER (10T)	SANDVIK			YES	1
	CONVEYOR-TRANSFER	SANDVIK	PX200-1200		YES	1
	BELT MAGNET-SELF CLEANING	ERIEZ			YES	1
	SIZER-SECONDARY HYBRID	SANDVIK	CR810/08-30		NO	1
	CONVEYOR-PROCESSING PLANT FEED	TS MANUFACTURING			YES	1
	Side Wall Fans	Aerovent	BSBP 42B304		NO	14
	Roof Fans	Aerovent	BSBP 42B304		NO	8
	Side Ventilation Fans	Bousquet	BC-500-RH-THD-O-HW	33035 130103	NO	6
	Dryer Fan	Robinson	BC0928		YES	1
	2 MW Generator	CAT			NO	6
	Vacuum Pump	NASH	2BE4-52		NO	2
	Centrifugal Blower	Gardner Denver			NO	1
	Generator Rad Fans	Sutton Stromart	SVS-0412053		NO	6

Location	Equipment Description	Make	Model Number	Serial Number	Negligible?	Plant 2 Number	Mini-Plant Number
Plant 2/Howse Mini-Plant	DIVERTER GATE-MAIN PLANT BYPASS				YES	1	1
	CONVEYOR-SCREEN FEED	MODULAR			YES	1	1
	VIBRATION SCREEN	METSO		SNSM2129	NO	1	1
	CONVEYOR-UNDER SCREEN	MODULAR			YES	1	1
	CONVEYOR-FINES TRANSFER #1	THOR	TC115-15	2126	YES	1	1
	CONVEYOR-FINES TRANSFER #2	THOR	TC115-15	2127	YES	1	1
	CONVEYOR-FINES STOCKPILER	THOR	T170-15	2123	YES	1	1
	CROSS CONVEYOR-LUMP	MODULAR			YES	1	1
	CONVEYOR-LUMP TRANSFER	THOR	TC150-4	2176	YES	1	1
	CONVEYOR-LUMP STOCKPILER	THOR	T170-15	2124	YES	1	1
	CONVEYOR-OVERSIZE STOCKPILER	THOR	RS70-2	2175	YES	1	1
	HOPPER-FEED HOPPER	SANDVIK	PX200-1200		NO	1	1
	APRON FEEDER-MINERAL SIZER	SANDVIK	PX200-1200		NO	1	1
	HYDRAULIC ROCK BREAKER	ALLIED	1505HD	02227	NO	1	1
	SIZER-PRIMARY HYBRID	SANDVIK	CR810/12-20		NO	1	1
	OVERHEAD CRANE-PRIMARY SIZER (10T)	SANDVIK			YES	1	1
	CONVEYOR-TRANSFER	SANDVIK	PX200-1200		YES	1	1
	BELT MAGNET-SELF CLEANING	ERIEZ			YES	1	1
	SIZER-SECONDARY HYBRID	SANDVIK	CR810/08-30		NO	1	1
	CONVEYOR-PROCESSING PLANT FEED	TS MANUFACTURING			YES	1	1
	Dryer - Induced Draft Fan				NO	1	2
	Dryer - Burner	Gencor	Astraflame AF-100		NO	1	2
	2 MW Generator	CAT			NO	1	1

Location	Equipment Description	Make	Model Number	Serial Number	Negligible?	Number
Howse, Timmins, and Flemming Mine Sites (Each)	Hydraulic Excavators 6m^3	Komatsu	PC1250 Class		NO	2
	Haul Trucks - 64/100 tonne payload	CAT	775/777 Class		NO	8
	Production Drill -160mm diameter holes	CAT	MD5125 Class		NO	1
	Track dozer - 250 kW	CAT	D8 Class		NO	1
	Road Grader - 200 kW	CAT	14M Class		NO	1

Location	Equipment Description	Make	Model Number	Serial Number	Negligible?	Number
Roads (Howse)	Haul Trucks - 64/100 tonne payload	CAT	775/777 Class		NO	71/hour
Roads (Mini-Plant)	Haul Trucks - 64/100 tonne payload	CAT	775/777 Class		NO	10/hour
Roads (Plant 2 to Rail Loading)	Haul Trucks - 64/100 tonne payload	CAT	775/777 Class		NO	15/hour

Location	Equipment Description	Make	Model Number	Serial Number	Negligible?	Base DSO3 Number	Future Number
Roads (Timmins, Fleming)	Haul Trucks - 64/100 tonne payload	CAT	775/777 Class		NO	24/hour	25/hour
Roads (Kivivic to DSO3)	Haul Trucks - 64/100 tonne payload	CAT	775/777 Class		NO	46/hour	46/hour

Location	Equipment Description	Make	Model Number	Serial Number	Negligible?	Number
Trains	Rail Cars - 25km/h				NO	212
	Locomotives -25 km/h				NO	2
	Dust Collector Fan	Twin City			NO	1

Performance Number: DM7916 **Change Level:** 01

Sales Model: 3516B
Application: PACKAGED GENSET
Rating Level: STANDBY

Rated Speed (RPM): 1,800
Rated Power (BKW): 2,145.0
Rated Power (BHP): 2,876

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

GENSET POWER WITH FAN EKW	PERCENT LOAD %	ENGINE POWER BKW	ENGINE POWER BHP	OVERALL DB(A)	125 HZ DB	250 HZ DB	500 HZ DB	1000 HZ DB	2000 HZ DB	4000 HZ DB	8000 HZ DB
2.000.0	100	2.151.2	2.885	116	121	117	109	108	109	109	107
1.800.0	90	1.939.6	2.601	116	121	117	109	107	108	108	106
1.600.0	80	1.730.2	2.320	114	119	115	107	106	107	107	105
1.500.0	75	1.626.0	2.181	114	119	115	107	105	107	107	105
1.400.0	70	1.521.9	2.041	113	118	114	106	105	106	106	104
1.200.0	60	1.314.8	1.763	112	117	113	105	104	105	105	103
1.000.0	50	1.108.5	1.487	111	116	112	104	103	104	104	102
800.0	40	904.2	1.213	110	115	111	103	101	102	102	100
600.0	30	698.9	937	108	113	109	101	100	101	101	99
500.0	25	595.2	798	107	112	108	100	99	100	100	98
400.0	20	490.4	658	106	111	107	99	98	99	99	97
200.0	10	276.6	371	104	109	105	97	96	97	97	95

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

GENSET POWER WITH FAN EKW	PERCENT LOAD %	ENGINE POWER BKW	ENGINE POWER BHP	OVERALL DB(A)	125 HZ DB	250 HZ DB	500 HZ DB	1000 HZ DB	2000 HZ DB	4000 HZ DB	8000 HZ DB
2.000.0	100	2.151.2	2.885	103	111	105	97	95	96	96	93
1.800.0	90	1.939.6	2.601	102	110	104	96	94	95	95	92
1.600.0	80	1.730.2	2.320	101	109	103	95	93	94	94	91
1.500.0	75	1.626.0	2.181	101	109	103	94	93	93	93	90
1.400.0	70	1.521.9	2.041	100	108	102	94	92	93	93	90
1.200.0	60	1.314.8	1.763	99	107	101	92	91	92	91	89
1.000.0	50	1.108.5	1.487	98	106	100	91	90	90	90	87
800.0	40	904.2	1.213	96	104	98	90	88	89	89	86
600.0	30	698.9	937	95	103	97	88	87	87	87	85
500.0	25	595.2	798	94	102	96	88	86	87	86	84
400.0	20	490.4	658	93	101	95	87	85	86	86	83
200.0	10	276.6	371	91	99	93	84	83	83	83	81

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

GENSET POWER WITH FAN EKW	PERCENT LOAD %	ENGINE POWER BKW	ENGINE POWER BHP	OVERALL DB(A)	125 HZ DB	250 HZ DB	500 HZ DB	1000 HZ DB	2000 HZ DB	4000 HZ DB	8000 HZ DB
2.000.0	100	2.151.2	2.885	96	104	99	90	88	89	89	86
1.800.0	90	1.939.6	2.601	96	104	98	89	88	88	88	85
1.600.0	80	1.730.2	2.320	94	102	97	88	86	87	87	84
1.500.0	75	1.626.0	2.181	94	102	96	88	86	87	87	84
1.400.0	70	1.521.9	2.041	93	101	96	87	85	86	86	83
1.200.0	60	1.314.8	1.763	92	100	94	86	84	85	85	82
1.000.0	50	1.108.5	1.487	91	99	93	85	83	84	84	81
800.0	40	904.2	1.213	90	98	92	83	82	82	82	79
600.0	30	698.9	937	88	96	90	82	80	81	81	78
500.0	25	595.2	798	87	95	90	81	79	80	80	77
400.0	20	490.4	658	86	94	89	80	78	79	79	76
200.0	10	276.6	371	84	92	86	78	76	77	77	74

Performance Number: DM7916 **Change Level:** 01

Sales Model: 3516B
Application: PACKAGED GENSET
Rating Level: STANDBY

Rated Speed (RPM): 1,800
Rated Power (BKW): 2,145.0
Rated Power (BHP): 2,876

MECHANICAL Sound Pressure Data (OBCF) Distance: 1 Meters (3.3 Feet)

GENSET POWER WITH FAN EKW	PERCENT LOAD %	ENGINE POWER BKW	ENGINE POWER BHP	OVERALL DB(A)	125 HZ DB	250 HZ DB	500 HZ DB	1000 HZ DB	2000 HZ DB	4000 HZ DB	8000 HZ DB
2.000.0	100	2.151.2	2.885	105	100	101	99	100	101	99	103
1.800.0	90	1.939.6	2.601	105	100	101	99	100	101	99	103
1.600.0	80	1.730.2	2.320	105	100	101	99	100	101	99	103
1.500.0	75	1.626.0	2.181	105	100	101	99	100	101	99	103
1.400.0	70	1.521.9	2.041	105	100	101	99	100	101	99	103
1.200.0	60	1.314.8	1.763	105	100	101	99	100	101	99	103
1.000.0	50	1.108.5	1.487	105	100	101	99	100	101	99	103
800.0	40	904.2	1.213	105	100	101	99	100	101	99	103
600.0	30	698.9	937	105	100	101	99	100	101	99	103
500.0	25	595.2	798	105	100	101	99	100	101	99	103
400.0	20	490.4	658	105	100	101	99	100	101	99	103
200.0	10	276.6	371	105	100	101	99	100	101	99	103

MECHANICAL Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

GENSET POWER WITH FAN EKW	PERCENT LOAD %	ENGINE POWER BKW	ENGINE POWER BHP	OVERALL DB(A)	125 HZ DB	250 HZ DB	500 HZ DB	1000 HZ DB	2000 HZ DB	4000 HZ DB	8000 HZ DB
2.000.0	100	2.151.2	2.885	94	88	89	87	89	90	87	91
1.800.0	90	1.939.6	2.601	94	88	89	87	89	90	87	91
1.600.0	80	1.730.2	2.320	94	88	89	87	89	90	87	91
1.500.0	75	1.626.0	2.181	94	88	89	87	89	90	87	91
1.400.0	70	1.521.9	2.041	94	88	89	87	89	90	87	91
1.200.0	60	1.314.8	1.763	94	88	89	87	89	90	87	91
1.000.0	50	1.108.5	1.487	94	88	89	87	89	90	87	91
800.0	40	904.2	1.213	94	88	89	87	89	90	87	91
600.0	30	698.9	937	94	88	89	87	89	90	87	91
500.0	25	595.2	798	94	88	89	87	89	90	87	91
400.0	20	490.4	658	94	88	89	87	89	90	87	91
200.0	10	276.6	371	94	88	89	87	89	90	87	91

MECHANICAL Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

GENSET POWER WITH FAN EKW	PERCENT LOAD %	ENGINE POWER BKW	ENGINE POWER BHP	OVERALL DB(A)	125 HZ DB	250 HZ DB	500 HZ DB	1000 HZ DB	2000 HZ DB	4000 HZ DB	8000 HZ DB
2.000.0	100	2.151.2	2.885	88	83	84	82	83	84	82	86
1.800.0	90	1.939.6	2.601	88	83	84	82	83	84	82	86
1.600.0	80	1.730.2	2.320	88	83	84	82	83	84	82	86
1.500.0	75	1.626.0	2.181	88	83	84	82	83	84	82	86
1.400.0	70	1.521.9	2.041	88	83	84	82	83	84	82	86
1.200.0	60	1.314.8	1.763	88	83	84	82	83	84	82	86
1.000.0	50	1.108.5	1.487	88	83	84	82	83	84	82	86
800.0	40	904.2	1.213	88	83	84	82	83	84	82	86
600.0	30	698.9	937	88	83	84	82	83	84	82	86
500.0	25	595.2	798	88	83	84	82	83	84	82	86
400.0	20	490.4	658	88	83	84	82	83	84	82	86
200.0	10	276.6	371	88	83	84	82	83	84	82	86

AECOM

TABLE B1

ASHRAE PREDICTED SOUND POWER LEVELS

Measurement Date: ASHRAE PREDICT | Last Updated: September 8, 2015

Project Name: Tata Mines

Project Code: 60344074

Staff: BB

2 | DataType = 2

Sheet #[1]	Source ID	Source Tag	Source Description	Flow rate ($A.m^3/s$)	Flow rate (cfm)	Static Pressure (inches WG)	ASHRAE FanType	Fan Efficiency Ratio%	Fan Efficiency Correction Factor (dB)	Band Frequency (Hz)	Band Frequency Correction (dB)
	AMU	AMU	Air Make Up Unit	23.60	50,000	3.86	2	85	3	250	3
	RoofFan	RoofFan	Roof Fans	10.38	22,000	0.63	12	85	3	63	5
	SideFan	SideFan	SideFan	10.38	22,000	0.63	12	85	3	63	5
	VacuumPumpFan	VacuumPumpFan	Vacuum Pump Fan	3.15	6,680	140.00	1	74	9	250	3
	IDFan	IDFan	ID Fan for Bag House	35.40	75,000	6.00	1	85	3	250	3
					0				0		#N/A

Source ID	ASHRAE Predicted Base Total Sound Power (dB ref. 10-12W) 63	125	250	500	1k	2k	4k	8k	ASHRAE Pressure/ Flowrate Adj (dB)
AMU	45	45	43	39	34	28	24	19	58.72
RoofFan	48	51	58	56	55	52	46	42	39.34
SideFan	48	51	58	56	55	52	46	42	39.34
VacuumPumpFan	40	40	39	34	30	23	19	17	81.17
IDFan	40	40	39	34	30	23	19	17	64.31
	###	###	###	###	###	###	###	###	#NUM!

Source ID	ASHRAE Predicted Efficiency and BFI Adjustments (dB) 63	125	250	500	1k	2k	4k	8k
AMU	3	3	6	3	3	3	3	3
RoofFan	8	3	3	3	3	3	3	3
SideFan	8	3	3	3	3	3	3	3
VacuumPumpFan	9	9	12	9	9	9	9	9
IDFan	3	3	6	3	3	3	3	3
	0	0	0	0	0	0	0	0

Source ID	Total Sound Power (dB re 10^{-12} Watts) 63	125	250	500	1000	2000	4000	8000	Overall Sound Power (dB)	Overall Sound Power (dBA)
AMU	107	107	108	101	96	90	86	81	112	103
RoofFan	95	93	100	98	97	94	88	84	105	102
SideFan	95	93	100	98	97	94	88	84	105	102
VacuumPumpFan	130	130	132	124	120	113	109	107	136	127
IDFan	107	107	109	101	97	90	86	84	113	104
	#N/A	#N/A	###	#N/A	###	###	###	###	#N/A	#######

Source ID	NOTES: Source Notes	Source Character (16)	CADNA IMPORT (17)
AMU	Taken from manufacturing data.	S	1
RoofFan	Taken from fan submittal data.	S	1
SideFan	Taken from fan submittal data.	S	1
VacuumPumpFan	Taken from fan manufacturer data.	S	0
IDFan	Taken from baghouse data using fan specs. Remember to subtract 3	S	0

Measurement Date ~ Last Updated September 8, 2015
Project Name Tata Mines
Project Code 60344074
Staff BB

4 DataType = 4

TABLE B2

SOUND POWER LEVEL PREDICTIONS BASED ON CALCULATIONS

Calculated L_W in Octave Bands [Hz]

Sheet #(1)	Source ID	Source Tag	Source Description	Wtd(2)	31.5	63	125	250	500	1k	2k	4k	8k	Overall Leq	Dir Type(4)	Angle(5)
	HaulTruck	HaulTruck775	CAT Haul Truck 775	Linear		99	95	87	86	84	83	77	73	101	0	0
	Excavator	Excavator	Komatsu PC1250	Linear	69	79	69	68	66	63	59	55	54	80	0	0
	Dozer	Dozer	250 kW CAT D8	Linear		89	92	83	81	82	78	73	65	95	0	0
	Loader	Loader	Loader	Linear	72	77	85	77	78	80	77	70	68	88	0	0
	Grader	Grader	200 kW CAT 14M Class	Linear		81	87	79	77	77	74	70	67	89	0	0
	Vibration_Screen	VibrationScreen	Metso SNSM2129	Linear										10	0	0
	Primary Hybrid_Crusher	Crusher1	Sandvik CR810/12-20	Linear										10	0	0
	Secondary_Hybrid Crusher	Crusher2	Sandvik CR810/08-30	Linear										10	0	0
	Feed_Hopper	Feed_Hopper	Feed Hopper	Linear	77	84	85	79	76	76	72	67	63	89	0	0
	Apron_Feeder	Apron_Feeder	Feed Hopper	Linear	77	84	85	79	76	76	72	67	63	89	0	0
	HydraulicRockBreaker	HydraulicRockBreaker	Hoe Ram	Linear	79	79	82	81	82	86	86	86	85	93	0	0
	OverheadCrane	OverheadCrane	Overhead Crane - Sandvik	Linear										10	0	0
	TruckLoading	TruckLoading	Truck Loading	Linear	77	84	85	79	76	76	72	67	63	89	0	0
	Crushers_Generator	Crushers_Generator	Primary, Secondary Crushers and Gensets	Linear	73	84	86	81	79	84	79	73	64	91	0	0
	Track_Drill	TrackDrill	CAT MD5125 Track Drill	Linear		86	92	85	88	84	83	78	77	95	0	0
	Fans	Fan	Generator Rad Fan	Linear		48	51	58	56	55	52	46	42	62	0	0
	GenIntake	GenIntake	5 Generator Intake	Linear		53	125	125	120	118	118	116		130	0	0
	GenandDryerFan	GenandDryerFan	Generator Exhaust and Dryer Fan	Linear		34	142	137	127	125	126	126		144	1	0
	IdlingDiesel	IdlingDiesel	Idling Diesel locomotive	Linear	123	131	132	123	125	125	118	114	110	136	0	0
	Generator_for_calc		Mechanical Noise	A			83	84	82	83	84	82	86	92	0	0
	GeneratorExhaust	GenExhaust	2MW Generator	Linear			104	99	90	88	89	89	86	106	0	0
	DustCollector	DustCollector	Dust Collector	Linear		81	80	79	78	75	69	61	52	86	0	0
	VacuumBlowerHoused	VacuumBlowerHoused	Vacuum Blower with fan housing	Linear		40	40	39	34	30	23	19	17	45	0	0
	VacuumBlowerHousingAdj	VacuumBlowerHousingAdj	uum Blower with fan housing 85dBA adjusted @	Linear	0	40	40	34	24	15	3	-3	-8	44	0	0
	VacuumBlower	VacuumBlower	Vacuum Blower	Linear	56	96	96	90	80	71	59	53	48	100	0	0
	VacuumBlowerDucted	VacuumBlowerDucted	Vacuum Blower Ducted	Linear		84	89	81	58	38	22	18		91	0	0
	IDFan	IDFan	IDFan	Linear		107	107	109	101	97	90	86	84	113	0	0
	VacuumPumps	VacuumPumps	Vacuum Pump 2BE4	Linear		53	53	43	36	36	31	26	21	56	0	0
	VacuumPumpDucted1	VacuumPumpDucted1	Vacuum Pump 2BE4 1 Ducted	Linear		95	96	84	73	70	67	67		99	0	0
	VacuumPumpDucted2	VacuumPumpDucted2	Vacuum Pump 2BE4 2 Ducted	Linear		95	96	84	73	70	67	67		99	0	0
	DryerBurner	DryerBurner	Dryer Burner	Linear	24	24	23	21	18	15	12	9	6	30	0	0

Sound Pressure Level Corrections/Adjustments

Source ID	Directivity Corrections in dB (6) 32	63	125	250	500	1k	2k	4k	8k	Adj(7)	misc Corrections in dB 31.5	63	125	250	500	1k	2k	4k	8k	Corrected/Adjusted L_{EQ}(8) 31.5	63	125	250	500	1k	2k	4k	8k	Overall Leq
HaulTruck	0	0	0	0	0	0	0	0	0	-32	0	0	0	0	0	0	0	0	0	-32	67	63	55	54	52	51	45	41	69
Excavator	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	82	92	82	81	79	76	72	68	67	93
Dozer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	89	92	83	81	82	78	73	65	95
Loader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	77	85	77	78	80	77	70	68	88
Grader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	87	79	77	77	74	70	67	89
Vibration_Screen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Primary Hybrid_Crusher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Secondary_Hybrid Crusher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Feed_Hopper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	84	85	79	76	76	72	67	63	89
Apron_Feeder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	84	85	79	76	76	72	67	63	89
HydraulicRockBreaker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	79	79	82	81	82	86	86	86	85	93
OverheadCrane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
TruckLoading	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	84	85	79	76	76	72	67	63	89
Crushers_Generator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73	84	86	81	79	84	79	73	64	91
Track_Drill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	86	92	85	88	84	83	78	77	95
Fans	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	16	64	67	74	72	71	68	62	58	78
GenIntake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53	125	125	120	118	118	116	0	130
GenandDryerFan	-8	-8	-8	-8	-9	-9	-10	-10	-10	0	0	0	0	0	0	0	0	0	0	-8	26	134	129	118	116	116	116	-10	135
IdlingDiesel	0	0	0	0	0	0	0	0	0	-55	0	0	0	0	0	0	0	0	0	68	76	77	68	70	70	63	59	55	81
Generator_for_calc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83	84	82	83	84	82	86	92
GeneratorExhaust	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	104	99	90	88	89	89	86	106
DustCollector	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	80	79	78	75	69	61	52	86
VacuumBlowerHoused	0	0	0	0	0	0	0	0	0	0	0	0	0	-5	-10	-15	-20	-22	-25	0	40	40	34	24	15	3	-3	-8	44
VacuumBlowerHousingAdj	0	0	0	0	0	0	0	0	0	0	49	49	49	49	49	49	49	49	49	49	89	89	83	73	64	52	46	41	93
VacuumBlower	0	0	0	0	0	0	0	0	0	0	0	0	0	5	10	15	20	22	25	56	96	96	95	90	86	79	75	73	101
VacuumBlowerDucted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84	89	81	58	38	22	18	0	91
IDFan	0	0	0	0	0	0	0	0	0	-3	0	0	0	0	0	0	0	0	0	-3	104	104	106	98	94	87	83	81	110
VacuumPumps	0	0	0	0	0	0	0	0	0	57	0	0	0	0	0	0	0	0	0	57	110	110	100	93	93	88	83	78	113
VacuumPumpDucted1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	95	96	84	73	70	67	67	0	99
VacuumPumpDucted2	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	95	96	84	73	70	67	67	0	99
DryerBurner	0	0	0	0	0	0	0	0	0	92	0	0	0	0	0	0	0	0	0	116	116	115	113	110	107	104	101	98	122

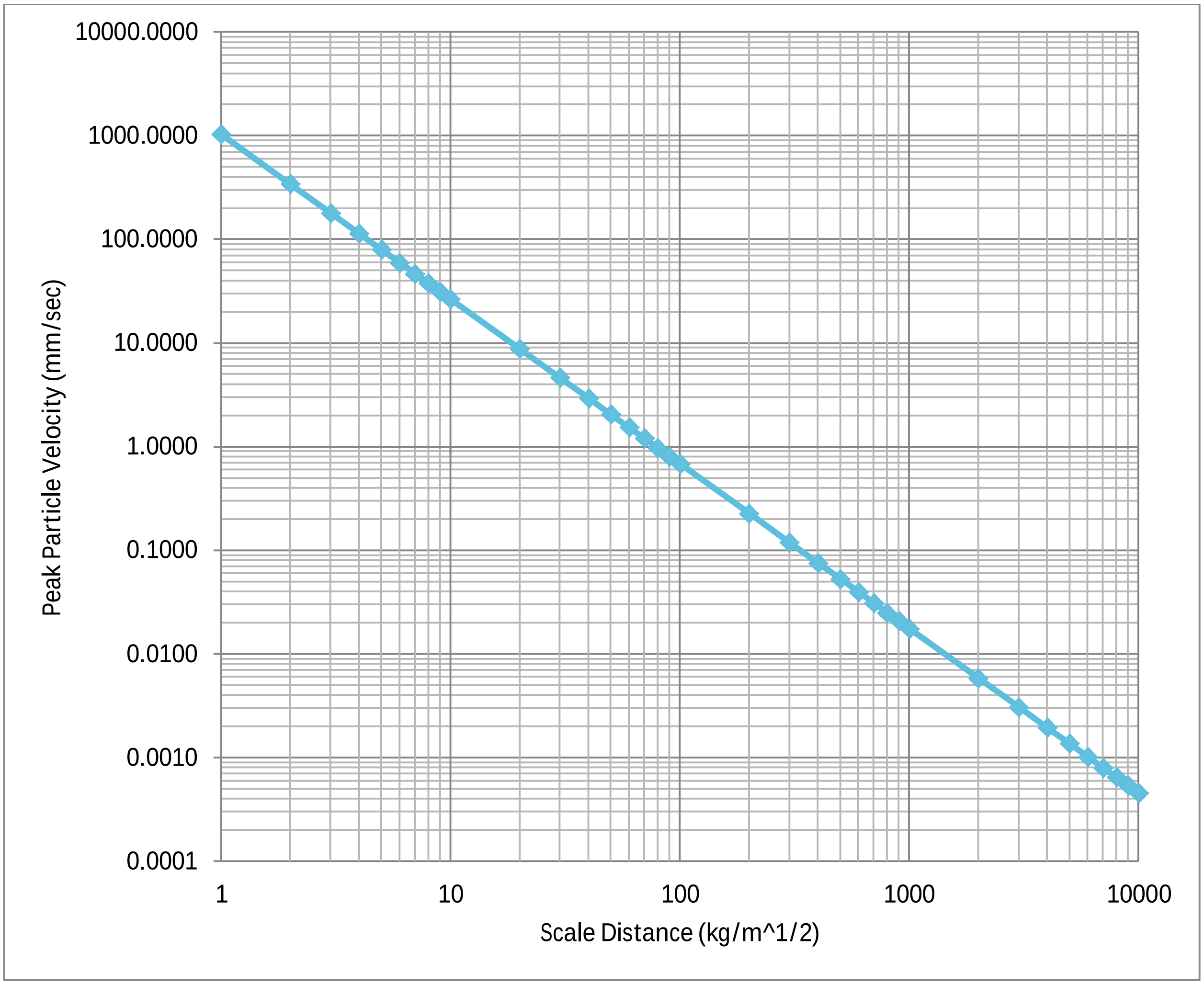
Source Power/Intensity Level Calculations and **NOTES**

Source ID	STYPI (9)	SPH% (10)	Dist(11) (m)	Area(12) (m²)	Sound Power Lw or Sound Intensity Li(13) 31.5	63	125	250	500	1k	2k	4k	8k	Overall Lw/Li	Overall Lw/Li dBA	TYPE (14)	Measurement/Source Notes	Source Character (15)	CADNA IMPORT (16)
HaulTruck	4	50	10.00		-4	95	91	83	82	80	79	73	69	97	86	Lw (D)	Spectrum of dump truck taken from BS5228-1:2009, adjusted to 86 dBA per manufacturer's spec data (SAE J88)	S	1
Excavator	4	50	15.24		114	124	114	113	111	108	104	100	99	125	113	Lw (D)	Spectrum of excavator taken from Gravenhurst, adjusted to 81 dBA per RCNM data	S	1
Dozer	4	50	10.00		28	117	120	111	109	110	106	101	93	123	114	Lw (D)	Levels taken from BS5228-1:2009	S	1
Loader	4	50	5.10		94	99	107	99	100	102	99	92	90	110	106	Lw (D)	Cat 996 from Gravenhurst	S	1
Grader	4	50	10.00		28	109	115	107	105	105	102	98	95	117	110	Lw (D)	Levels taken from BS5228-1:2009	S	1
Vibration_Screen					0	0	0	0	0	0	0	0	0	10	7	Li	From Dunville, use measurement of combined gen-crushers below	S	0
Primary Hybrid_Crusher					0	0	0	0	0	0	0	0	0	10	7	Li	From Dunville Quarry Project, use measurement of combined gen-crushers below	S	0
Secondary_Hybrid Crusher					0	0	0	0	0	0	0	0	0	10	7	Li	From Dunville Quarry Project, use measurement of combined gen-crushers below	S	0
Feed_Hopper	4	50	15.20		109	116	117	111	108	108	104	99	95	121	112	Lw (D)	Used measurements from Truck loading	S	1
Apron_Feeder	4	50	15.20		109	116	117	111	108	108	104	99	95	121	112	Lw (D)	Used measurements from Truck loading	S	1
HydraulicRockBreaker	4	50	10.00		107	107	110	109	110	114	114	114	113	121	120	Lw (D)	Levels taken from BS5228-1:2009	S	1
OverheadCrane					0	0	0	0	0	0	0	0	0	10	7	Li	Electric powered, inside dome, negligible	S	0
TruckLoading	4	50	15.20		109	116	117	111	108	108	104	99	95	121	112	Lw (D)	Truck loading from Dunnville Quarry	S	1
Crushers_Generator	4	50	30.50		111	122	124	119	117	122	117	111	102	129	124	Lw (D)	Screen, primary crusher, secondary crusher, and 2MW generator lumped together using Dunville Quarry measurements	S	1
Track_Drill	4	50	10.00		28	114	120	113	116	112	111	106	105	123	118	Lw (D)	Levels taken from BS5228-1:2009	S	1
Fans	4	50	7.00		41	89	92	99	97	96	93	87	83	103	100	Lw (D)	ASHRAE spectrum adjusted to value given from designer - e-mail from Barbara Ruttle	S	1
GenIntake	2				0	53	125	125	120	118	118	116	0	130	125	Lw	Duct and opening calcs performed in soundcalc	S	1
GenandDryerFan	2				-8	26	134	129	118	116	116	116	-10	135	125	Lw	Duct and opening calcs performed in soundcalc	S	1
IdlingDiesel	4	50	15.24		100	108	109	100	102	102	95	91	87	113	105	Lw (D)	Measurements taken from Willowbrook project, adjusted to 73dBA Lmax from FTA at 50ft	S	1
Generator_for_calc	4	50	15.00		32	32	115	116	114	115	116	114	118	124	124	Lw (D)	For use in calc from Manufacturer data	S	0
GeneratorExhaust	4	50	15.00		32	32	136	131	122	120	121	121	118	137	129	Lw (D)	Taken from DM8779-10, data sent by Alex Lee	S	0
DustCollector					0	81	80	79	78	75	69	61	52	86	79	Li	Taken from fan specifications	S	1
VacuumBlowerHoused					0	40	40	34	24	15	3	-3	-8	44	29	Li	Centrifugal Fan Data from Architectural Acoustics (Marshall Long) Table 13.5, Enclosure Adjustment from Table 13.8	S	0
VacuumBlowerHousingAdj	4	50	0.91		56	96	96	90	80	71	59	53	48	100	85	Lw (D)	Adjusted to 85dBA at 3 feet per Manufacturing data for blower w/ fan housing	S	0
VacuumBlower					56	96	96	95	90	86	79	75	73	101	92	Li	Adjusted to remove fan housing to obtain outlet value	S	0
VacuumBlowerDucted					0	84	89	81	58	38	22	18	0	91	76	Li	Vacuum Blower sound power level used with Soundplan duct calcs	S	1
IDFan					-3	104	104	106	98	94	87	83	81	110	101	Li	IO ASHRAE Sound level adjusted for outlet only	S	1
VacuumPumps					57	110	110	100	93	93	88	83	78	113	99	Li	Pump correction level (architectural acoustics, Long) subtracted from whole number, and adjusted to 2BE4 manufacturing data overall sound power level	S	0
VacuumPumpDucted1					0	95	96	84	73	70	67	67	0	99	82	Li	Duct calculations performed in soundcalc	S	1
VacuumPumpDucted2					0	95	96	84	73	70	67	67	0	99	82	Li	Duct calculations performed in soundcalc	S	1
DryerBurner	4	50	0.91		123	123	122	120	117	114	111	108	105	129	120	Lw (D)	Overall dBA taken from manufacturing data, spectrum from Engineering noise control book (Bies&Hansen) Table 11.16 (boilers)	S	1

SEE ATTACHED NOTES

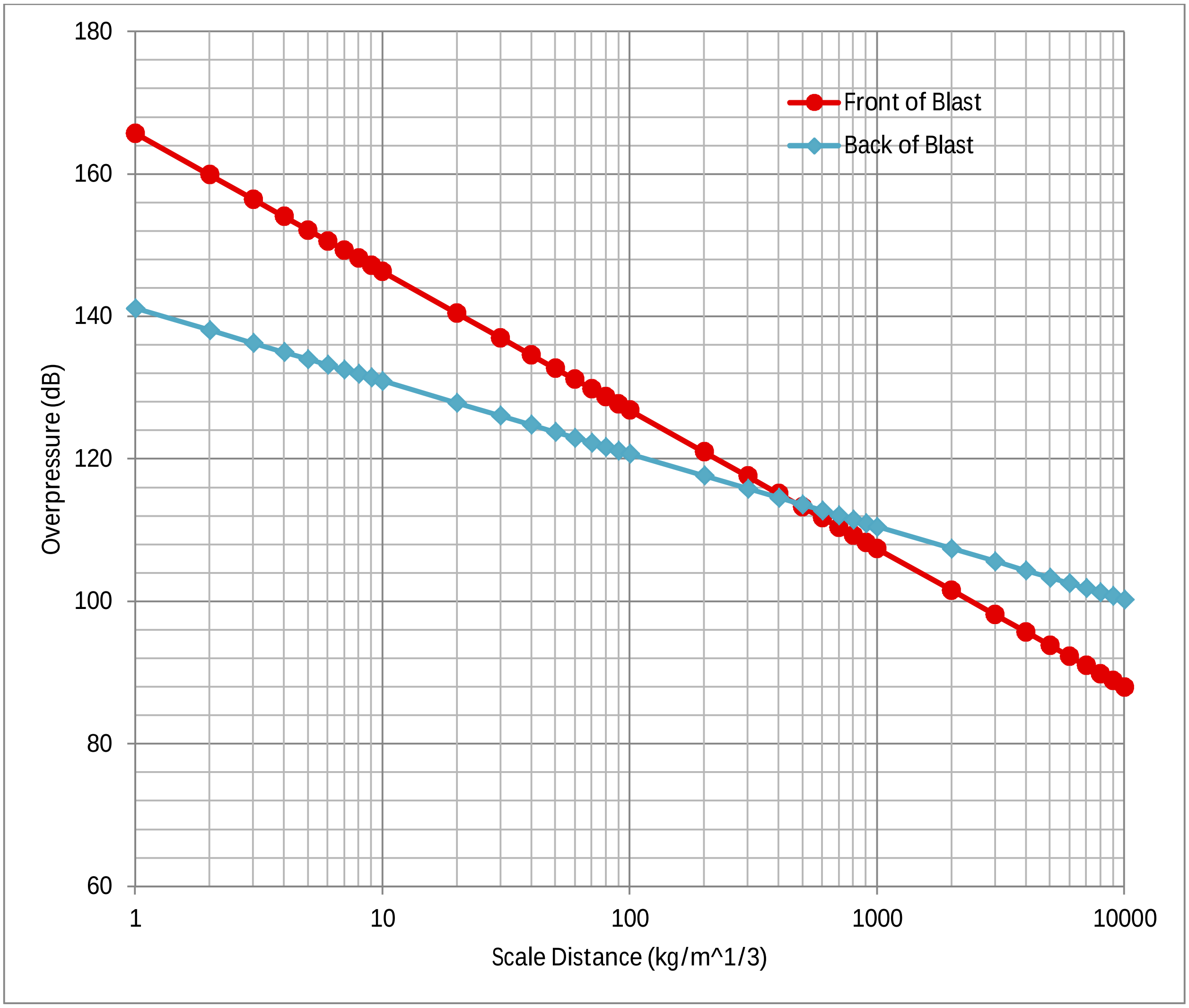
Appendix C

Appendix C: Ontario Ministry of the Environment Predictive Models for Blast ground vibration and overpressure



Peak Particle Velocity (mm/sec) versus scale distance ($kg/m^{1/2}$ - charge weight per delay divided by square root of distance)

Source: Ontario Ministry of the Environment "Guidelines on Information Required for Assessment of Blasting Noise and Vibration – December 1985 ".



Blast overpressure versus scale distance (kg/m$^{1/3}$ - Charge weight per delay divided by square root of distance)

Source: Ontario Ministry of the Environment "Guidelines on Information Required for Assessment of Blasting Noise and Vibration – December 1985 ".

Howse Mineral Limited

DSO Howse Property Environmental Assessment – Ambient Light Technical Report

Prepared by:

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Date:

January, 2015 (Revision 1 in October 2015)

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Revision #	Revised By	Date	Issue / Revision Description
1	Denis Lalonde	29-Oct-2015	Minor revisions to DSO3 and Howse project description

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Executive Summary

In accordance with the Canadian Environmental Assessment Agency (CEAA) document *Guidelines for the Preparation of an Environmental Impact Statement – Howse Property Iron Mine (July 14, 2014),* a night-time light level (or ambient light) assessment is required to be completed for the operation of the Howse Mining site. This report documents the night-time light levels on selected sensitive receptors surrounding the Howse Mining Site.

The proposed Howse mining site is located in Newfoundland and Labrador, approximately twenty-three kilometres northwest of Schefferville, Quebec, near the provincial border of Newfoundland and Labrador, and Quebec. The site will be located in close proximity to the Direct Shipping Ore 3 (DSO3) project. DSO3 consists of Timmins 3, Timmins 4, Timmins 7, and Fleming 7 mining sites, in addition to a processing plant complex. The ore from the Howse mining area will be transported to a processing plant located east of the rail loop and comprising a crusher/screener and 2 dryers. The processed Howse ore is then shipped by rail.

The Howse Mining Project will have limited impact on ambient light levels since:

- no power lines will be constructed to bring electricity to the Howse Mining site due to its relatively remote location, consequently no permanent light fixtures will be installed at the mine site;
- most activities at the site will be during the day time;
- limited mining activities will occur during the winter months, when the nights are longer and there is snow on the ground which reflects light (artificial or natural).

Light pollution is an issue that has gained prominence within the context of environmental assessment. However, standardized quantification methods, procedures and standards are limited to non-existent, particularly in a remote location such as the region of Schefferville where artificial light is minimal and the sky and air are clear (compared to more densely populated areas).

Taking the above project specificities into consideration, TSMC decided to use an innovative assessment methodology that combines on-site ambient light measurements, a radiative transfer model and the most recent available satellite images in order to characterize ambient light on a set of identified sensitive receptors in the vicinity of the Howse/DSO project region.

In November 2014, an ambient light measurement program was conducted on-site. A Sky Quality Meter (SQM Model SQM-LU-DL by Unihedron) was used to measure sky brightness at 7 sites located in the vicinity of the project site. The SQM provides measurements in units of “magnitudes per square arcsecond" which are commonly used in astronomy to measure sky brightness. Measurements were conducted under strict night sky conditions in order to be representative and useable for modeling purposes. These measurements were then used to calibrate the radiative transfer model (Illumina). Using the Illumina model, it was possible to conduct an assessment of ambient light in the project region for the winter season (with snow cover and clear skies) and the summer season (without snow on the ground, with clear skies or during sporadic air pollution events caused by forest fires). The Illumina model outputs were used to generate maps and tables of the sky radiance for different seasons and air quality levels at 8 sensitive receptors; these are available in this report.

The modelling results demonstrate that:

a) During the wintertime (with snow cover), the ratio of artificial sky radiance to natural sky radiance increase by a factor of 3 to 10, compared to summertime (no snow cover).

b) In Schefferville and Kawawachikamach, sky radiance is almost entirely due (>99.5%) to the artificial lighting of these towns; the Howse/DSO mining complex lighting has minimal effect, if any, on the ambient light of these two towns.

c) Conversely, the artificial lighting of Schefferville and Kawawachikamach contributes for approximately 10% to the ambient light levels at receptors located close the Howse mining site (such as Irony Mountain and Pinette Lake).

d) At more distant locations (>15 km) North of the Howse mining site, where the DSO4 mining areas (Goodwood, Sunny, Kiviviks) will be located, the contribution of artificial sky radiance is approximately equal between the towns Schefferville/ Kawawachikamach and the activities of the DSO3 complex and Howse.

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1. Introduction

In accordance with the Canadian Environmental Assessment Agency (CEAA) document *Guidelines for the Preparation of an Environmental Impact Statement – Howse Property Iron Mine,* an environmental assessment is required to be completed for the operation of the Howse Mine site. The proposed Howse Mine is located in close proximity to the Direct Shipping Ore 3 (DSO3) project site. This report documents the night-time light levels on selected sensitive receptors surrounding the Howse Mining Site.

A radiative transfer model called Illumina is used to determine the complete field of artificial light for different observer positions and for different periods of the year. Seasonal variations in aerosol content of the atmosphere along with changes in ground reflectivity (vegetation and snow cover changes) are considered. In order to assure a tight link between model estimations and the ground conditions, sky brightness measurements were acquired on site with a Sky Quality Meter (SQM) and used as reference points for model calibration. Night time and day time satellite images are used to infer the installed luminosity and the ground reflectance respectively which are inputs to the model. Ground elevation is derived from the digital elevation model obtained from the Shuttle Radar Topography Mission [29]. Along with the sky brightness, Illumina provides a set of contribution maps. The contribution maps allow an easy identification of the geographical origin of the sky brightness while giving the percentage of contribution per sq km. Results are analyzed with a focus on a set of identified sensitive receptors.

2. Background

From the 1980s, the astrophysical research community conducted the first studies regarding light pollution. They originally focused on the impact of artificial lighting on the starry sky. In recent years, however, the study of light pollution was updated due to the varied effects on the integrity of the nocturnal environment being discovered. These effects impact both the balance of the natural environment (flora and fauna) [1-10] and the social and economic activities of humans [11-15]. Light pollution even has significant impact on human health [16–18].

To characterize light pollution, we must conduct both field measurements and numerical modelling relying on satellite data. The interaction of artificial light at night (ALAN) with the environment shows an extremely complex and non-linear behavior, which to-date cannot be analytically solved. To overcome this limitation, several numerical models of radiative transfer were developed in recent years [19-22]. These new developments were made possible thanks to the increasing availability of high-performance computers, as well as the availability of satellite datasets, such as the Visible/Infrared Imager/Radiometer Suite – Day-Night Band (VIIRS-DNB) data [23]. Multiple variables affect the propagation of light pollution in the environment including: 1) the optical properties of the atmosphere; 2) the spectral reflectance properties of the ground; 3) the presence of masking by terrain and obstacles (e.g., trees, buildings); and 4) the optical characteristics of lighting devices and their geographical distribution.

Light pollution can reach the environment via three main paths. The first, which generally has the highest light intensity, is direct illumination. This is a short distance effect that rapidly vanishes due to terrain and obstacles blocking it. The second largest contributor is the scattering of artificial light by cloud cover. The importance of scattering by clouds in comparison to the backscatter from the clear atmosphere is generally many times greater for sites near sources of light, such as urban and suburban environments and is generally lower for remote rural sites. Finally, the last contribution, which will be main topic for this study, is indirect illumination in clear sky conditions. This process is prevalent in cases where direct illumination does not reach the observer and where clouds are darker than the starry sky, as is often the case in areas far from major cities.

Our methodology involved in-situ sampling of the night sky brightness over a limited number of observing locations and time periods combined with numerical modeling using a radiative transfer model. The in-situ data is used for model calibration and the extraction of the natural background sky brightness. Use of the numerical model permits inference of results across the study area and for additional periods of the year from what was collected as a part of the in-situ sampling.

The proposed Howse Project site is located in Newfoundland and Labrador, approximately twenty-three kilometres northwest of Schefferville, Quebec, near the provincial border of Quebec and Newfoundland and Labrador. The site will be located in the vicinity of the DSO3 project. The DSO3 operations include the Timmins 3, Timmins 4, Timmins 7, and Fleming 7 mine sites, in addition to the production plants (Main Processing Plant and Plant 2).

3. Model Description

The radiative transfer model used for this study is Illumina, Version 2 [19]. Illumina acts as a ray-tracing software where a set of photons is thrown from light fixtures located above ground level pixels, and then reaches the observer's Field Of View (FOV) following four different light paths: 1) first scattering by molecules and aerosols in voxels of the line of sight, 2) first scattering after a lambertian reflexion on the ground, and 3) a second scattering in a voxel of the line of sight after a first scattering from atmospheric voxels contained in a surrounding volume. The fourth path is the same path as 3, but it occurs after a reflexion on the ground pixel, whereas path 3) occurs after a first scatting from atmospheric voxels contained in a surrounding volume. For all of the light paths considered, the scattering processes toward the observer and the extinction by aerosols (scattering and absorption) and molecules (scattering only) are computed. Illumina computes the first and second orders of scattering of light. The second order of scattering may have a significant impact on sky radiances, up to 40% of the total sky radiance especially when the observer is far from urban areas [23]. At this time, Illumina is the only model available that computes explicitly the second order of scattering which requires a considerable computing time and consequently requires access to a supercomputer. In our opinion, it is for this reason that Illumina is the most reliable tool to infer accurately the sky brightness field for remote sites such as the Howse mining project site and the entire DSO complex.

4. In-situ measurements

The measurement of the sky brightness (S_s) is historically based on the units defined by astronomers, the magnitude per squared arc second (mag/sq arcsec). The sky brightness is defined by Equation 1.

$$S_s = S_0 - 2.5\log\left(E_m + E_n\right) \tag{1}$$

S_s is the sky brightness at a given point of the territory, E_m is the modelled sky radiance (i.e the sky radiance produced by ALAN), and E_n the natural sky radiance in the absence of light pollution. S_0 is the reference brightness. Equation 1 can be reorganized to solve for E_m.

$$E_m = 10^{\left(\frac{S_s - S_0}{2.5}\right)} - E_n \tag{2}$$

$$E_m = 10^{-\left(\frac{S_0}{2.5}\right)} 10^{\left(\frac{S_s}{2.5}\right)} - E_n \tag{3}$$

With a minimum number of E_m (modeled radiance) values and corresponding in-situ measured sky brightness, it is possible to derive the constants S_0 and E_n by plotting E_m versus 10^(S_s /2.5). For the Howse Mine site project, sky brightness measurements were obtained at different sites in the vicinity of the DSO complex site, as shown on the sky quality location map presented in Appendix 1. The measurements were obtained with a Sky Quality Meter (SQM), manufactured by Unihedron. Unihedron Model No. SQM-LU-DL with data logger was used for the in-situ measurements for the Howse Mine project evaluation, as shown in Figure 1. Field data sheets and output files of recorded data are included in Appendix 2. Systematic measurement conditions and methodology were used during the sampling program to obtain a variety of sky brightness conditions.

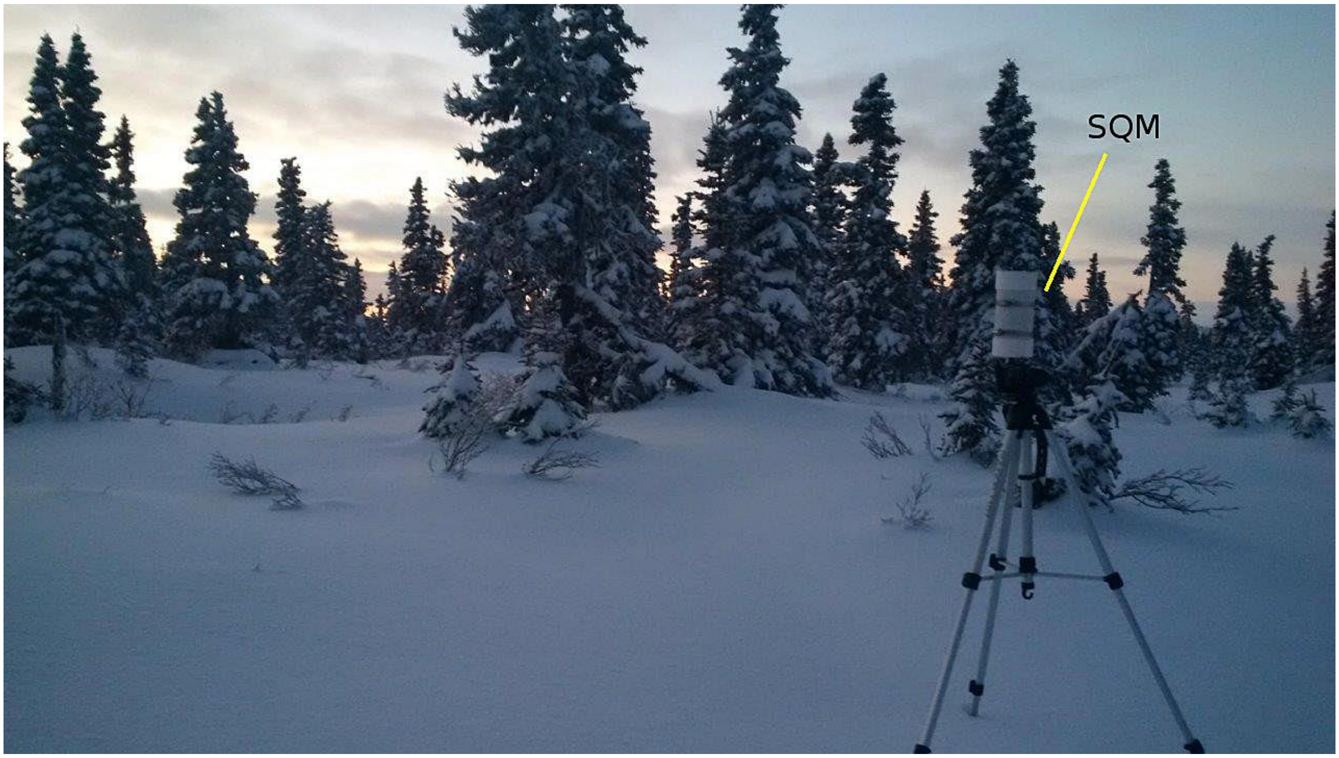

Figure 1 SQM-LU-DL with a protective housing mounted on a tripod. Credits: Denis Lalonde. AECOM

This instrument allows for automated measurements of the sky brightness. Clear weather conditions during the data collection period have allowed for the collection of 7 data points, 5 of which were used for modeling purposes. Table 1 shows the measurement results. SQM sky brightness measurements can have significant uncertainties and therefore the more data that is available for analysis, the more representative the analysis will be. Having less than 5 measuring points may result in an inaccurate evaluation. Uncertainties not only comes from the instrument itself but also from changes in atmospheric conditions (clouds & aerosols), stellar background in the area of the sky sampled and the presence or absence of atmospheric emission lines (northern lights). In order to be representative and useable for modeling purposes, measurements were conducted under strict night sky conditions. Based on best practices found in the literature review, strict night sky conditions can be described as follows:

- Moonless night.
- No clouds or fog.
- The Sun is at least 18 degrees below the horizon (astronomical twilight).
- No direct light from artificial sources reaches the detector of the device.

Note that all data were collected after astronomical twilight to exclude indirect solar radiation. By linear regression of the E_m vs 10^(S_s / 2.5) plot, the intercept (-E_n) and slope (10^(S_0 / 2.5) were obtained. This is shown in Figure 2.

Table 1 In Situ Night-Time Illumination Results, November 26 to 28, 2014

SITE ID	DESCRIPTION	DATE AND TIME OF MEASUREMENT	AVG. SQM READING mag/arcsec^2
Irony Mountain / Howse	Important site for First Nations and project site ≈1.5 km west of Howse	27-Nov-14 00:37 to 00:43	20.52
Pinette Lake	Innu camp, hunting site and potential migratory birds area. ≈2 km southeast of Howse	26-Nov-14 23:14 to 23:20	20.50
Kawawachikamach-1	Town center ≈26 km east to south-east of Howse	26-Nov-14 20:40 to 20:46	19.95
Kawawachikamach-2	On the road out of town	26-Nov-14 21:05 to 21:11	21.16
Schefferville-1	Town center ≈24 km east-south-east of Howse	26-Nov-14 21:30 to 21:36	19.13
Schefferville-2	On the road out of town	26-Nov-14 21:49 to 21:54	20.50
Dark point	Old Goodwood Rd, on the way to Kivivik. ≈13 km from Howse.	27-Nov-14 to 28-Nov-14 21:14 to 05:09	21.74*

* Maximum reading over the period of unattended sampling

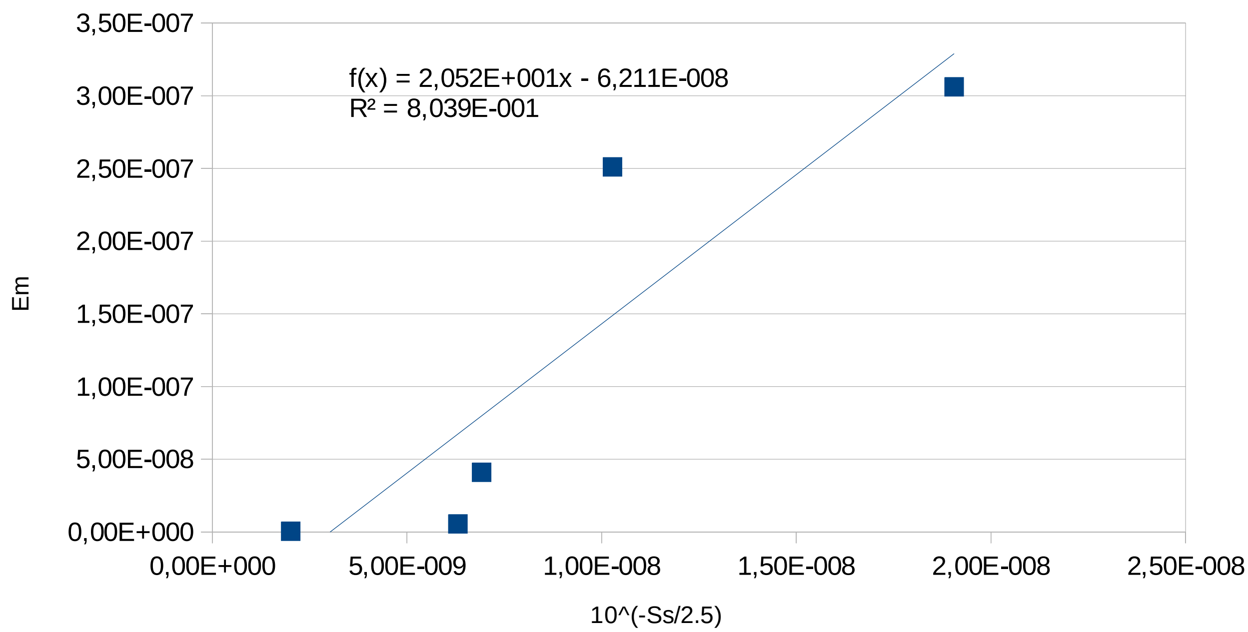

Figure 2 Linearization of Equation 3
The regression line is shown along with the corresponding equation and the correlation coefficient

Using the intercept ($-E_n$) value of 6.211×10^{-8} and slope ($10^{\wedge}(S_0 / 2.5)$) value of 20.52 obtained from Figure 2, and a reference brightness (S_0) of 3.28, these constants are used to transform the artificial radiance calculated by the model into sky brightness values using Equation 1. When considering a null artificial sky radiance (E_n), we obtain a natural sky brightness of 21.30, which is the very minimum brightness that one can measure in that region.

5. Seasonal changes in the sky brightness

When excluding sky brightness variations due to the moon, the stellar background and the northern lights, the main factors that influence the night sky brightness changes is the amount of aerosols (small particles) in the air and the change in the reflectance of the ground.

In the region of Schefferville, the aerosol optical depth (AOD), which is an indicator of the interaction between light and aerosols, is relatively stable and has averaged value 0.1. However, this value is significantly increased during sporadic pollution events, which occur mainly in the summer and fall seasons and are typically the result of transport of wildfire smoke. In such circumstances, the AOD averaged value is higher at 0.8. These AOD values are taken from the database of the AERONET network [24] (http://aeronet.gsfc.nasa.gov/) maintained by the NASA. We chose the site of Kuujjuarapik (55N, 77W) to accomplish this estimate. This site is located on the shores of the Hudson Bay. Although the site is 680km away from our study site, in our opinion it is the AERONET site that has an atmospheric pattern that is most similar to the atmospheric pattern of the Howse mining site.

The change in the reflectance of the ground is primarily determined by the presence or absence of snow. Indeed, snow is a very effective reflector, which has the effect of returning to the sky much of the light emitted towards the ground. For bare soil, the typical reflectance is approximately 8%, whereas it can increase to 95% for a snow covered ground. The presence or absence of snow has a major impact because the most common type of lighting installed in the Schefferville area is the cobrahead style that projects about 7% of its light directly above the horizon (i.e. 93% toward the ground), as shown in Figure 3. Thus, for bare soil, 14.4% (93% x 8% + 7% = 14.4%) of the light is projected towards the sky (direct and reflected). When snow covers the ground 95.4% (93% x 95% + 7% = 95.4%) of the light that is projected is projected into the sky. Consequently, snow cover acts as an efficient amplifying factor for the night sky brightness.

Figure 3 Cobrahead fixture typically used in the Schefferville area

6. Modelling results

The model Illumina requires satellite images as inputs (night radiance VIIRS-DNB [25], MODIS ground reflectance [26] and SRTM topography [27]). The abundance of satellite data available allows for evaluation of large territories and then refinement using in-situ data to define local environmental properties. Three scenarios presented below include most scenarios of sky brightness for all seasons in the region of the Howse project:

1. Winter with AOD=0.1: This scenario includes a period with snow cover.
2. Summer with AOD=0.1: This scenario includes the majority of time with bare soil cover. Such situation occurs most of the time in late spring, summer and early fall.
3. Summer with AOD=0.8: This scenario covers sporadic air pollution events caused by forest fires. This scenario typically occurs in summer and early fall.

The satellite data from 2013 is used for the three scenarios described above. At the time of writing this report, the most recent valid acquisition of the night time lights by VIIRS-DNB is January 2013. On the satellite image, a certain amount of light was detected in the region between Pinette Lake and Innu camp (see Figure 4). This light is coming from human activity already taking place in this area in January 2013.

In addition to satellite images and SQM calibration data, a number of global parameters must be defined for the modeling domain. In this case we have defined the average height of light fixtures relative to the ground to be 7 m. The spatial resolution is 1 km by 1 km, the relative humidity is estimated at 70%, the typical distance between sub-grid obstacles (i.e., trees, buildings) and averaged obstacle height are 40 m and 5 m, respectively. Calculations were made for a wavelength of 550 nm which corresponds to the maximum sensitivity of the human eye. Finally, a light fixture photometry was used corresponding to the Cobrahead style fixture. The modeling domain is 400 km by 400 km in an area centered at 55^{o}N 67^{o}W to consider all potential sources of light pollution. However, sky radiance was only calculated over a subdomain area of 65 km (east to west) by 69 km (north to south). This subdomain includes all sensitive receptors and mining/construction sites. The modelling domain is shown on Figure 5.

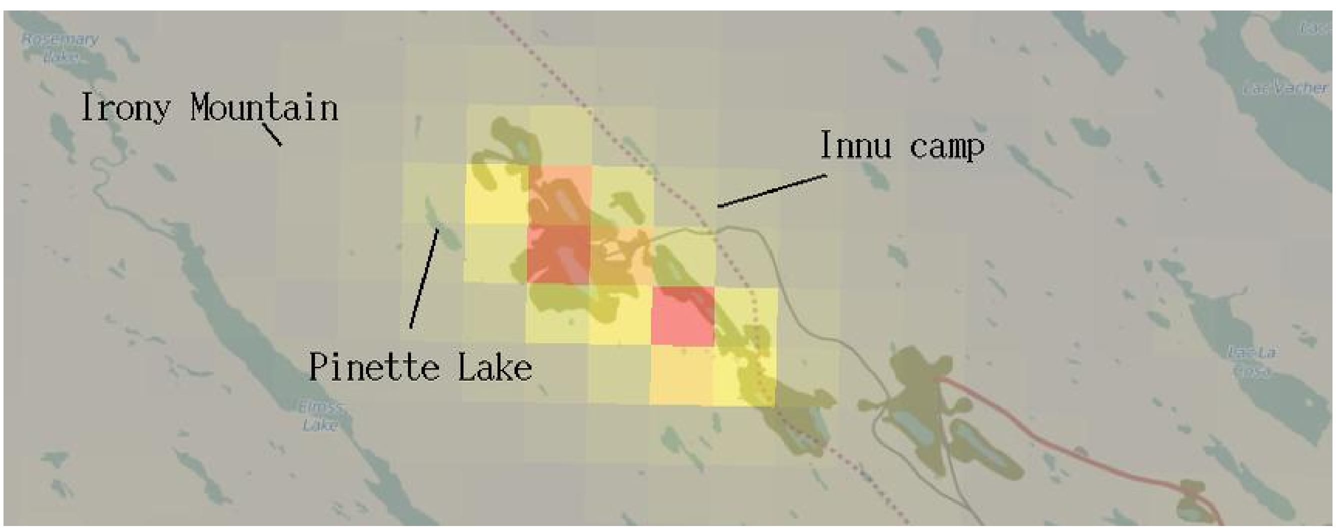

Figure 4 Lights associated with mining activity detected with VIIRS-DNB on January 2013

Figure 5 Modelling domain extent

6.1 Results

6.1.1 Sky brightness maps

The sky brightness results according to different seasonal conditions and for different sites or sensitive receptors identified in this study are detailed in Table 3, which is presented in Section 7 of this report. However, prior to presenting these data, figures showing the zenith sky brightness on the territory surrounding the Howse project is presented for the three seasonal/atmospheric scenarios described earlier as Figures 6 through 8.

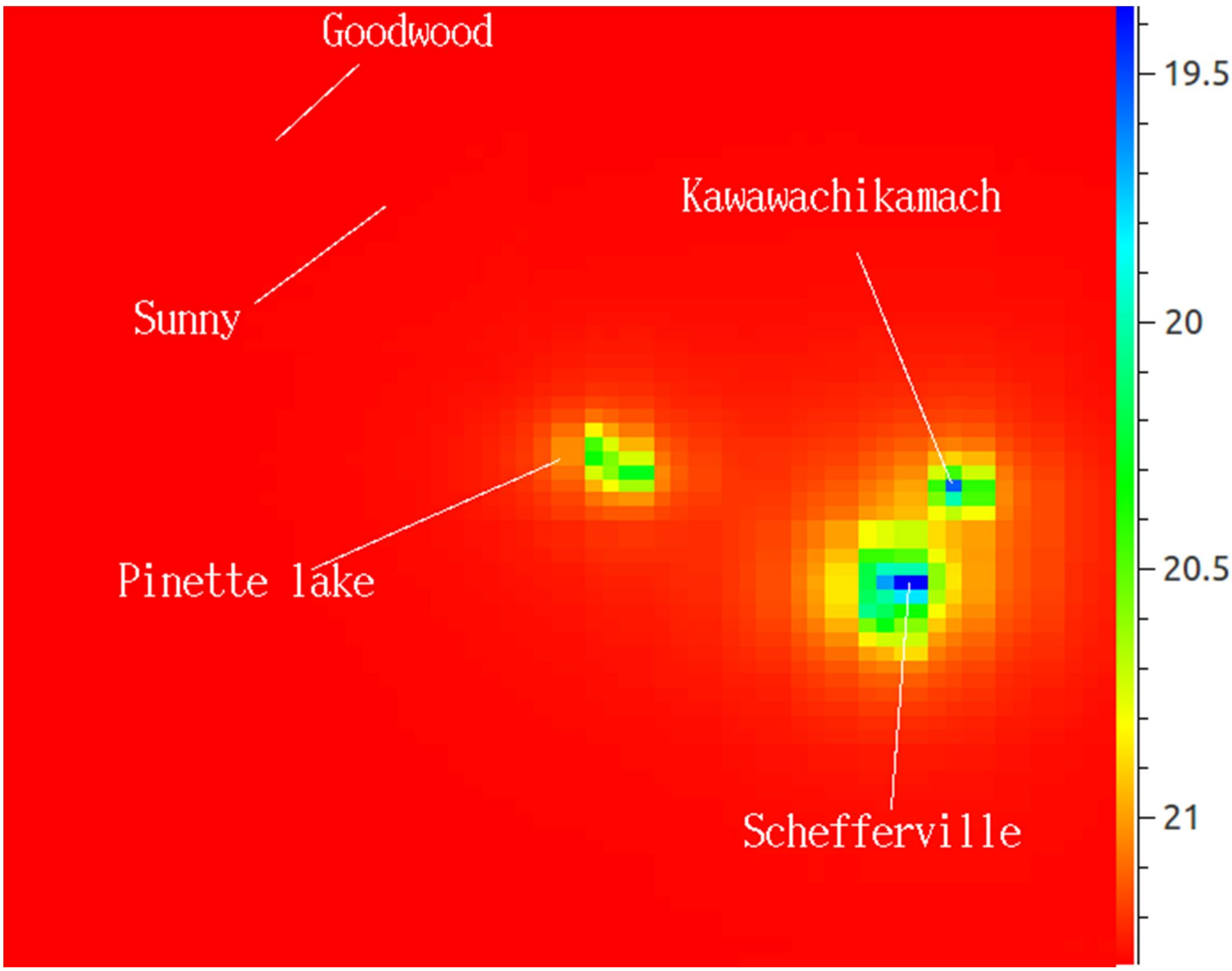

Figure 6 Scenario 1 - Winter sky brightness in units of mag per squared arcsec with an aerosol optical depth of 0.1 (clean atmosphere)

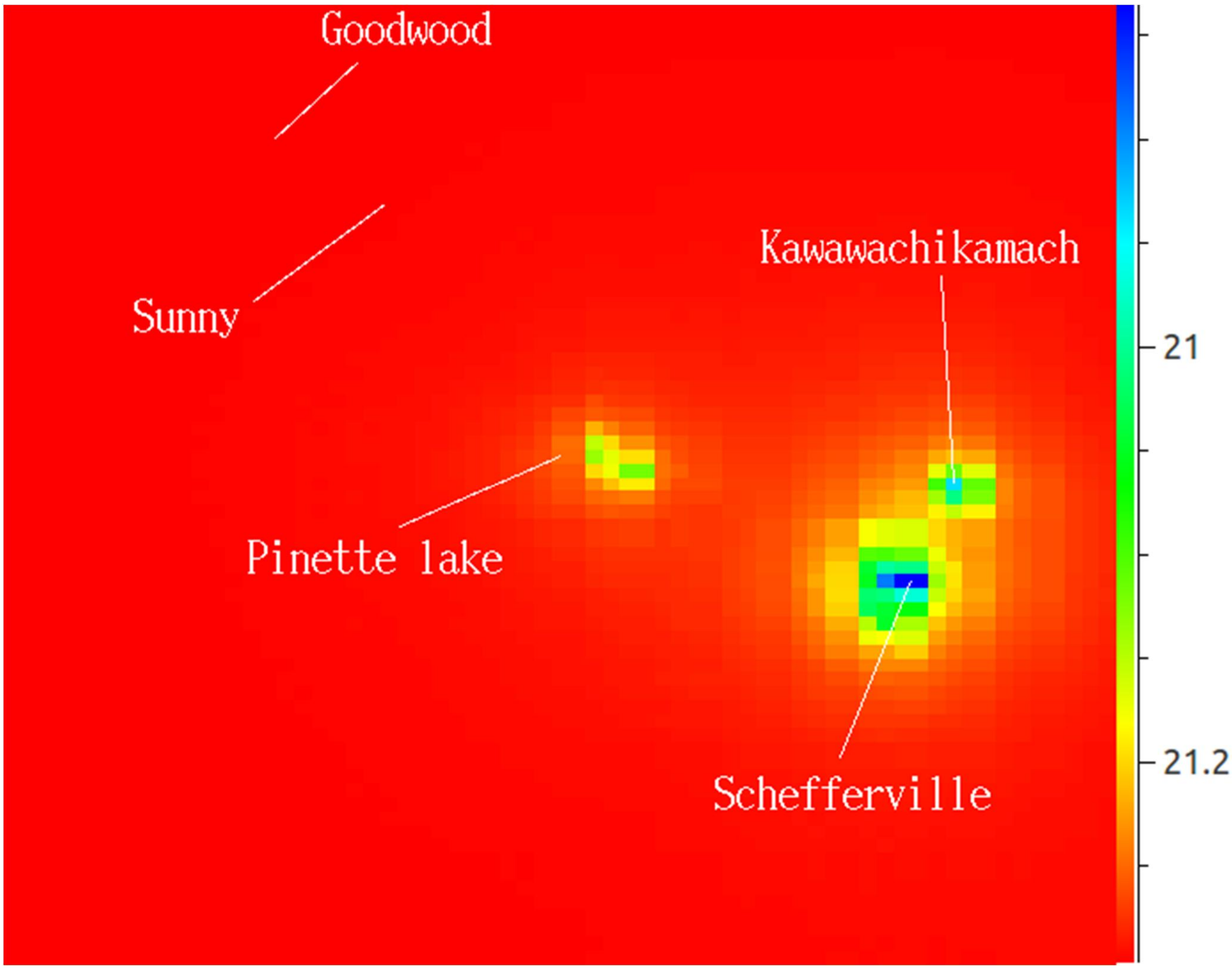

Figure 7 Scenario 2 - Summer sky brightness in units of mag per squared arcsec with an aerosol optical depth of 0.1 (clean atmosphere)

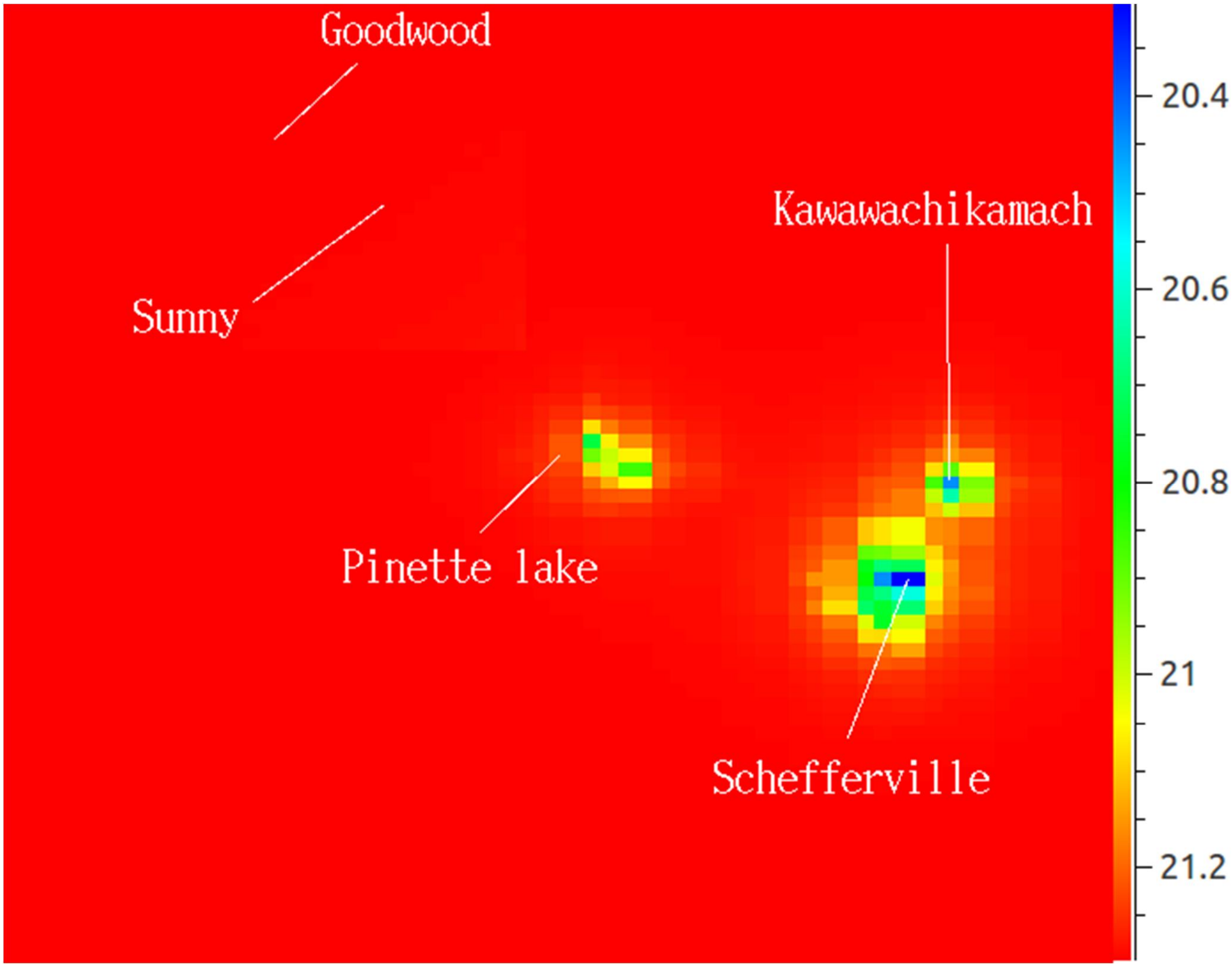

Figure 8 Scenario 3 - Summer sky brightness in units of mag per squared arcsec with an aerosol optical depth of 0.8 (polluted atmosphere)

As expected, the sky brightness level is much higher when there is snow cover. As an example, it can be seen that the center of Schefferville has a sky brightness of approximately 19.3 in the winter, but has a value of approximately 20.9 in the summer. This presents a difference in magnitude of 1.6 per squared arc second, which is equivalent to a decrease of radiance by a factor of 4.2 times (i.e. the radiance of the sky is 4.2 times larger in winter compared to summer). Note that the color scales of Figures 6 to 8 vary from one to another. However, the minimum level of sky brightness shown on all figures (i.e. red color) is the same (i.e. 21.3 mag/arcsec^2). This can be explained by the fact that far from the source, the brightness of the sky is dominated by the natural sky brightness while artificial sky brightness becomes negligible. A natural sky brightness of 21.3 mag / arcsec^2 was found regardless of the conditions of ground reflectance and regardless aerosol content. This value is 0.4 mag / arcsec^2 higher than the minimal level of 21.7 provided in the Berry (1976) [28] sky brightness scale (Table 2). A 0.4 mag difference indicates that the sky radiance is 44% higher than the absolute natural sky brightness. One important element to consider to explain the difference between the natural sky brightness measured in the Howse project region and the one defined by Berry (1976), is the presence of a constant background atmospheric excitation in the northern regions. This background atmospheric excitation can be understood as the minimal level of northern lights activity that are indistinguishable from the pure natural background for a visual observer or for the SQM measurement.

Table 2 Reference night sky brightness scale as defined by Berry (1976)

Sky Glow* (Mag/Arcsec^2)	Naked-Eye Appearance of the Sky (M.W. = Milky Way)
21.7	The sky is crowded with stars, extending to the horizon in all directions. In the absence of haze the M.W. can be seen to the horizon. Clouds appear as black silhouettes against the sky. Stars look large and close.
21.6	Essentially as above, but a glow in the direction of one or more cities is seen on the horizon. Clouds are bright near the city glow.
21.1	The M.W. is brilliant overhead but cannot be seen near the horizon. Clouds have a greyish glow at the zenith and appear bright in the direction of one or more prominent city glows.
20.4	To a city dweller the M.W. is magnificent, but contrast is markedly reduced, and delicate detail is lost. Limiting magnitude is noticeably reduced. Clouds are bright against the zenith sky. Stars no longer appear large and near.
19.5	M.W. is marginally visible, and only near the zenith. Sky is bright and discoloured near the horizon in the direction of cities. The sky looks dull grey.
18.5	Stars are weak and washed out, and reduced to a few hundred. The sky is bright and discoloured everywhere.

** Referred to as Sky Brightness in this report.*

7. Sensitive receptors

Some sensitive receptors were selected based on the features of the area occupied by the local population and/or on the basis of their cultural significance (e.g. Naskapi, Irony Mountain, Innu camp center Schefferville, and Kawawachikamach center). Other sensitive receptors were chosen for their importance to the preservation of the environmental conditions in light of their particular wildlife population (Sunny, Innu camp, Pinette Lake). Finally, a third category of sensitive receptors are evaluated due to their proximity to the proposed mining sites (Sunny, Goodwood, Kiviviks). The list of sensitive receptors with their coordinates is presented in Table 3 and Appendix 1 provides a figure showing receptor locations on a map.

For each sensitive receptor, the value of the sky brightness was calculated for the three season / atmospheric scenarios evaluated. This data are presented in Table 4. The sky brightness values include sky brightness from both natural and artificial origins. This data may serve as a comparative basis for quantifying future sky brightness changes as a result of a future increase in mining activity for the area.

In Table 4, it is noted that the sky radiance for Goodwood and Sunny is equal to the natural sky brightness previously estimated at 21.30. Therefore, the only significant light related to mining activity were located at the Pinette Lake and Innu camp receptors, whereas, Goodwood and Sunny receptors are free of light pollution. Light pollution in winter remains low for Naskapi camp/activity and Irony Mountain receptors, where there is a decrease of 0.04 mag/sq arcsec and 0.1 mag/sq arcsec, each respectively. These values correspond to 4% and 10% increases in the sky radiance compared to the natural sky radiance. For the Innu camp and Pinette Lake receptors, the sky radiance is respectively 38% and 66% higher than the natural sky radiance. Such an increase is noteworthy, but it is not surprising given there are light sources located in this area which is within 2 km from each sensitive receptor. For further analysis, the ratio of artificial radiance on the natural radiance was calculated for each season/atmosphere and each sensitive receptor. These percentages are presented in Table 5.

Table 3 Coordinates of the sensitive receptors and corresponding SQM measurement

Receptor ID	Description	Latitude	Longitude	Quality checked measured sky brightness (Mag/Arcsec^2)
Goodwood	Northernmost proposed mine site. ≈25 km from Howse, far from artificial lights	55° 6'2.87"N	67°20'12.05"W	-
Sunny	Proposed mine site. ≈17 km from Howse, far from artificial lights	55° 2'59.99"N	67°14'47.30"W	-
Naskapi camp/activity	Curlingstone Lake. Fishing. ≈4.2 km north-west of Howse	54°56'06.48"N	67°11'19.19"W	-
Irony Mountain	Important site for First Nations. ≈1.5 km west of Howse	54°54'3.71"N	67° 9'29.59"W	20.50
Innu camp	Lac Inukshuk. ≈5.7 east of Howse. Northeast of main plant and rail loop	54°53'37.10"N	67° 3'9.10"W	-
Pinette Lake	Innu camp, hunting site and potential migratory birds area. ≈2 km southeast of Howse	54°53'16.91"N	67° 6'43.63"W	20.40
Kawawachikamach	Town center. Population 600 (approx.). ≈26 km east-south-east of Howse	54°51'49.03"N	66°45'39.00"W	19.97
Schefferville	Town center. Population 900 (approx.). ≈24 km east-south-east of Howse	54°48'7.09"N	66°48'57.18"W	19.30
Dark point	Old Goodwood Rd, on the way to Kivivik. Considered as a darkest point during the measurement program. ≈13 km from Howse.	55° 0'43.00"N	67°14'42.00"W	21.74

Table 4 Summary of Sky Brightness Results by Modelling Scenario

Receptor ID	Winter AOD=0.1	Summer AOD=0.1	Summer AOD=0.8
	Mag/sq arcsec	*Mag/sq arcsec*	*Mag/sq arcsec*
Goodwood	21.29	21.30	21.30
Sunny	21.29	21.29	21.30
Naskapi camp/activity	21.26	21.29	21.29
Irony Mountain	21.20	21.28	21.28
Innu camp	20.95	21.23	21.16
Pinette Lake	20.75	21.20	21.10
Kawawachikamach	19.54	20.94	20.44
Schefferville	19.36	20.84	20.30

Table 5 Summary of Artificial Sky Radiance to Natural Sky Radiance ratios by Modelling Scenario

Receptor ID	Winter AOD=0.1	Summer AOD=0.1	Summer AOD=0.8
	%	%	%
Goodwood	0.2	0.1	0.0
Sunny	0.5	0.2	0.0
Naskapi camp/activity	3.5	0.9	0.5
Irony Mountain	8.9	1.9	2.0
Innu camp	37.5	6.3	13.6
Pinette Lake	66.1	9.1	19.6
Kawawachikamach	404.3	39.5	120.0
Schefferville	492.8	53.0	149.6

Among many outputs of the Illumina model, the contribution map is one of the most powerful when used as a tool to assess and control light pollution. Each 1 km by 1 km ground pixel of the contribution map contains its percentage of contribution to the artificial sky radiance. To better understand the origin of the artificial sky radiance for each sensitive receptor and separate the contribution of nearby villages from the mining activity contribution, AECOM integrated the contribution map values around the towns of Schefferville and Kawawachikamach. For Schefferville, the values within a radius of 4 km were added, whereas a radius of 3 km was used for Kawawachikamach. Each evaluation radius was chosen to comprise the complete contribution of each village. The result of that analysis is presented in Table 6.

Table 6 Origin of the artificial sky radiance at each sensitive receptor by Scenario

Receptor site	Winter AOD=0.1		Summer AOD=0.1		Summer AOD=0.8	
	%	%	%	%	%	%
	Schefferville	Kawawa.	Schefferville	Kawawa.	Schefferville	Kawawa.
Goodwood	30.3	15.8	34.0	18.7	20.7	10.8
Sunny	25.4	12.5	31.5	15.4	13.1	7.2
Naskapi camp/activity	12.7	4.9	19.6	7.3	3.4	1.5
Irony Mountain	7.5	2.9	13.4	5.2	2.0	0.8
Innu camp	3.4	1.4	6.7	2.6	0.7	0.3
Pinette Lake	1.6	0.6	4.3	1.7	0.7	0.2
Kawawachikamach	2.4	97.4	5.8	92.6	1.5	97.4
Schefferville	98.9	0.9	97.5	1.9	99.3	0.5

It should be noted that the percentages listed in Table 6 provides the portion of the corresponding Table 5 value that originates from a given town. As an example, for the case of Irony Mountain, in winter, the artificial sky radiance level is 8.9% of the natural radiance (Table 5) but 7.5% of that amount is coming from Schefferville (Table 6). In other words, 8.9% x 7.5% = 0.7% is the artificial radiance to natural radiance ratio that can be assigned to Schefferville at Irony mountain. Currently, the winter artificial sky radiance at the Goodwood receptor is coming from Schefferville (30.3%) and Kawawachikamach (15.8%). In other words, 53.9% (100%-30.3%-15.8%) of the artificial sky brightness at the Goodwood receptor is coming from ongoing mining and construction activities. For the Sunny receptor, 62.1%

of the artificial sky brightness is coming from ongoing mining/construction activities. This higher percentage compared to Goodwood receptor may be explained by the fact that Sunny is closer to the mining/construction activities sites in comparison to Goodwood. The same analysis can be made with any other sensitive receptor. In the case of Irony Mountain, 89.6% of the artificial sky radiance is coming from the nearby mining/construction activities.

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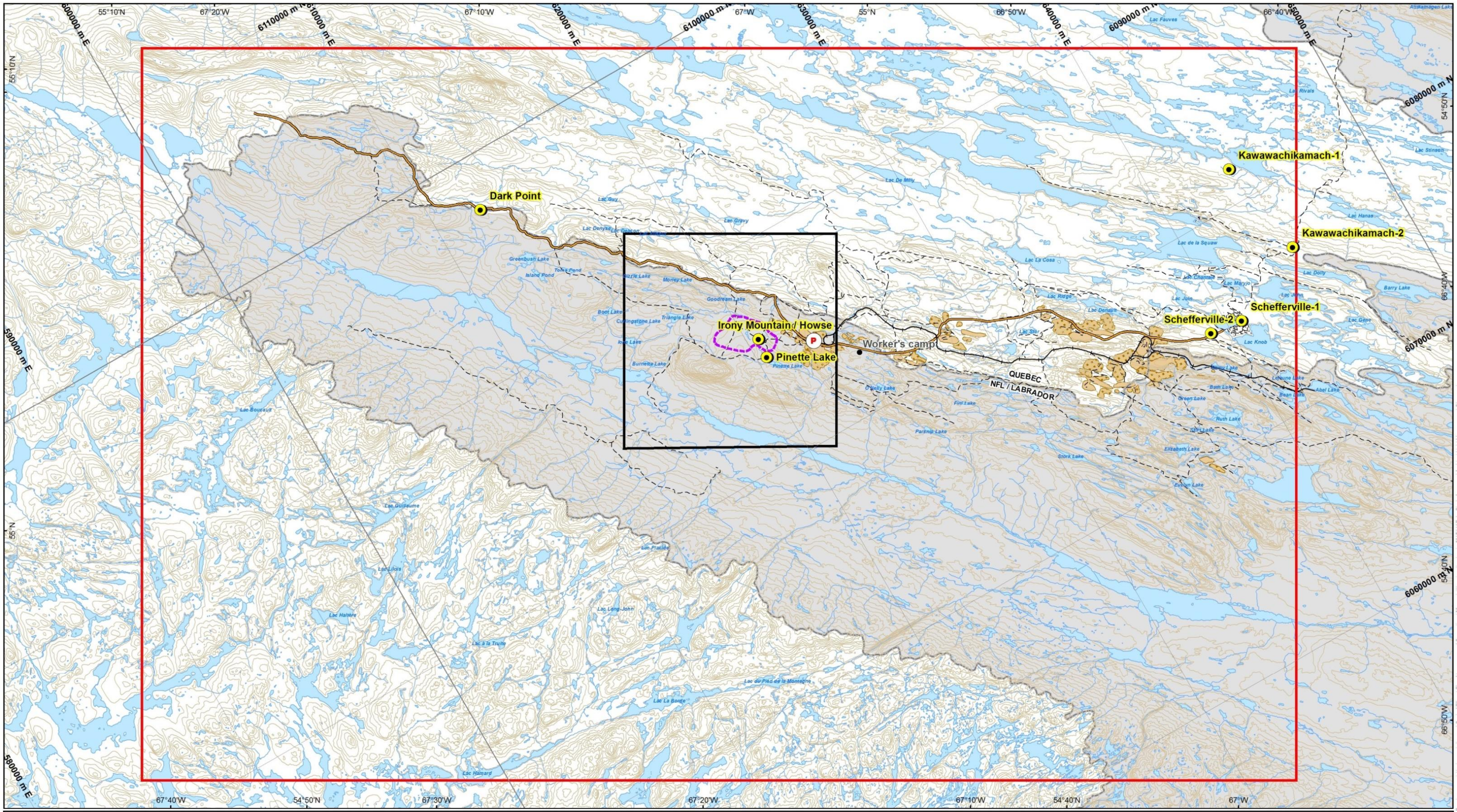
Appendix

Appendix 1
Study Areas and Sky Quality Measurement Locations and Sensitive Receptor Locations Maps



Legend

- Sky Quality Measurement Sites
- Regional Study Area
- Local Study Area
- Border

Infrastructure and Mining Components

- Existing Mined-out Pit
- Existing Waste Dump
- Main Access Road
- Road
- Howse Mining Area (approximative)
- Main Processing Plant Area
- Railway

1:170 000

0 2 4 km

UTM 19N NAD 83

SOURCES:

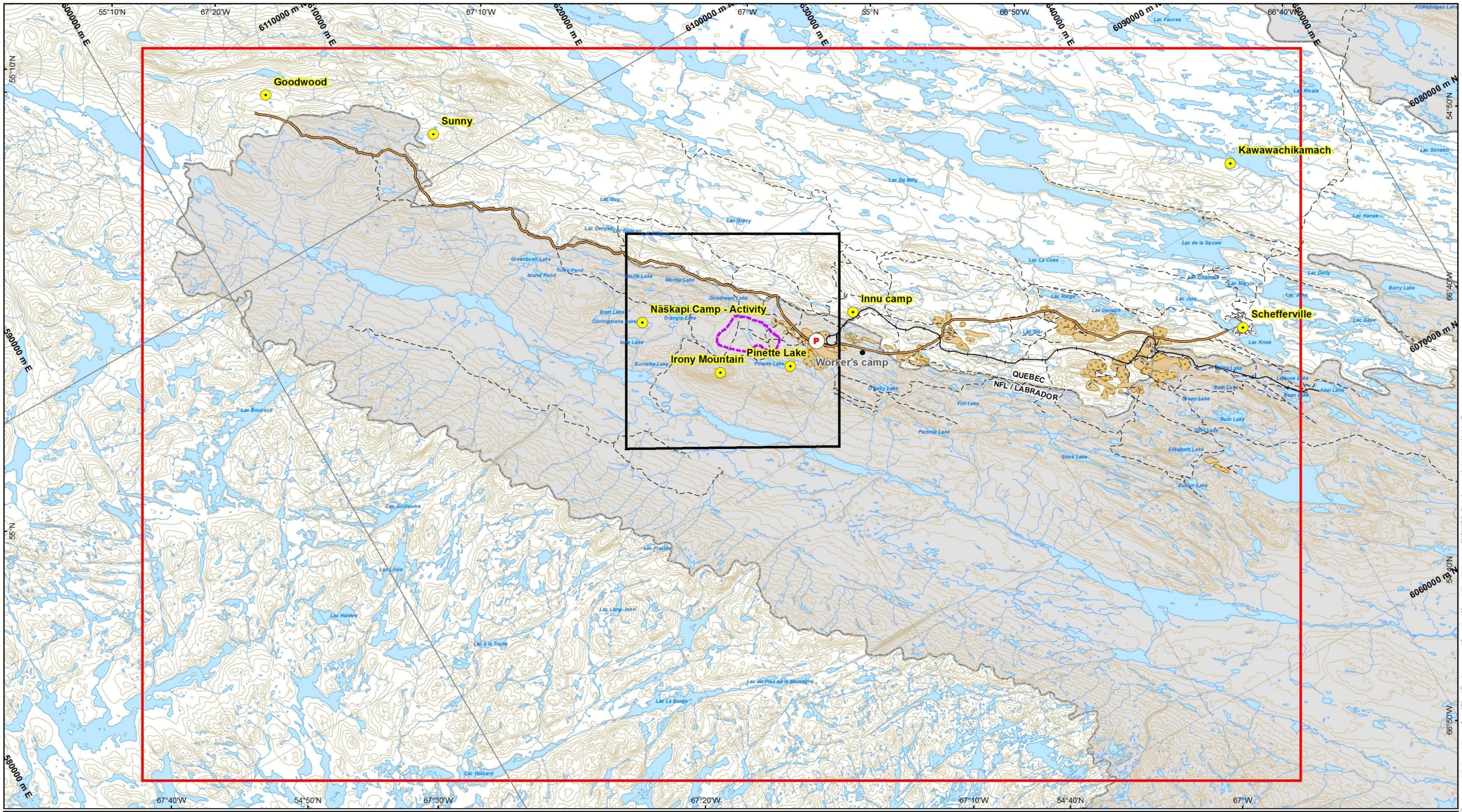
NTDB, 1:50,000, edition 3.1
Gov. of NL and Gov. of Qc, Border
NML, Mining sites and roads
GH, Hydrology update, 2008

DSO Howse Project EIS

Study Areas and Ambiant Light Measurement Sites

January 2015 MAP 1

AECOM



Legend

- Sky Radiance Receptors used in modelling
- Regional Study Area
- Local Study Area
- Border

Infrastructure and Mining Components

- Existing Mined-out Pit
- Existing Waste Dump
- Main Access Road
- Road
- Howse Mining Area (approximative)
- Main Processing Plant Area
- Railway

1:170 000

0 2 4 km

UTM 19N NAD 83

SOURCES:

NTDB, 1:50,000, edition 3.1
Gov. of NL and Gov. of Qc, Border
NML, Mining sites and roads
GH, Hydrology update, 2008

DSO Howse Project EIS

Study Areas and Ambiant Light Modeled Receptors

January 2015 MAP 2

AECOM

Appendix

Appendix 2:
In-situ measurement datasheets,
SQM-LU-DL data output and pictures

UNIHEDRON SQM-LU-DL MEASUREMENT DATASHEET
Ambient light - TSMC

* *Before measurement, program the Sky Quality Meter (SQM). See back of page.*

** *Before measurement, plan for acceptable time and weather conditions. See back of page.*

			GPS Garmin	Smartphone app
Site name	KAWAWA - CENTER	Lat.	N 54° 51' 38.6"	N 54° 51.6417'
Date	26/NOV/14	Long.	W 066° 45' 40.3"	W 066° 45.6725'
Observer name	M. Lewis / D. Lalonde	Elevation	495 m	487 m

Timing		Describe Sky conditions (clouds, humidity, etc...)
End Twilight (HH:MIN)	15:53	Clear sky 100%
Begin Twilight - following day (HH:MIN)	6:37	Very light wind
Moonset (HH:MIN)	19:54	* Snowmobile passed by @ 20:42
Next moonrise - following day (HH:MIN)	11:10	
New moon date (DD-MM-YR)	22-11-14	**Describe surroundings (% snow cover, trees, buildings, etc...)**
Outside Temperature (°C)	-14°C	Surrounded by homes at ≈50m away
SQM placed in Outdoor housing (Y/N)?	N	
SQM data logging frequency (sec or min)	10 Sec	

PROCEDURE:

1. No artificial light directly on lens (lens reads a 20° wide cone)
2. No aircraft passing close to the zenith
3. Avoid using the SQM near lights like streetlights and in areas that are shaded by trees or buildings. A rule of thumb for the SQM is to be as far from the object as it is high. For streetlights, stand at least 7.5 meters (or 25 feet) away. Keep away from objects that can reflect light
4. Point the SQM directly overhead (at the zenith). The meter should be held above head level so that shadows or reflections from your body do not interfere with the reading. Keep it steady.
5. The meter is somewhat temperature dependent. Leave the meter outside for at least 5 minutes to reach ambient temperature before taking any measurements.
6. Clean lens (from SQM and outdoor housing if used) with a soft cloth. Ensure no condensation on lense.

MEASUREMENT:

Connect the battery pack when ready to measure (This turns on the SQM)	✓
For short term measurement, take readings for about 5 minutes per site	✓
Start time (HH:MIN)	≈ 20:40
End time (HH:MIN)	≈ 20:46
Disconnect battery pack when finished (This turns off the SQM)	✓

NOTES:

INSTRUCTIONS

* ***Before measurement, program the Sky Quality Meter (SQM).***

1- Program the SQM using the Unihedron Device Manager software
2- Connect the SQM and click Find to ensure the SQM has been detected
3- Go to the "Data Logging" tab
4- Click on "Settings" button under Device Clock. Ensure SQM and computer times are synchronized.
5- If data stored in the SQM have already been saved, you can "Erase all", this will free up memory.
6- For short term measurements, set "Every x seconds (always on)" at 10 s.
7- For long term measurements, set "Every x minutes (power save mode)" at 5 m.

Note: There is no display on the SQM, consequently, you must ensure the device is correctly programmed, before any measurement

** ***Before measurement, plan for acceptable time and weather conditions.***

1. Measurements should be taken on clear nights
2. Moon is < ¼ full
3. Moon is NOT up
4. 1.5 hours after end of civil twilight (http://www.sunrisesunset.com/Canada/Quebec/Schefferville.asp)
5. 1.5 hours before beginning of civil twilight
6. No aurora borealis

Example : For measurement on November 25th, 2014.

End Twilight is 15:54 + 1.5 hour = 17:23 Begin Twilight (following day) is 6:35 – 1.5 hour = 5:05 Moonset is 18:40 Next moonrise (following day) is 10:35	Measurements can be taken: From: November 25^{th} at 18:40 To: November 26^{th} at 5:05 *New moon date: Nov. 22^{nd}*

November 2014

Schefferville, Québec, Canada

Latitude, Longitude: 54 48.0' N, 66 48.6' W Time zone: -5:00 (Eastern) DST observance: North America

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1 Twi: 6:51 Sunrise: 7:29 Sunset: 16:52 Twi: 17:31 Moonrise: 14:35 Moonset: 0:23 Day length: 9h 23m
2 DST Ends Twi: 5:53 Sunrise: 6:31 Sunset: 15:50 Twi: 16:29 Moonrise: 14:01 Moonset: 0:43 Day length: 9h 19m	3 Twi: 5:55 Sunrise: 6:33 Sunset: 15:48 Twi: 16:27 Moonrise: 14:26 Moonset: 2:03 Day length: 9h 15m	4 Twi: 5:57 Sunrise: 6:35 Sunset: 15:46 Twi: 16:25 Moonrise: 14:52 Moonset: 3:23 Day length: 9h 11m	5 Twi: 5:59 Sunrise: 6:37 Sunset: 15:44 Twi: 16:23 Moonrise: 15:19 Moonset: 4:43 Day length: 9h 7m	6 Twi: 6:01 Sunrise: 6:40 Sunset: 15:42 Twi: 16:21 Moonrise: 15:50 Moonset: 6:01 Full Moon: 17:24 Day length: 9h 3m	7 Twi: 6:02 Sunrise: 6:42 Sunset: 15:40 Twi: 16:19 Moonrise: 16:26 Moonset: 7:16 Day length: 8h 59m	8 Twi: 6:04 Sunrise: 6:44 Sunset: 15:38 Twi: 16:18 Moonrise: 17:08 Moonset: 8:24 Day length: 8h 55m
9 Twi: 6:06 Sunrise: 6:46 Sunset: 15:37 Twi: 16:16 Moonrise: 17:57 Moonset: 9:25 Day length: 8h 51m	10 Twi: 6:08 Sunrise: 6:48 Sunset: 15:35 Twi: 16:14 Moonrise: 18:51 Moonset: 10:16 Day length: 8h 47m	11 Twi: 6:10 Sunrise: 6:50 Sunset: 15:33 Twi: 16:13 Moonrise: 19:51 Moonset: 10:58 Day length: 8h 43m	12 Twi: 6:12 Sunrise: 6:52 Sunset: 15:31 Twi: 16:11 Moonrise: 20:53 Moonset: 11:32 Day length: 8h 40m	13 Twi: 6:13 Sunrise: 6:54 Sunset: 15:29 Twi: 16:10 Moonrise: 21:57 Moonset: 12:01 Day length: 8h 36m	14 Twi: 6:15 Sunrise: 6:55 Sunset: 15:28 Twi: 16:08 Moonrise: 23:01 Moonset: 12:25 Last Qtr: 10:17 Day length: 8h 32m	15 Twi: 6:17 Sunrise: 6:57 Sunset: 15:26 Twi: 16:07 Moonrise: none Moonset: 12:47 Day length: 8h 29m
16 Twi: 6:19 Sunrise: 6:59 Sunset: 15:24 Twi: 16:05 Moonrise: 0:06 Moonset: 13:08 Day length: 8h 25m	17 Twi: 6:20 Sunrise: 7:01 Sunset: 15:23 Twi: 16:04 Moonrise: 1:12 Moonset: 13:28 Day length: 8h 22m	18 Twi: 6:22 Sunrise: 7:03 Sunset: 15:21 Twi: 16:02 Moonrise: 2:19 Moonset: 13:49 Day length: 8h 18m	19 Twi: 6:24 Sunrise: 7:05 Sunset: 15:20 Twi: 16:01 Moonrise: 3:28 Moonset: 14:12 Day length: 8h 15m	20 Twi: 6:26 Sunrise: 7:07 Sunset: 15:18 Twi: 16:00 Moonrise: 4:38 Moonset: 14:38 Day length: 8h 11m	21 Twi: 6:27 Sunrise: 7:09 Sunset: 15:17 Twi: 15:59 Moonrise: 5:49 Moonset: 15:09 Day length: 8h 8m	22 Twi: 6:29 Sunrise: 7:11 Sunset: 15:16 Twi: 15:57 Moonrise: 6:58 Moonset: 15:48 New Moon: 7:33 Day length: 8h 5m
23 Twi: 6:31 Sunrise: 7:13 Sunset: 15:14 Twi: 15:56 Moonrise: 8:04 Moonset: 16:35 Day length: 8h 2m	24 Twi: 6:32 Sunrise: 7:14 Sunset: 15:13 Twi: 15:55 Moonrise: 9:03 Moonset: 17:33 Day length: 7h 59m	25 Twi: 6:34 Sunrise: 7:16 Sunset: 15:12 Twi: 15:54 Moonrise: 9:53 Moonset: 18:40 Day length: 7h 56m	26 Twi: 6:35 Sunrise: 7:18 Sunset: 15:11 Twi: 15:53 Moonrise: 10:35 Moonset: 19:54 Day length: 7h 53m	27 Twi: 6:37 Sunrise: 7:20 Sunset: 15:10 Twi: 15:52 Moonrise: 11:10 Moonset: 21:12 Day length: 7h 50m	28 Twi: 6:39 Sunrise: 7:21 Sunset: 15:09 Twi: 15:51 Moonrise: 11:40 Moonset: 22:31 Day length: 7h 47m	29 Twi: 6:40 Sunrise: 7:23 Sunset: 15:08 Twi: 15:51 Moonrise: 12:07 Moonset: 23:50 First Qtr: 5:07 Day length: 7h 44m

UNIHEDRON SQM-LU-DL MEASUREMENT DATASHEET
Ambient light - TSMC

* *Before measurement, program the Sky Quality Meter (SQM). See back of page.*
** *Before measurement, plan for acceptable time and weather conditions. See back of page.*

			GPS Garmin	Smartphone app
Site name	KAWAWA - OUT OF TOWN	Lat.	N 54° 49' 07.1"	N 54° 49.1194'
Date	26/NOV/14	Long.	W 066° 45' 05.5"	W 066° 45.0898'
Observer name	M. Lewis / D. Lalonde	Elevation	594m	600m

Timing		Describe Sky conditions (clouds, humidity, etc...)
End Twilight (HH:MIN)	15:53	Clear Sky - 100% Bright stars, almost see milky way Light wind.
Begin Twilight - following day (HH:MIN)	6:37	
Moonset (HH:MIN)	19:54	
Next moonrise - following day (HH:MIN)	11:10	
New moon date (DD-MM-YR)	22-11-14	**Describe surroundings (% snow cover, trees, buildings, etc...)**
Outside Temperature (°C)	-15°C	Corner of road 100% snow Cover ≈100 ft from trees 1 car + 1 snowmobile passed by
SQM placed in Outdoor housing (Y/N)?	N	
SQM data logging frequency (sec or min)	10 sec	

PROCEDURE:

1. No artificial light directly on lens (lens reads a 20° wide cone)
2. No aircraft passing close to the zenith
3. Avoid using the SQM near lights like streetlights and in areas that are shaded by trees or buildings. A rule of thumb for the SQM is to be as far from the object as it is high. For streetlights, stand at least 7.5 meters (or 25 feet) away. Keep away from objects that can reflect light
4. Point the SQM directly overhead (at the zenith). The meter should be held above head level so that shadows or reflections from your body do not interfere with the reading. Keep it steady.
5. The meter is somewhat temperature dependent. Leave the meter outside for at least 5 minutes to reach ambient temperature before taking any measurements.
6. Clean lens (from SQM and outdoor housing if used) with a soft cloth. Ensure no condensation on lense.

MEASUREMENT:

Connect the battery pack when ready to measure (This turns on the SQM)	✓
For short term measurement, take readings for about 5 minutes per site	✓
Start time (HH:MIN)	≈ 21:05
End time (HH:MIN)	≈ 21:11
Disconnect battery pack when finished (This turns off the SQM)	✓

NOTES:

INSTRUCTIONS

* ***Before measurement, program the Sky Quality Meter (SQM).***

1- Program the SQM using the Unihedron Device Manager software
2- Connect the SQM and click Find to ensure the SQM has been detected
3- Go to the "Data Logging" tab
4- Click on "Settings" button under Device Clock. Ensure SQM and computer times are synchronized.
5- If data stored in the SQM have already been saved, you can "Erase all", this will free up memory.
6- For short term measurements, set "Every x seconds (always on)" at 10 s.
7- For long term measurements, set "Every x minutes (power save mode)" at 5 m.

Note: There is no display on the SQM, consequently, you must ensure the device is correctly programmed, before any measurement

** ***Before measurement, plan for acceptable time and weather conditions.***

1. Measurements should be taken on clear nights
2. Moon is < ¼ full
3. Moon is NOT up
4. 1.5 hours after end of civil twilight (http://www.sunrisesunset.com/Canada/Quebec/Schefferville.asp)
5. 1.5 hours before beginning of civil twilight
6. No aurora borealis

Example : For measurement on November 25th, 2014.

End Twilight is 15:54 + 1.5 hour = 17:23 Begin Twilight (following day) is 6:35 – 1.5 hour = 5:05 Moonset is 18:40 Next moonrise (following day) is 10:35	Measurements can be taken: From: November 25th at 18:40 To: November 26th at 5:05 *New moon date: Nov. 22nd*

November 2014

Schefferville, Québec, Canada

Latitude, Longitude: 54 48.0' N, 66 49.6' W Time zone: -5:00 (Eastern) DST observance: North America

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1 Twi: 6:51 Sunrise: 7:29 Sunset: 16:52 Twi: 17:31 Moonrise: 14:35 Moonset: 0:23 Day length: 9h 23m
2 DST Ends Twi: 5:53 Sunrise: 6:31 Sunset: 15:50 Twi: 16:29 Moonrise: 14:01 Moonset: 0:43 Day length: 9h 19m	3 Twi: 5:55 Sunrise: 6:33 Sunset: 15:48 Twi: 16:27 Moonrise: 14:26 Moonset: 2:03 Day length: 9h 15m	4 Twi: 5:57 Sunrise: 6:35 Sunset: 15:46 Twi: 16:25 Moonrise: 14:52 Moonset: 3:23 Day length: 9h 11m	5 Twi: 5:59 Sunrise: 6:37 Sunset: 15:44 Twi: 16:23 Moonrise: 15:19 Moonset: 4:43 Day length: 9h 7m	6 Twi: 6:01 Sunrise: 6:40 Sunset: 15:42 Twi: 16:21 Moonrise: 15:50 Moonset: 6:01 Full Moon: 17:24 Day length: 9h 3m	7 Twi: 6:02 Sunrise: 6:42 Sunset: 15:40 Twi: 16:19 Moonrise: 16:26 Moonset: 7:16 Day length: 8h 59m	8 Twi: 6:04 Sunrise: 6:44 Sunset: 15:38 Twi: 16:18 Moonrise: 17:08 Moonset: 8:24 Day length: 8h 55m
9 Twi: 6:06 Sunrise: 6:46 Sunset: 15:37 Twi: 16:16 Moonrise: 17:57 Moonset: 9:25 Day length: 8h 51m	10 Twi: 6:08 Sunrise: 6:48 Sunset: 15:35 Twi: 16:14 Moonrise: 18:51 Moonset: 10:16 Day length: 8h 47m	11 Twi: 6:10 Sunrise: 6:50 Sunset: 15:33 Twi: 16:13 Moonrise: 19:51 Moonset: 10:58 Day length: 8h 43m	12 Twi: 6:12 Sunrise: 6:52 Sunset: 15:31 Twi: 16:11 Moonrise: 20:53 Moonset: 11:32 Day length: 8h 40m	13 Twi: 6:13 Sunrise: 6:54 Sunset: 15:29 Twi: 16:10 Moonrise: 21:57 Moonset: 12:01 Day length: 8h 36m	14 Twi: 6:15 Sunrise: 6:55 Sunset: 15:28 Twi: 16:08 Moonrise: 23:01 Moonset: 12:25 Last Qtr: 10:17 Day length: 8h 32m	15 Twi: 6:17 Sunrise: 6:57 Sunset: 15:26 Twi: 16:07 Moonrise: none Moonset: 12:47 Day length: 8h 29m
16 Twi: 6:19 Sunrise: 6:59 Sunset: 15:24 Twi: 16:05 Moonrise: 0:06 Moonset: 13:08 Day length: 8h 25m	17 Twi: 6:20 Sunrise: 7:01 Sunset: 15:23 Twi: 16:04 Moonrise: 1:12 Moonset: 13:28 Day length: 8h 22m	18 Twi: 6:22 Sunrise: 7:03 Sunset: 15:21 Twi: 16:02 Moonrise: 2:19 Moonset: 13:49 Day length: 8h 18m	19 Twi: 6:24 Sunrise: 7:05 Sunset: 15:20 Twi: 16:01 Moonrise: 3:28 Moonset: 14:12 Day length: 8h 15m	20 Twi: 6:26 Sunrise: 7:07 Sunset: 15:18 Twi: 16:00 Moonrise: 4:38 Moonset: 14:38 Day length: 8h 11m	21 Twi: 6:27 Sunrise: 7:09 Sunset: 15:17 Twi: 15:59 Moonrise: 5:49 Moonset: 15:09 Day length: 8h 8m	22 Twi: 6:29 Sunrise: 7:11 Sunset: 15:16 Twi: 15:57 Moonrise: 6:58 Moonset: 15:48 New Moon: 7:33 Day length: 8h 5m
23 Twi: 6:31 Sunrise: 7:13 Sunset: 15:14 Twi: 15:56 Moonrise: 8:04 Moonset: 16:35 Day length: 8h 2m	24 Twi: 6:32 Sunrise: 7:14 Sunset: 15:13 Twi: 15:55 Moonrise: 9:03 Moonset: 17:33 Day length: 7h 59m	25 Twi: 6:34 Sunrise: 7:16 Sunset: 15:12 Twi: 15:54 Moonrise: 9:53 Moonset: 18:40 Day length: 7h 56m	26 Twi: 6:35 Sunrise: 7:18 Sunset: 15:11 Twi: 15:53 Moonrise: 10:35 Moonset: 19:54 Day length: 7h 53m	27 Twi: 6:37 Sunrise: 7:20 Sunset: 15:10 Twi: 15:52 Moonrise: 11:10 Moonset: 21:12 Day length: 7h 50m	28 Twi: 6:39 Sunrise: 7:21 Sunset: 15:09 Twi: 15:51 Moonrise: 11:40 Moonset: 22:31 Day length: 7h 47m	29 Twi: 6:40 Sunrise: 7:23 Sunset: 15:08 Twi: 15:51 Moonrise: 12:07 Moonset: 23:50 First Qtr: 5:07 Day length: 7h 44m

UNIHEDRON SQM-LU-DL MEASUREMENT DATASHEET
Ambient light - TSMC

* *Before measurement, program the Sky Quality Meter (SQM). See back of page.*

** *Before measurement, plan for acceptable time and weather conditions. See back of page.*

			GPS Garmin	Smartphone app
Site name	SCHEFFERVILLE - CENTER	Lat.	N 54°48' 12.4"	N 54°48.2098'
Date	26/Nov/14	Long.	W 066° 48' 41.8"	W 066° 48.7035'
Observer name	M. Lewis / D. Lalonde	Elevation	514m	526 m

Timing		Describe Sky conditions (clouds, humidity, etc...)
End Twilight (HH:MIN)	15:53	100% Clear sky
Begin Twilight - following day (HH:MIN)	6:37	
Moonset (HH:MIN)	19:54	
Next moonrise - following day (HH:MIN)	11:10	
New moon date (DD-MM-YR)	22-11-14	**Describe surroundings (% snow cover, trees, buildings, etc...)**
Outside Temperature (°C)	-15°C	Snow Cover 100% In baseball park
SQM placed in Outdoor housing (Y/N)?	N	
SQM data logging frequency (sec or min)	10sec	

PROCEDURE:

1. No artificial light directly on lens (lens reads a 20° wide cone)
2. No aircraft passing close to the zenith
3. Avoid using the SQM near lights like streetlights and in areas that are shaded by trees or buildings. A rule of thumb for the SQM is to be as far from the object as it is high. For streetlights, stand at least 7.5 meters (or 25 feet) away. Keep away from objects that can reflect light
4. Point the SQM directly overhead (at the zenith). The meter should be held above head level so that shadows or reflections from your body do not interfere with the reading. Keep it steady.
5. The meter is somewhat temperature dependent. Leave the meter outside for at least 5 minutes to reach ambient temperature before taking any measurements.
6. Clean lens (from SQM and outdoor housing if used) with a soft cloth. Ensure no condensation on lense.

MEASUREMENT:

Connect the battery pack when ready to measure (This turns on the SQM)	✓
For short term measurement, take readings for about 5 minutes per site	✓
Start time (HH:MIN)	≈21:30
End time (HH:MIN)	≈ 21:36
Disconnect battery pack when finished (This turns off the SQM)	✓

NOTES:

INSTRUCTIONS

* ***Before measurement, program the Sky Quality Meter (SQM).***

1- Program the SQM using the Unihedron Device Manager software
2- Connect the SQM and click Find to ensure the SQM has been detected
3- Go to the "Data Logging" tab
4- Click on "Settings" button under Device Clock. Ensure SQM and computer times are synchronized.
5- If data stored in the SQM have already been saved, you can "Erase all", this will free up memory.
6- For short term measurements, set "Every x seconds (always on)" at 10 s.
7- For long term measurements, set "Every x minutes (power save mode)" at 5 m.

Note: There is no display on the SQM, consequently, you must ensure the device is correctly programmed, before any measurement

** ***Before measurement, plan for acceptable time and weather conditions.***

1. Measurements should be taken on clear nights
2. Moon is < ¼ full
3. Moon is NOT up
4. 1.5 hours after end of civil twilight (http://www.sunrisesunset.com/Canada/Quebec/Schefferville.asp)
5. 1.5 hours before beginning of civil twilight
6. No aurora borealis

Example : For measurement on November 25th, 2014.

End Twilight is 15:54 + 1.5 hour = 17:23 Begin Twilight (following day) is 6:35 – 1.5 hour = 5:05 Moonset is 18:40 Next moonrise (following day) is 10:35	Measurements can be taken: From: November 25th at 18:40 To: November 26th at 5:05 *New moon date: Nov. 22nd*

November 2014

Schefferville, Québec, Canada

Latitude, Longitude: 54 48.0' N, 66 48.6' W Time zone: -5:00 (Eastern) DST observance: North America

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1 Twi: 6:51 Sunrise: 7:29 Sunset: 16:52 Twi: 17:31 Moonrise: 14:35 Moonset: 0:23 Day length: 9h 23m
2 DST Ends Twi: 5:53 Sunrise: 6:31 Sunset: 15:50 Twi: 16:29 Moonrise: 14:01 Moonset: 0:43 Day length: 9h 19m	3 Twi: 5:55 Sunrise: 6:33 Sunset: 15:48 Twi: 16:27 Moonrise: 14:26 Moonset: 2:03 Day length: 9h 15m	4 Twi: 5:57 Sunrise: 6:35 Sunset: 15:46 Twi: 16:25 Moonrise: 14:52 Moonset: 3:23 Day length: 9h 11m	5 Twi: 5:59 Sunrise: 6:37 Sunset: 15:44 Twi: 16:23 Moonrise: 15:19 Moonset: 4:43 Day length: 9h 7m	6 Twi: 6:01 Sunrise: 6:40 Sunset: 15:42 Twi: 16:21 Moonrise: 15:50 Moonset: 6:01 Full Moon: 17:24 Day length: 9h 3m	7 Twi: 6:02 Sunrise: 6:42 Sunset: 15:40 Twi: 16:19 Moonrise: 16:26 Moonset: 7:16 Day length: 8h 59m	8 Twi: 6:04 Sunrise: 6:44 Sunset: 15:38 Twi: 16:18 Moonrise: 17:08 Moonset: 8:24 Day length: 8h 55m
9 Twi: 6:06 Sunrise: 6:46 Sunset: 15:37 Twi: 16:16 Moonrise: 17:57 Moonset: 9:25 Day length: 8h 51m	10 Twi: 6:08 Sunrise: 6:48 Sunset: 15:35 Twi: 16:14 Moonrise: 18:51 Moonset: 10:16 Day length: 8h 47m	11 Twi: 6:10 Sunrise: 6:50 Sunset: 15:33 Twi: 16:13 Moonrise: 19:51 Moonset: 10:58 Day length: 8h 43m	12 Twi: 6:12 Sunrise: 6:52 Sunset: 15:31 Twi: 16:11 Moonrise: 20:53 Moonset: 11:32 Day length: 8h 40m	13 Twi: 6:13 Sunrise: 6:54 Sunset: 15:29 Twi: 16:10 Moonrise: 21:57 Moonset: 12:01 Day length: 8h 36m	14 Twi: 6:15 Sunrise: 6:55 Sunset: 15:28 Twi: 16:08 Moonrise: 23:01 Moonset: 12:25 Last Qtr: 10:17 Day length: 8h 32m	15 Twi: 6:17 Sunrise: 6:57 Sunset: 15:26 Twi: 16:07 Moonrise: none Moonset: 12:47 Day length: 8h 29m
16 Twi: 6:19 Sunrise: 6:59 Sunset: 15:24 Twi: 16:05 Moonrise: 0:06 Moonset: 13:08 Day length: 8h 25m	17 Twi: 6:20 Sunrise: 7:01 Sunset: 15:23 Twi: 16:04 Moonrise: 1:12 Moonset: 13:28 Day length: 8h 22m	18 Twi: 6:22 Sunrise: 7:03 Sunset: 15:21 Twi: 16:02 Moonrise: 2:19 Moonset: 13:49 Day length: 8h 18m	19 Twi: 6:24 Sunrise: 7:05 Sunset: 15:20 Twi: 16:01 Moonrise: 3:28 Moonset: 14:12 Day length: 8h 15m	20 Twi: 6:26 Sunrise: 7:07 Sunset: 15:18 Twi: 16:00 Moonrise: 4:38 Moonset: 14:38 Day length: 8h 11m	21 Twi: 6:27 Sunrise: 7:09 Sunset: 15:17 Twi: 15:59 Moonrise: 5:49 Moonset: 15:09 Day length: 8h 8m	22 Twi: 6:29 Sunrise: 7:11 Sunset: 15:16 Twi: 15:57 Moonrise: 6:58 Moonset: 15:48 New Moon: 7:33 Day length: 8h 5m
23 Twi: 6:31 Sunrise: 7:13 Sunset: 15:14 Twi: 15:56 Moonrise: 8:04 Moonset: 16:35 Day length: 8h 2m	24 Twi: 6:32 Sunrise: 7:14 Sunset: 15:13 Twi: 15:55 Moonrise: 9:03 Moonset: 17:33 Day length: 7h 59m	25 Twi: 6:34 Sunrise: 7:16 Sunset: 15:12 Twi: 15:54 Moonrise: 9:53 Moonset: 18:40 Day length: 7h 56m	26 Twi: 6:35 Sunrise: 7:18 Sunset: 15:11 Twi: 15:53 Moonrise: 10:35 Moonset: 19:54 Day length: 7h 53m	27 Twi: 6:37 Sunrise: 7:20 Sunset: 15:10 Twi: 15:52 Moonrise: 11:10 Moonset: 21:12 Day length: 7h 50m	28 Twi: 6:39 Sunrise: 7:21 Sunset: 15:09 Twi: 15:51 Moonrise: 11:40 Moonset: 22:31 Day length: 7h 47m	29 Twi: 6:40 Sunrise: 7:23 Sunset: 15:08 Twi: 15:51 Moonrise: 12:07 Moonset: 23:50 First Qtr: 5:07 Day length: 7h 44m

UNIHEDRON SQM-LU-DL MEASUREMENT DATASHEET
Ambient light - TSMC

* *Before measurement, program the Sky Quality Meter (SQM). See back of page.*
** *Before measurement, plan for acceptable time and weather conditions. See back of page.*

			GPS Garmin	Smart phone app
Site name	SCHEFFERVILLE - OUT OF TOWN	Lat.	N 54°48' 20.5"	N 54° 48.3448'
Date	26/NOV/14	Long.	W 066°50' 08.8"	W 066° 50.1434'
Observer name	M. Lewis / D. Lalonde	Elevation	532 m	531 m

Timing		Describe Sky conditions (clouds, humidity, etc...)
End Twilight (HH:MIN)		Clear Sky 100% Light wind
Begin Twilight - following day (HH:MIN)		
Moonset (HH:MIN)		
Next moonrise - following day (HH:MIN)		
New moon date (DD-MM-YR)		**Describe surroundings (% snow cover, trees, buildings, etc...)**
Outside Temperature (°C)		100% snow cover In field besides road No trees / no building
SQM placed in Outdoor housing (Y/N)?		
SQM data logging frequency (sec or min)		

PROCEDURE:
1. No artificial light directly on lens (lens reads a 20° wide cone)
2. No aircraft passing close to the zenith
3. Avoid using the SQM near lights like streetlights and in areas that are shaded by trees or buildings. A rule of thumb for the SQM is to be as far from the object as it is high. For streetlights, stand at least 7.5 meters (or 25 feet) away. Keep away from objects that can reflect light
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5. The meter is somewhat temperature dependent. Leave the meter outside for at least 5 minutes to reach ambient temperature before taking any measurements.
6. Clean lens (from SQM and outdoor housing if used) with a soft cloth. Ensure no condensation on lense.

MEASUREMENT:

Connect the battery pack when ready to measure (This turns on the SQM)	✓
For short term measurement, take readings for about 5 minutes per site	✓
Start time (HH:MIN)	21:51
End time (HH:MIN)	21:56
Disconnect battery pack when finished (This turns off the SQM)	✓

NOTES:

INSTRUCTIONS

* ***Before measurement, program the Sky Quality Meter (SQM).***

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2- Connect the SQM and click Find to ensure the SQM has been detected
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4- Click on "Settings" button under Device Clock. Ensure SQM and computer times are synchronized.
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** ***Before measurement, plan for acceptable time and weather conditions.***

1. Measurements should be taken on clear nights
2. Moon is < ¼ full
3. Moon is NOT up
4. 1.5 hours after end of civil twilight (http://www.sunrisesunset.com/Canada/Quebec/Schefferville.asp)
5. 1.5 hours before beginning of civil twilight
6. No aurora borealis

<u>Example : For measurement on November 25th, 2014.</u>

End Twilight is 15:54 + 1.5 hour = 17:23 Begin Twilight (following day) is 6:35 – 1.5 hour = 5:05 Moonset is 18:40 Next moonrise (following day) is 10:35	Measurements can be taken: From: November 25th at 18:40 To: November 26th at 5:05 *New moon date: Nov. 22nd*

November 2014

Schefferville, Québec, Canada

Latitude, Longitude: 54 48.0' N, 66 48.6' W Time zone: -5:00 (Eastern) DST observance: North America

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1 Twi: 6:51 Sunrise: 7:29 Sunset: 16:52 Twi: 17:31 Moonrise: 14:35 Moonset: 0:23 Day length: 9h 23m
2 DST Ends Twi: 5:53 Sunrise: 6:31 Sunset: 15:50 Twi: 16:29 Moonrise: 14:01 Moonset: 0:43 Day length: 9h 19m	3 Twi: 5:55 Sunrise: 6:33 Sunset: 15:48 Twi: 16:27 Moonrise: 14:26 Moonset: 2:03 Day length: 9h 15m	4 Twi: 5:57 Sunrise: 6:35 Sunset: 15:46 Twi: 16:25 Moonrise: 14:52 Moonset: 3:23 Day length: 9h 11m	5 Twi: 5:59 Sunrise: 6:37 Sunset: 15:44 Twi: 16:23 Moonrise: 15:19 Moonset: 4:43 Day length: 9h 7m	6 ○ Twi: 6:01 Sunrise: 6:40 Sunset: 15:42 Twi: 16:21 Moonrise: 15:50 Moonset: 6:01 Full Moon: 17:24 Day length: 9h 3m	7 Twi: 6:02 Sunrise: 6:42 Sunset: 15:40 Twi: 16:19 Moonrise: 16:26 Moonset: 7:16 Day length: 8h 59m	8 Twi: 6:04 Sunrise: 6:44 Sunset: 15:38 Twi: 16:18 Moonrise: 17:08 Moonset: 8:24 Day length: 8h 55m
9 Twi: 6:06 Sunrise: 6:46 Sunset: 15:37 Twi: 16:16 Moonrise: 17:57 Moonset: 9:25 Day length: 8h 51m	10 Twi: 6:08 Sunrise: 6:48 Sunset: 15:35 Twi: 16:14 Moonrise: 18:51 Moonset: 10:16 Day length: 8h 47m	11 Twi: 6:10 Sunrise: 6:50 Sunset: 15:33 Twi: 16:13 Moonrise: 19:51 Moonset: 10:58 Day length: 8h 43m	12 Twi: 6:12 Sunrise: 6:52 Sunset: 15:31 Twi: 16:11 Moonrise: 20:53 Moonset: 11:32 Day length: 8h 40m	13 Twi: 6:13 Sunrise: 6:54 Sunset: 15:29 Twi: 16:10 Moonrise: 21:57 Moonset: 12:01 Day length: 8h 36m	14 ◑ Twi: 6:15 Sunrise: 6:55 Sunset: 15:28 Twi: 16:08 Moonrise: 23:01 Moonset: 12:25 Last Qtr: 10:17 Day length: 8h 32m	15 Twi: 6:17 Sunrise: 6:57 Sunset: 15:26 Twi: 16:07 Moonrise: none Moonset: 12:47 Day length: 8h 29m
16 Twi: 6:19 Sunrise: 6:59 Sunset: 15:24 Twi: 16:05 Moonrise: 0:06 Moonset: 13:08 Day length: 8h 25m	17 Twi: 6:20 Sunrise: 7:01 Sunset: 15:23 Twi: 16:04 Moonrise: 1:12 Moonset: 13:28 Day length: 8h 22m	18 Twi: 6:22 Sunrise: 7:03 Sunset: 15:21 Twi: 16:02 Moonrise: 2:19 Moonset: 13:49 Day length: 8h 18m	19 Twi: 6:24 Sunrise: 7:05 Sunset: 15:20 Twi: 16:01 Moonrise: 3:28 Moonset: 14:12 Day length: 8h 15m	20 Twi: 6:26 Sunrise: 7:07 Sunset: 15:18 Twi: 16:00 Moonrise: 4:38 Moonset: 14:38 Day length: 8h 11m	21 Twi: 6:27 Sunrise: 7:09 Sunset: 15:17 Twi: 15:59 Moonrise: 5:49 Moonset: 15:09 Day length: 8h 8m	22 ● Twi: 6:29 Sunrise: 7:11 Sunset: 15:16 Twi: 15:57 Moonrise: 6:58 Moonset: 15:48 New Moon: 7:33 Day length: 8h 5m
23 Twi: 6:31 Sunrise: 7:13 Sunset: 15:14 Twi: 15:56 Moonrise: 8:04 Moonset: 16:35 Day length: 8h 2m	24 Twi: 6:32 Sunrise: 7:14 Sunset: 15:13 Twi: 15:55 Moonrise: 9:03 Moonset: 17:33 Day length: 7h 59m	25 Twi: 6:34 Sunrise: 7:16 Sunset: 15:12 Twi: 15:54 Moonrise: 9:53 Moonset: 18:40 Day length: 7h 56m	26 Twi: 6:35 Sunrise: 7:18 Sunset: 15:11 Twi: 15:53 Moonrise: 10:35 Moonset: 19:54 Day length: 7h 53m	27 Twi: 6:37 Sunrise: 7:20 Sunset: 15:10 Twi: 15:52 Moonrise: 11:10 Moonset: 21:12 Day length: 7h 50m	28 Twi: 6:39 Sunrise: 7:21 Sunset: 15:09 Twi: 15:51 Moonrise: 11:40 Moonset: 22:31 Day length: 7h 47m	29 ◐ Twi: 6:40 Sunrise: 7:23 Sunset: 15:08 Twi: 15:51 Moonrise: 12:07 Moonset: 23:50 First Qtr: 5:07 Day length: 7h 44m

UNIHEDRON SQM-LU-DL MEASUREMENT DATASHEET
Ambient light - TSMC

* *Before measurement, program the Sky Quality Meter (SQM). See back of page.*
** *Before measurement, plan for acceptable time and weather conditions. See back of page.*

			GPS Garmin	Smartphone app
Site name	PINETTE LAKE	Lat.	N54°53'44.1"	N 54°53.7311'
Date	26/NOV/14	Long.	W 067°07'19.0"	W 067°07.3198'
Observer name	M. Lewis / D. Lalonde	Elevation	631 m	633 m

Timing		Describe Sky conditions (clouds, humidity, etc...)
End Twilight (HH:MIN)		100% clear sky - Light wind Small aurora borealis. Green - north direction See light "candles" from main plant, almost like Las Vegas light going straight up.
Begin Twilight - following day (HH:MIN)		
Moonset (HH:MIN)		
Next moonrise - following day (HH:MIN)		
New moon date (DD-MM-YR)		**Describe surroundings (% snow cover, trees, buildings, etc...)**
Outside Temperature (°C)		On lake shore Small trees 100% snow cover.
SQM placed in Outdoor housing (Y/N)?		
SQM data logging frequency (sec or min)		

PROCEDURE:

1. No artificial light directly on lens (lens reads a 20° wide cone)
2. No aircraft passing close to the zenith
3. Avoid using the SQM near lights like streetlights and in areas that are shaded by trees or buildings. A rule of thumb for the SQM is to be as far from the object as it is high. For streetlights, stand at least 7.5 meters (or 25 feet) away. Keep away from objects that can reflect light
4. Point the SQM directly overhead (at the zenith). The meter should be held above head level so that shadows or reflections from your body do not interfere with the reading. Keep it steady.
5. The meter is somewhat temperature dependent. Leave the meter outside for at least 5 minutes to reach ambient temperature before taking any measurements.
6. Clean lens (from SQM and outdoor housing if used) with a soft cloth. Ensure no condensation on lense.

MEASUREMENT:

Connect the battery pack when ready to measure (This turns on the SQM)	✓
For short term measurement, take readings for about 5 minutes per site	✓
Start time (HH:MIN)	23:14
End time (HH:MIN)	23:20
Disconnect battery pack when finished (This turns off the SQM)	✓

NOTES:

INSTRUCTIONS

* ***Before measurement, program the Sky Quality Meter (SQM).***

1- Program the SQM using the Unihedron Device Manager software
2- Connect the SQM and click Find to ensure the SQM has been detected
3- Go to the "Data Logging" tab
4- Click on "Settings" button under Device Clock. Ensure SQM and computer times are synchronized.
5- If data stored in the SQM have already been saved, you can "Erase all", this will free up memory.
6- For short term measurements, set "Every x seconds (always on)" at 10 s.
7- For long term measurements, set "Every x minutes (power save mode)" at 5 m.

Note: There is no display on the SQM, consequently, you must ensure the device is correctly programmed, before any measurement

** ***Before measurement, plan for acceptable time and weather conditions.***

1. Measurements should be taken on clear nights
2. Moon is < ¼ full
3. Moon is NOT up
4. 1.5 hours after end of civil twilight (http://www.sunrisesunset.com/Canada/Quebec/Schefferville.asp)
5. 1.5 hours before beginning of civil twilight
6. No aurora borealis

Example : For measurement on November 25th, 2014.

End Twilight is 15:54 + 1.5 hour = 17:23 Begin Twilight (following day) is 6:35 – 1.5 hour = 5:05 Moonset is 18:40 Next moonrise (following day) is 10:35	Measurements can be taken: From: November 25th at 18:40 To: November 26th at 5:05 *New moon date: Nov. 22nd*

November 2014

Schefferville, Québec, Canada

Latitude, Longitude: 54 48.0' N, 66 48.6' W Time zone: -5:00 (Eastern) DST observance: North America

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1 Twi: 6:51 Sunrise: 7:29 Sunset: 16:52 Twi: 17:31 Moonrise: 14:35 Moonset: 0:23 Day length: 9h 23m
2 DST Ends Twi: 5:53 Sunrise: 6:31 Sunset: 15:50 Twi: 16:29 Moonrise: 14:01 Moonset: 0:43 Day length: 9h 19m	3 Twi: 5:55 Sunrise: 6:33 Sunset: 15:48 Twi: 16:27 Moonrise: 14:26 Moonset: 2:03 Day length: 9h 15m	4 Twi: 5:57 Sunrise: 6:35 Sunset: 15:46 Twi: 16:25 Moonrise: 14:52 Moonset: 3:23 Day length: 9h 11m	5 Twi: 5:59 Sunrise: 6:37 Sunset: 15:44 Twi: 16:23 Moonrise: 15:19 Moonset: 4:43 Day length: 9h 7m	6 ○ Twi: 6:01 Sunrise: 6:40 Sunset: 15:42 Twi: 16:21 Moonrise: 15:50 Moonset: 6:01 Full Moon: 17:24 Day length: 9h 3m	7 Twi: 6:02 Sunrise: 6:42 Sunset: 15:40 Twi: 16:19 Moonrise: 16:26 Moonset: 7:16 Day length: 8h 59m	8 Twi: 6:04 Sunrise: 6:44 Sunset: 15:38 Twi: 16:18 Moonrise: 17:08 Moonset: 8:24 Day length: 8h 55m
9 Twi: 6:06 Sunrise: 6:46 Sunset: 15:37 Twi: 16:16 Moonrise: 17:57 Moonset: 9:25 Day length: 8h 51m	10 Twi: 6:08 Sunrise: 6:48 Sunset: 15:35 Twi: 16:14 Moonrise: 18:51 Moonset: 10:16 Day length: 8h 47m	11 Twi: 6:10 Sunrise: 6:50 Sunset: 15:33 Twi: 16:13 Moonrise: 19:51 Moonset: 10:58 Day length: 8h 43m	12 Twi: 6:12 Sunrise: 6:52 Sunset: 15:31 Twi: 16:11 Moonrise: 20:53 Moonset: 11:32 Day length: 8h 40m	13 Twi: 6:13 Sunrise: 6:54 Sunset: 15:29 Twi: 16:10 Moonrise: 21:57 Moonset: 12:01 Day length: 8h 36m	14 ◑ Twi: 6:15 Sunrise: 6:55 Sunset: 15:28 Twi: 16:08 Moonrise: 23:01 Moonset: 12:25 Last Qtr: 10:17 Day length: 8h 32m	15 Twi: 6:17 Sunrise: 6:57 Sunset: 15:26 Twi: 16:07 Moonrise: none Moonset: 12:47 Day length: 8h 29m
16 Twi: 6:19 Sunrise: 6:59 Sunset: 15:24 Twi: 16:05 Moonrise: 0:06 Moonset: 13:08 Day length: 8h 25m	17 Twi: 6:20 Sunrise: 7:01 Sunset: 15:23 Twi: 16:04 Moonrise: 1:12 Moonset: 13:28 Day length: 8h 22m	18 Twi: 6:22 Sunrise: 7:03 Sunset: 15:21 Twi: 16:02 Moonrise: 2:19 Moonset: 13:49 Day length: 8h 18m	19 Twi: 6:24 Sunrise: 7:05 Sunset: 15:20 Twi: 16:01 Moonrise: 3:28 Moonset: 14:12 Day length: 8h 15m	20 Twi: 6:26 Sunrise: 7:07 Sunset: 15:18 Twi: 16:00 Moonrise: 4:38 Moonset: 14:38 Day length: 8h 11m	21 Twi: 6:27 Sunrise: 7:09 Sunset: 15:17 Twi: 15:59 Moonrise: 5:49 Moonset: 15:09 Day length: 8h 8m	22 ● Twi: 6:29 Sunrise: 7:11 Sunset: 15:16 Twi: 15:57 Moonrise: 6:58 Moonset: 15:48 New Moon: 7:33 Day length: 8h 5m
23 Twi: 6:31 Sunrise: 7:13 Sunset: 15:14 Twi: 15:56 Moonrise: 8:04 Moonset: 16:35 Day length: 8h 2m	24 Twi: 6:32 Sunrise: 7:14 Sunset: 15:13 Twi: 15:55 Moonrise: 9:03 Moonset: 17:33 Day length: 7h 59m	25 Twi: 6:34 Sunrise: 7:16 Sunset: 15:12 Twi: 15:54 Moonrise: 9:53 Moonset: 18:40 Day length: 7h 56m	26 Twi: 6:35 Sunrise: 7:18 Sunset: 15:11 Twi: 15:53 Moonrise: 10:35 Moonset: 19:54 Day length: 7h 53m	27 Twi: 6:37 Sunrise: 7:20 Sunset: 15:10 Twi: 15:52 Moonrise: 11:10 Moonset: 21:12 Day length: 7h 50m	28 Twi: 6:39 Sunrise: 7:21 Sunset: 15:09 Twi: 15:51 Moonrise: 11:40 Moonset: 22:31 Day length: 7h 47m	29 ◐ Twi: 6:40 Sunrise: 7:23 Sunset: 15:08 Twi: 15:51 Moonrise: 12:07 Moonset: 23:50 First Qtr: 5:07 Day length: 7h 44m

UNIHEDRON SQM-LU-DL MEASUREMENT DATASHEET
Ambient light - TSMC

* *Before measurement, program the Sky Quality Meter (SQM). See back of page.*
** *Before measurement, plan for acceptable time and weather conditions. See back of page.*

			GPS Garmin	Smartphone app.
Site name	IRONY MOUNTAIN	Lat.	N 54° 54' 13.9"	—
Date	27 / NOV / 14	Long.	W 067° 07' 12.6"	—
Observer name	M. Lewis / D. Lalonde	Elevation	670 m	—

Timing		Describe Sky conditions (clouds, humidity, etc...)
End Twilight (HH:MIN)	15:53	Sky = 90% clear - 10% light clouds Small / green aurora borealis Can see main plant lights - in the sky
Begin Twilight - following day (HH:MIN)	6:37	
Moonset (HH:MIN)	19:54	
Next moonrise - following day (HH:MIN)	11:10	
New moon date (DD-MM-YR)	22-11-14	**Describe surroundings (% snow cover, trees, buildings, etc...)**
Outside Temperature (°C)	-18 °C	On the road unplowed. 100% snow cover. 15% trees around In front of ~~us~~ is future HOUSE + Irony Mountain
SQM placed in Outdoor housing (Y/N)?	N	
SQM data logging frequency (sec or min)	10 sec	

PROCEDURE:

1. No artificial light directly on lens (lens reads a 20° wide cone)
2. No aircraft passing close to the zenith
3. Avoid using the SQM near lights like streetlights and in areas that are shaded by trees or buildings. A rule of thumb for the SQM is to be as far from the object as it is high. For streetlights, stand at least 7.5 meters (or 25 feet) away. Keep away from objects that can reflect light
4. Point the SQM directly overhead (at the zenith). The meter should be held above head level so that shadows or reflections from your body do not interfere with the reading. Keep it steady.
5. The meter is somewhat temperature dependent. Leave the meter outside for at least 5 minutes to reach ambient temperature before taking any measurements.
6. Clean lens (from SQM and outdoor housing if used) with a soft cloth. Ensure no condensation on lense.

MEASUREMENT:

Connect the battery pack when ready to measure (This turns on the SQM)	✓
For short term measurement, take readings for about 5 minutes per site	✓
Start time (HH:MIN)	00:37
End time (HH:MIN)	00:43
Disconnect battery pack when finished (This turns off the SQM)	✓

NOTES:

INSTRUCTIONS

* ***Before measurement, program the Sky Quality Meter (SQM).***

1- Program the SQM using the Unihedron Device Manager software
2- Connect the SQM and click Find to ensure the SQM has been detected
3- Go to the "Data Logging" tab
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7- For long term measurements, set "Every x minutes (power save mode)" at 5 m.

Note: There is no display on the SQM, consequently, you must ensure the device is correctly programmed, before any measurement

** ***Before measurement, plan for acceptable time and weather conditions.***

1. Measurements should be taken on clear nights
2. Moon is < ¼ full
3. Moon is NOT up
4. 1.5 hours after end of civil twilight (http://www.sunrisesunset.com/Canada/Quebec/Schefferville.asp)
5. 1.5 hours before beginning of civil twilight
6. No aurora borealis

Example : For measurement on November 25th, 2014.

End Twilight is 15:54 + 1.5 hour = 17:23 Begin Twilight (following day) is 6:35 – 1.5 hour = 5:05 Moonset is 18:40 Next moonrise (following day) is 10:35	Measurements can be taken: From: November 25th at 18:40 To: November 26th at 5:05 *New moon date: Nov. 22nd*

November 2014
Schefferville, Québec, Canada
Latitude, Longitude: 54 48.0' N, 66 48.6' W Time zone: -5:00 (Eastern) DST observance: North America

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1 Twi: 6:51 Sunrise: 7:29 Sunset: 16:52 Twi: 17:31 Moonrise: 14:35 Moonset: 0:23 Day length: 9h 23m
2 DST Ends Twi: 5:53 Sunrise: 6:31 Sunset: 15:50 Twi: 16:29 Moonrise: 14:01 Moonset: 0:43 Day length: 9h 19m	3 Twi: 5:55 Sunrise: 6:33 Sunset: 15:48 Twi: 16:27 Moonrise: 14:26 Moonset: 2:03 Day length: 9h 15m	4 Twi: 5:57 Sunrise: 6:35 Sunset: 15:46 Twi: 16:25 Moonrise: 14:52 Moonset: 3:23 Day length: 9h 11m	5 Twi: 5:59 Sunrise: 6:37 Sunset: 15:44 Twi: 16:23 Moonrise: 15:19 Moonset: 4:43 Day length: 9h 7m	6 Twi: 6:01 Sunrise: 6:40 Sunset: 15:42 Twi: 16:21 Moonrise: 15:50 Moonset: 6:01 Full Moon: 17:24 Day length: 9h 3m	7 Twi: 6:02 Sunrise: 6:42 Sunset: 15:40 Twi: 16:19 Moonrise: 16:26 Moonset: 7:16 Day length: 8h 59m	8 Twi: 6:04 Sunrise: 6:44 Sunset: 15:38 Twi: 16:18 Moonrise: 17:08 Moonset: 8:24 Day length: 8h 55m
9 Twi: 6:06 Sunrise: 6:46 Sunset: 15:37 Twi: 16:16 Moonrise: 17:57 Moonset: 9:25 Day length: 8h 51m	10 Twi: 6:08 Sunrise: 6:48 Sunset: 15:35 Twi: 16:14 Moonrise: 18:51 Moonset: 10:16 Day length: 8h 47m	11 Twi: 6:10 Sunrise: 6:50 Sunset: 15:33 Twi: 16:13 Moonrise: 19:51 Moonset: 10:58 Day length: 8h 43m	12 Twi: 6:12 Sunrise: 6:52 Sunset: 15:31 Twi: 16:11 Moonrise: 20:53 Moonset: 11:32 Day length: 8h 40m	13 Twi: 6:13 Sunrise: 6:54 Sunset: 15:29 Twi: 16:10 Moonrise: 21:57 Moonset: 12:01 Day length: 8h 36m	14 Twi: 6:15 Sunrise: 6:55 Sunset: 15:28 Twi: 16:08 Moonrise: 23:01 Moonset: 12:25 Last Qtr: 10:17 Day length: 8h 32m	15 Twi: 6:17 Sunrise: 6:57 Sunset: 15:26 Twi: 16:07 Moonrise: none Moonset: 12:47 Day length: 8h 29m
16 Twi: 6:19 Sunrise: 6:59 Sunset: 15:24 Twi: 16:05 Moonrise: 0:06 Moonset: 13:08 Day length: 8h 25m	17 Twi: 6:20 Sunrise: 7:01 Sunset: 15:23 Twi: 16:04 Moonrise: 1:12 Moonset: 13:28 Day length: 8h 22m	18 Twi: 6:22 Sunrise: 7:03 Sunset: 15:21 Twi: 16:02 Moonrise: 2:19 Moonset: 13:49 Day length: 8h 18m	19 Twi: 6:24 Sunrise: 7:05 Sunset: 15:20 Twi: 16:01 Moonrise: 3:28 Moonset: 14:12 Day length: 8h 15m	20 Twi: 6:26 Sunrise: 7:07 Sunset: 15:18 Twi: 16:00 Moonrise: 4:38 Moonset: 14:38 Day length: 8h 11m	21 Twi: 6:27 Sunrise: 7:09 Sunset: 15:17 Twi: 15:59 Moonrise: 5:49 Moonset: 15:09 Day length: 8h 8m	22 Twi: 6:29 Sunrise: 7:11 Sunset: 15:16 Twi: 15:57 Moonrise: 6:58 Moonset: 15:48 New Moon: 7:33 Day length: 8h 5m
23 Twi: 6:31 Sunrise: 7:13 Sunset: 15:14 Twi: 15:56 Moonrise: 8:04 Moonset: 16:35 Day length: 8h 2m	24 Twi: 6:32 Sunrise: 7:14 Sunset: 15:13 Twi: 15:55 Moonrise: 9:03 Moonset: 17:33 Day length: 7h 59m	25 Twi: 6:34 Sunrise: 7:16 Sunset: 15:12 Twi: 15:54 Moonrise: 9:53 Moonset: 18:40 Day length: 7h 56m	26 Twi: 6:35 Sunrise: 7:18 Sunset: 15:11 Twi: 15:53 Moonrise: 10:35 Moonset: 19:54 Day length: 7h 53m	27 Twi: 6:37 Sunrise: 7:20 Sunset: 15:10 Twi: 15:52 Moonrise: 11:10 Moonset: 21:12 Day length: 7h 50m	28 Twi: 6:39 Sunrise: 7:21 Sunset: 15:09 Twi: 15:51 Moonrise: 11:40 Moonset: 22:31 Day length: 7h 47m	29 Twi: 6:40 Sunrise: 7:23 Sunset: 15:08 Twi: 15:51 Moonrise: 12:07 Moonset: 23:50 First Qtr: 5:07 Day length: 7h 44m

```
# Light Pollution Monitoring Data Format 1.0
# URL: http://www.darksky.org/measurements
# Number of header lines: 35+
# This data is released under the following license: ODbL 1.0 http://opendatacommons.org/licenses/odbl/summary/
# Device type: SQM-LU-DL
# Instrument ID: TSMC_SQM
# Data supplier: TSMC
# Location name: Schefferville - Howse Project
# Position (lat, lon, elev(m)): 54.799999, -66.833336, 549
# Local timezone: America/Montreal
# Time Synchronization:
# Moving / Stationary position: STATIONARY
# Moving / Fixed look direction: FIXED
# Number of channels: 1
# Filters per channel: HOYA CM-500
# Measurement direction per channel: up - zenith
# Field of view (degrees): 20
# Number of fields per line: 5
# SQM serial number: 2913
# SQM firmware version: 4-6-32
# SQM cover offset value:
# SQM readout test ix: i,00000004,00000006,00000032,00002913
# SQM readout test rx: r, 11.81m,0000001697Hz,0000000000c,0000000.000s,-012.3C
# SQM readout test cx: c,00000019.88m,0000124.363s, 020.3C,00000008.71m, 020.9C
# Comment: SQM purchased by AECOM on behlaf of TSMC
# Comment: For HOWSE Env Impact Statement
# Comment: November 2014
# Comment:
# Comment:
# UDM version: 1.0.0.40
# UDM setting: DL Retrieve All
# blank line 32
# UTC Date & Time, Local Date & Time, Temperature, Voltage, MSAS
# YYYY-MM-DDTHH:mm:ss.fff          YYYY-MM-DDTHH:mm:ss.fff     Celsius    Volts   mag/arcsec^2
# END OF HEADER
```

2014-11-27 at 00:03:39	2014-11-26 at 19:03:39	19.3	5.04	21.34	Not valid
2014-11-27 at 00:03:51	2014-11-26 at 19:03:51	19.3	5.04	21.34	
2014-11-27 at 00:04:43	2014-11-26 at 19:04:43	18.6	4.88	10.65	
2014-11-27 at 00:07:41	2014-11-26 at 19:07:41	19	5.04	9.12	
2014-11-27 at 00:07:51	2014-11-26 at 19:07:51	19.3	5.04	8.83	
2014-11-27 at 00:08:01	2014-11-26 at 19:08:01	19	5.04	9.13	
2014-11-27 at 01:40:10	2014-11-26 at 20:40:10	15.4	4.88	19.69	
2014-11-27 at 01:40:20	2014-11-26 at 20:40:20	15.4	4.88	18.18	

Kawawa - Center	**54° 51.6417' N**	**066° 45.6725' W**	**487 m**	**Prise avec Smartphone app**
	54° 51' 38.6" N	**066° 45' 40.3" W**	**495 m**	**Prise avec GPS Garmin**
	54°51'38.5020"	**-066°45'40.3500"**		**Conversion for use in Google Map**

2014-11-27 at 01:40:30	2014-11-26 at 20:40:30	15.1	4.88	19.52
2014-11-27 at 01:40:40	2014-11-26 at 20:40:40	14.8	4.88	19.98
2014-11-27 at 01:40:50	2014-11-26 at 20:40:50	14.5	4.88	19.89
2014-11-27 at 01:41:00	2014-11-26 at 20:41:00	13.8	4.88	19.92
2014-11-27 at 01:41:10	2014-11-26 at 20:41:10	13.5	4.88	20.01
2014-11-27 at 01:41:20	2014-11-26 at 20:41:20	13.2	4.88	19.96
2014-11-27 at 01:41:30	2014-11-26 at 20:41:30	12.5	4.88	19.98
2014-11-27 at 01:41:40	2014-11-26 at 20:41:40	12.2	4.88	19.98
2014-11-27 at 01:41:50	2014-11-26 at 20:41:50	11.6	4.88	19.97
2014-11-27 at 01:42:00	2014-11-26 at 20:42:00	10.9	4.88	19.96
2014-11-27 at 01:42:10	2014-11-26 at 20:42:10	10.6	4.88	19.96
2014-11-27 at 01:42:20	2014-11-26 at 20:42:20	10.3	4.88	19.85
2014-11-27 at 01:42:30	2014-11-26 at 20:42:30	9.3	4.88	19.9
2014-11-27 at 01:42:40	2014-11-26 at 20:42:40	9	4.88	19.93
2014-11-27 at 01:42:50	2014-11-26 at 20:42:50	8.7	4.88	19.97
2014-11-27 at 01:43:00	2014-11-26 at 20:43:00	8	4.88	19.96
2014-11-27 at 01:43:10	2014-11-26 at 20:43:10	7.4	4.88	19.94
2014-11-27 at 01:43:20	2014-11-26 at 20:43:20	7	4.88	19.96
2014-11-27 at 01:43:30	2014-11-26 at 20:43:30	6.4	5.76	19.9
2014-11-27 at 01:43:40	2014-11-26 at 20:43:40	6.1	4.88	19.96
2014-11-27 at 01:43:50	2014-11-26 at 20:43:50	5.8	4.88	19.97
2014-11-27 at 01:44:00	2014-11-26 at 20:44:00	5.1	4.88	19.97
2014-11-27 at 01:44:10	2014-11-26 at 20:44:10	4.8	4.88	19.98
2014-11-27 at 01:44:20	2014-11-26 at 20:44:20	4.5	4.88	19.97
2014-11-27 at 01:44:30	2014-11-26 at 20:44:30	3.8	4.88	19.95
2014-11-27 at 01:44:40	2014-11-26 at 20:44:40	3.5	4.88	19.98

2014-11-27 at 01:44:50	2014-11-26 at 20:44:50	2.9	4.88	19.98
2014-11-27 at 01:45:00	2014-11-26 at 20:45:00	2.5	4.88	19.96
2014-11-27 at 01:45:10	2014-11-26 at 20:45:10	2.2	4.88	19.95
2014-11-27 at 01:45:20	2014-11-26 at 20:45:20	1.6	4.88	19.97
2014-11-27 at 01:45:30	2014-11-26 at 20:45:30	1.2	4.88	19.98
2014-11-27 at 01:45:40	2014-11-26 at 20:45:40	0.9	4.88	19.97
2014-11-27 at 01:45:50	2014-11-26 at 20:45:50	0.6	4.88	19.96
2014-11-27 at 01:46:00	2014-11-26 at 20:46:00	0.3	4.88	19.97
2014-11-27 at 01:46:10	2014-11-26 at 20:46:10	0.1	4.88	20
2014-11-27 at 01:46:20	2014-11-26 at 20:46:20	-0.4	4.88	19.95
2014-11-27 at 01:46:30	2014-11-26 at 20:46:30	-0.7	4.88	19.96
2014-11-27 at 01:46:40	2014-11-26 at 20:46:40	-1	4.88	19.98

Kawawa - Out of town	**54° 49.1194' N**	**066° 45.0898' W**	**600 m**	**Prise avec Smartphone app**
	54° 49' 07.1" N	**066° 45' 05.5" W**	**594 m**	**Prise avec GPS Garmin**
	54.8186567°	**-066.7514967°**		**Conversion for use in Google Map**

2014-11-27 at 02:05:19	2014-11-26 at 21:05:19	-1.3	4.88	21.14
2014-11-27 at 02:05:29	2014-11-26 at 21:05:29	-1.3	4.88	21.03
2014-11-27 at 02:05:39	2014-11-26 at 21:05:39	-1.7	4.88	21.17
2014-11-27 at 02:05:49	2014-11-26 at 21:05:49	-2	4.88	21.17
2014-11-27 at 02:05:59	2014-11-26 at 21:05:59	-2.3	4.88	21.17
2014-11-27 at 02:06:09	2014-11-26 at 21:06:09	-2.6	4.88	21.18
2014-11-27 at 02:06:19	2014-11-26 at 21:06:19	-2.6	4.88	21.19
2014-11-27 at 02:06:29	2014-11-26 at 21:06:29	-3	4.88	21.26
2014-11-27 at 02:06:39	2014-11-26 at 21:06:39	-3.3	4.88	21.24
2014-11-27 at 02:06:49	2014-11-26 at 21:06:49	-3.6	4.88	21.19
2014-11-27 at 02:06:59	2014-11-26 at 21:06:59	-3.6	4.88	21.18
2014-11-27 at 02:07:09	2014-11-26 at 21:07:09	-3.9	4.88	21.19
2014-11-27 at 02:07:19	2014-11-26 at 21:07:19	-4.2	4.88	21.24
2014-11-27 at 02:07:29	2014-11-26 at 21:07:29	-4.2	4.88	21.24
2014-11-27 at 02:07:39	2014-11-26 at 21:07:39	-4.6	4.88	21.11
2014-11-27 at 02:07:49	2014-11-26 at 21:07:49	-4.9	4.88	21.24
2014-11-27 at 02:07:59	2014-11-26 at 21:07:59	-4.9	4.88	21.2
2014-11-27 at 02:08:09	2014-11-26 at 21:08:09	-5.2	4.88	21.1
2014-11-27 at 02:08:19	2014-11-26 at 21:08:19	-5.5	4.88	21.04
2014-11-27 at 02:08:29	2014-11-26 at 21:08:29	-5.5	4.88	21.19
2014-11-27 at 02:08:39	2014-11-26 at 21:08:39	-5.9	4.88	21.17
2014-11-27 at 02:08:49	2014-11-26 at 21:08:49	-6.2	4.88	21.2
2014-11-27 at 02:08:59	2014-11-26 at 21:08:59	-6.2	4.88	21.18
2014-11-27 at 02:09:09	2014-11-26 at 21:09:09	-6.5	4.88	21.21
2014-11-27 at 02:09:19	2014-11-26 at 21:09:19	-6.8	4.88	21.18
2014-11-27 at 02:09:29	2014-11-26 at 21:09:29	-6.8	4.88	21.16
2014-11-27 at 02:09:39	2014-11-26 at 21:09:39	-7.1	4.88	21.18
2014-11-27 at 02:09:49	2014-11-26 at 21:09:49	-7.1	4.88	21.12
2014-11-27 at 02:09:59	2014-11-26 at 21:09:59	-7.5	4.88	21.18
2014-11-27 at 02:10:19	2014-11-26 at 21:10:19	-7.8	4.88	20.64
2014-11-27 at 02:10:29	2014-11-26 at 21:10:29	-7.8	4.88	21.02
2014-11-27 at 02:10:39	2014-11-26 at 21:10:39	-8.1	4.88	21.15
2014-11-27 at 02:10:49	2014-11-26 at 21:10:49	-8.1	4.88	21.2
2014-11-27 at 02:10:59	2014-11-26 at 21:10:59	-8.1	4.88	21.18
2014-11-27 at 02:11:01	2014-11-26 at 21:11:01	-8.4	4.88	21.18
2014-11-27 at 02:11:19	2014-11-26 at 21:11:19	-8.4	4.88	21.19
2014-11-27 at 02:11:29	2014-11-26 at 21:11:29	-8.8	4.88	21.2

Schefferville - Town Center	**54° 48.2098' N**	**066° 48.7035' W**	**526 m**	**Prise avec Smartphone app**
	54° 48' 12.4" N	**066° 48' 41.8" W**	**514 m**	**Prise avec GPS Garmin**
	54.8034967°	**-066.8117250°**		**Conversion for use in Google Map**

2014-11-27 at 02:30:24	2014-11-26 at 21:30:24	0.9	4.88	19.06
2014-11-27 at 02:30:34	2014-11-26 at 21:30:34	0.6	4.88	19.25
2014-11-27 at 02:30:44	2014-11-26 at 21:30:44	0.3	4.88	19.17
2014-11-27 at 02:30:54	2014-11-26 at 21:30:54	0.1	4.88	19.23
2014-11-27 at 02:31:04	2014-11-26 at 21:31:04	-0.4	4.88	19.1
2014-11-27 at 02:31:14	2014-11-26 at 21:31:14	-0.7	4.88	19.03
2014-11-27 at 02:31:24	2014-11-26 at 21:31:24	-1	4.88	19.08
2014-11-27 at 02:31:34	2014-11-26 at 21:31:34	-1.3	4.88	19.04
2014-11-27 at 02:31:44	2014-11-26 at 21:31:44	-1.7	4.88	19.08
2014-11-27 at 02:31:54	2014-11-26 at 21:31:54	-2	4.88	19.16
2014-11-27 at 02:32:04	2014-11-26 at 21:32:04	-2	4.88	18.81
2014-11-27 at 02:32:14	2014-11-26 at 21:32:14	-2.6	4.88	18.91
2014-11-27 at 02:32:24	2014-11-26 at 21:32:24	-2.6	4.88	19.03

2014-11-27 at 02:32:34	2014-11-26 at 21:32:34	-3	4.88	19.03
2014-11-27 at 02:32:44	2014-11-26 at 21:32:44	-3.3	4.88	19.08
2014-11-27 at 02:32:54	2014-11-26 at 21:32:54	-3.6	4.88	19.06
2014-11-27 at 02:33:04	2014-11-26 at 21:33:04	-3.9	4.88	19.05
2014-11-27 at 02:33:14	2014-11-26 at 21:33:14	-4.2	4.88	19.13
2014-11-27 at 02:33:24	2014-11-26 at 21:33:24	-4.2	4.88	19
2014-11-27 at 02:33:34	2014-11-26 at 21:33:34	-4.6	4.88	19.14
2014-11-27 at 02:33:44	2014-11-26 at 21:33:44	-4.9	4.88	19.16
2014-11-27 at 02:33:54	2014-11-26 at 21:33:54	-4.9	4.88	19.21
2014-11-27 at 02:34:04	2014-11-26 at 21:34:04	-5.2	4.88	19.2
2014-11-27 at 02:34:14	2014-11-26 at 21:34:14	-5.5	4.88	19.15
2014-11-27 at 02:34:24	2014-11-26 at 21:34:24	-5.5	4.88	19.16
2014-11-27 at 02:34:34	2014-11-26 at 21:34:34	-5.5	4.88	19.21
2014-11-27 at 02:34:44	2014-11-26 at 21:34:44	-5.9	4.88	19.25
2014-11-27 at 02:34:54	2014-11-26 at 21:34:54	-6.2	4.88	19.28
2014-11-27 at 03:55:04	2014-11-26 at 22:55:04	-6.2	4.88	19.24
2014-11-27 at 02:35:14	2014-11-26 at 21:35:14	-6.5	4.88	19.18
2014-11-27 at 02:35:24	2014-11-26 at 21:35:24	-6.5	4.88	19.33
2014-11-27 at 02:35:34	2014-11-26 at 21:35:34	-6.8	4.88	18.97
2014-11-27 at 02:35:44	2014-11-26 at 21:35:44	-6.8	4.88	19.23
2014-11-27 at 02:35:54	2014-11-26 at 21:35:54	-7.1	4.88	19.3

Schefferville - out of town	**54° 48.3448' N**	**066° 50.1434' W**	**531 m**	**Prise avec Smartphone app**
	54° 48' 20.5" N	**066° 50' 08.8" W**	**532 m**	**Prise avec GPS Garmin**
	54.8057467°	**-066.8357233°**		**Conversion for use in Google Map**

2014-11-27 at 02:49:03	2014-11-26 at 21:49:03	-5.9	4.88	21.11
2014-11-27 at 02:49:13	2014-11-26 at 21:49:13	-5.9	4.88	20.45
2014-11-27 at 02:49:23	2014-11-26 at 21:49:23	-5.9	4.88	20.44
2014-11-27 at 02:49:33	2014-11-26 at 21:49:33	-6.2	4.88	20.47
2014-11-27 at 02:49:43	2014-11-26 at 21:49:43	-6.2	4.88	20.41
2014-11-27 at 02:49:53	2014-11-26 at 21:49:53	-6.5	4.88	20.43
2014-11-27 at 02:50:03	2014-11-26 at 21:50:03	-6.5	4.88	20.41
2014-11-27 at 02:50:13	2014-11-26 at 21:50:13	-6.5	4.88	20.46
2014-11-27 at 02:50:23	2014-11-26 at 21:50:23	-6.8	4.88	20.47
2014-11-27 at 02:50:33	2014-11-26 at 21:50:33	-6.8	4.88	20.44
2014-11-27 at 02:50:43	2014-11-26 at 21:50:43	-7.1	4.88	20.44
2014-11-27 at 02:50:53	2014-11-26 at 21:50:53	-7.1	4.88	20.47
2014-11-27 at 02:51:03	2014-11-26 at 21:51:03	-7.1	4.88	20.48
2014-11-27 at 02:51:13	2014-11-26 at 21:51:13	-7.5	4.88	20.49
2014-11-27 at 02:51:23	2014-11-26 at 21:51:23	-7.5	4.88	20.52
2014-11-27 at 02:51:33	2014-11-26 at 21:51:33	-7.8	4.88	20.48
2014-11-27 at 02:51:43	2014-11-26 at 21:51:43	-7.8	4.88	20.52
2014-11-27 at 02:51:53	2014-11-26 at 21:51:53	-8.1	4.88	20.5
2014-11-27 at 02:52:03	2014-11-26 at 21:52:03	-8.1	4.88	20.49
2014-11-27 at 02:52:13	2014-11-26 at 21:52:13	-8.1	4.88	20.48
2014-11-27 at 02:52:23	2014-11-26 at 21:52:23	-8.4	4.88	20.49
2014-11-27 at 02:52:33	2014-11-26 at 21:52:33	-8.4	4.88	20.54
2014-11-27 at 02:52:43	2014-11-26 at 21:52:43	-8.8	4.88	20.63
2014-11-27 at 02:52:53	2014-11-26 at 21:52:53	-8.8	4.88	20.55
2014-11-27 at 02:53:03	2014-11-26 at 21:53:03	-9.1	4.88	20.54
2014-11-27 at 02:53:13	2014-11-26 at 21:53:13	-9.1	4.88	20.54
2014-11-27 at 02:53:23	2014-11-26 at 21:53:23	-9.1	4.88	20.54
2014-11-27 at 02:53:33	2014-11-26 at 21:53:33	-9.1	4.88	20.54
2014-11-27 at 02:53:43	2014-11-26 at 21:53:43	-9.4	4.88	20.04

Pinette Lake	**54° 53.7311' N**	**067° 07.3198' W**	**633 m**	**Prise avec Smartphone app**
	54° 53' 44.1" N	**067° 07' 19.0" W**	**631 m**	**Prise avec GPS Garmin**
	54.8955183°	**-067.1219967°**		**Conversion for use in Google Map**

2014-11-27 at 04:14:34	2014-11-26 at 23:14:34	1.2	4.88	20.5
2014-11-27 at 04:14:44	2014-11-26 at 23:14:44	0.9	4.88	20.4
2014-11-27 at 04:14:54	2014-11-26 at 23:14:54	0.6	4.88	20.44
2014-11-27 at 04:15:04	2014-11-26 at 23:15:04	0.6	4.88	20.45
2014-11-27 at 04:15:14	2014-11-26 at 23:15:14	0.3	4.88	20.43
2014-11-27 at 04:15:24	2014-11-26 at 23:15:24	0.1	4.88	20.44
2014-11-27 at 04:15:34	2014-11-26 at 23:15:34	-0.4	4.88	20.43
2014-11-27 at 04:15:44	2014-11-26 at 23:15:44	-0.7	4.88	20.44
2014-11-27 at 04:15:54	2014-11-26 at 23:15:54	-1	4.88	20.75
2014-11-27 at 04:16:04	2014-11-26 at 23:16:04	-1.3	4.88	20.52
2014-11-27 at 04:16:14	2014-11-26 at 23:16:14	-1.7	4.88	20.52
2014-11-27 at 04:16:24	2014-11-26 at 23:16:24	-2	4.88	20.51
2014-11-27 at 04:16:34	2014-11-26 at 23:16:34	-2.3	4.88	20.53
2014-11-27 at 04:16:44	2014-11-26 at 23:16:44	-2.6	4.88	20.53

2014-11-27 at 04:16:54	2014-11-26 at 23:16:54	-3	4.88	20.52		
2014-11-27 at 04:17:04	2014-11-26 at 23:17:04	-3.3	4.88	20.56		
2014-11-27 at 04:17:14	2014-11-26 at 23:17:14	-3.3	4.88	20.55		
2014-11-27 at 04:17:24	2014-11-26 at 23:17:24	-3.6	4.88	20.53		
2014-11-27 at 04:17:34	2014-11-26 at 23:17:34	-3.9	4.88	20.49		
2014-11-27 at 04:17:44	2014-11-26 at 23:17:44	-4.2	4.88	20.49		
2014-11-27 at 04:17:54	2014-11-26 at 23:17:54	-4.6	4.88	20.4		
2014-11-27 at 04:18:04	2014-11-26 at 23:18:04	-4.9	4.88	20.54		
2014-11-27 at 04:18:14	2014-11-26 at 23:18:14	-5.2	4.88	20.52		
2014-11-27 at 04:18:24	2014-11-26 at 23:18:24	-5.5	4.88	20.52		
2014-11-27 at 04:18:34	2014-11-26 at 23:18:34	-5.5	4.88	20.52		
2014-11-27 at 04:18:44	2014-11-26 at 23:18:44	-5.9	4.88	20.52		
2014-11-27 at 04:18:54	2014-11-26 at 23:18:54	-6.2	4.88	20.53		
2014-11-27 at 04:19:04	2014-11-26 at 23:19:04	-6.5	4.88	20.53		
2014-11-27 at 04:19:14	2014-11-26 at 23:19:14	-6.5	4.88	20.55		
2014-11-27 at 04:19:24	2014-11-26 at 23:19:24	-6.8	4.88	20.4		
2014-11-27 at 04:19:34	2014-11-26 at 23:19:34	-7.1	4.88	20.55		
2014-11-27 at 04:19:44	2014-11-26 at 23:19:44	-7.1	4.88	20.51		
2014-11-27 at 04:19:54	2014-11-26 at 23:19:54	-7.5	4.88	20.34		
2014-11-27 at 04:20:04	2014-11-26 at 23:20:04	-7.5	4.88	20.5		
2014-11-27 at 04:20:14	2014-11-26 at 23:20:14	-7.8	4.88	20.49		
2014-11-27 at 04:20:24	2014-11-26 at 23:20:24	-8.1	4.88	20.49		
2014-11-27 at 04:20:34	2014-11-26 at 23:20:34	-8.1	4.88	20.53		
Irony Mountain - Howse	**n/a**	**n/a**			**n/a**	**Prise avec Smartphone app**
	54° 54' 13.9" N	**067° 07' 12.6" W**			**670 m**	**Prise avec GPS Garmin**
	54.9038611°	**-067.1201667°**				**Conversion for use in Google Map**
2014-11-27 at 05:37:03	2014-11-27 at 00:37:03	-11	4.88	20.53		
2014-11-27 at 05:37:13	2014-11-27 at 00:37:13	-11	4.88	20.16		
2014-11-27 at 05:37:23	2014-11-27 at 00:37:23	-11	4.88	20.66		
2014-11-27 at 05:37:33	2014-11-27 at 00:37:33	-11	4.88	20.52		
2014-11-27 at 05:37:43	2014-11-27 at 00:37:43	-11	4.88	20.52		
2014-11-27 at 05:37:53	2014-11-27 at 00:37:53	-11.3	4.88	20.58		
2014-11-27 at 05:38:03	2014-11-27 at 00:38:03	-11.3	4.88	20.38		
2054-11-27 at 05:38:13	2054-11-27 at 00:38:13	-11.3	4.88	20.52		
2014-11-27 at 05:38:23	2014-11-27 at 00:38:23	-11.7	4.88	20.57		
2014-11-27 at 05:38:33	2014-11-27 at 00:38:33	-11.7	4.88	20.62		
2014-11-27 at 05:38:43	2014-11-27 at 00:38:43	-11.7	4.88	20.56		
2014-11-27 at 05:38:53	2014-11-27 at 00:38:53	-12	4.88	20.61		
2014-11-27 at 05:39:03	2014-11-27 at 00:39:03	-12	4.88	20.35		
2014-11-27 at 05:39:13	2014-11-27 at 00:39:13	-12.3	4.88	20.6		
2014-11-27 at 05:39:23	2014-11-27 at 00:39:23	-12.3	4.88	20.7		
2014-11-27 at 05:39:33	2014-11-27 at 00:39:33	-12.6	4.88	20.72		
2014-11-27 at 05:39:43	2014-11-27 at 00:39:43	-12.6	4.88	20.65		
2014-11-27 at 05:39:53	2014-11-27 at 00:39:53	-12.6	4.88	20.46		
2014-11-27 at 05:40:03	2014-11-27 at 00:40:03	-12.9	4.88	20.54		
2014-11-27 at 05:40:13	2014-11-27 at 00:40:13	-12.9	4.88	20.58		
2014-11-27 at 05:40:23	2014-11-27 at 00:40:23	-12.9	4.88	20.55		
2014-11-27 at 05:40:33	2014-11-27 at 00:40:33	-13.3	4.88	20.58		
2014-11-27 at 05:40:43	2014-11-27 at 00:40:43	-13.3	4.88	20.07		
2014-11-27 at 05:40:53	2014-11-27 at 00:40:53	-13.3	4.88	20.63		
2014-11-27 at 05:41:03	2014-11-27 at 00:41:03	-13.6	4.88	20.61		
2014-11-27 at 05:41:13	2014-11-27 at 00:41:13	-13.6	4.88	20.64		
2014-11-27 at 05:41:23	2014-11-27 at 00:41:23	-13.6	4.88	20.69		
2014-11-27 at 05:41:33	2014-11-27 at 00:41:33	-13.9	4.88	20.28		
2014-11-27 at 05:41:43	2014-11-27 at 00:41:43	-13.9	4.88	20.55		
2014-11-27 at 05:41:53	2014-11-27 at 00:41:53	-13.9	4.88	20.4		
2014-11-27 at 05:42:03	2014-11-27 at 00:42:03	-13.9	4.88	20.62		
2014-11-27 at 05:42:13	2014-11-27 at 00:42:13	-14.2	4.88	20.61		
2014-11-27 at 05:42:23	2014-11-27 at 00:42:23	-14.2	4.88	20.58		
2014-11-27 at 05:42:33	2014-11-27 at 00:42:33	-14.2	4.88	20.26		
2014-11-27 at 05:42:43	2014-11-27 at 00:42:43	-14.2	4.88	20.39		
2014-11-27 at 05:42:53	2014-11-27 at 00:42:53	-14.6	4.88	19.95		
2014-11-27 at 06:25:50	2014-11-27 at 01:25:50	-14.9	5.04	11.83	Not valid	
2014-11-27 at 06:26:00	2014-11-27 at 01:26:00	-14.6	5.04	11.83		
2014-11-27 at 06:26:10	2014-11-27 at 01:26:10	-14.2	5.04	11.84		

UNIHEDRON SQM-LU-DL MEASUREMENT DATASHEET
Ambient light - TSMC

* *Before measurement, program the Sky Quality Meter (SQM). See back of page.*
** *Before measurement, plan for acceptable time and weather conditions. See back of page.*

			GPS Garmin	Smartphone app.
Site name	Old Goodwood Rd ≈ km 18	Lat.	55°00'43.0"N	N55° 00.7121'
Date	27/Nov/14	Long.	067°14'41.6"W	W067°14.7040'
Observer name	M. Lewis + D. Lalonde	Elevation	651 m	648 m

Timing		Describe Sky conditions (clouds, humidity, etc...)
End Twilight (HH:MIN)	15:52	At time of installation, we could see the moon and clouds were apparent
Begin Twilight - following day (HH:MIN)	06:39	
Moonset (HH:MIN)	21:12	
Next moonrise - following day (HH:MIN)	11:40	
New moon date (DD-MM-YR)	22-11-14	**Describe surroundings (% snow cover, trees, buildings, etc...)**
Outside Temperature (°C)	-18°C at installation	100% snow cover. Chose a clear area, surrounded by trees. Close to Innu teepee structure.
SQM placed in Outdoor housing (Y/N)?	Yes	
SQM data logging frequency (sec or min)	5 min	

PROCEDURE:

1. No artificial light directly on lens (lens reads a 20° wide cone)
2. No aircraft passing close to the zenith
3. Avoid using the SQM near lights like streetlights and in areas that are shaded by trees or buildings. A rule of thumb for the SQM is to be as far from the object as it is high. For streetlights, stand at least 7.5 meters (or 25 feet) away. Keep away from objects that can reflect light
4. Point the SQM directly overhead (at the zenith). The meter should be held above head level so that shadows or reflections from your body do not interfere with the reading. Keep it steady.
5. The meter is somewhat temperature dependent. Leave the meter outside for at least 5 minutes to reach ambient temperature before taking any measurements.
6. Clean lens (from SQM and outdoor housing if used) with a soft cloth. Ensure no condensation on lense.

MEASUREMENT:

Connect the battery pack when ready to measure (This turns on the SQM)		✓
For short term measurement, take readings for about 5 minutes per site		✓
Start time (HH:MIN)	27/Nov/14	15:40
End time (HH:MIN)	28/Nov/14	9:30
Disconnect battery pack when finished (This turns off the SQM)		No. Turned off at the office.

NOTES: Test to get dark night data. Unaffected by artificial light.

INSTRUCTIONS

* ***Before measurement, program the Sky Quality Meter (SQM).***

1- Program the SQM using the Unihedron Device Manager software
2- Connect the SQM and click Find to ensure the SQM has been detected
3- Go to the "Data Logging" tab
4- Click on "Settings" button under Device Clock. Ensure SQM and computer times are synchronized.
5- If data stored in the SQM have already been saved, you can "Erase all", this will free up memory.
6- For short term measurements, set "Every x seconds (always on)" at 10 s.
7- For long term measurements, set "Every x minutes (power save mode)" at 5 m.

Note: There is no display on the SQM, consequently, you must ensure the device is correctly programmed, before any measurement

** ***Before measurement, plan for acceptable time and weather conditions.***

1. Measurements should be taken on clear nights
2. Moon is < ¼ full
3. Moon is NOT up
4. 1.5 hours after end of civil twilight (http://www.sunrisesunset.com/Canada/Quebec/Schefferville.asp)
5. 1.5 hours before beginning of civil twilight
6. No aurora borealis

Example : For measurement on November 25th, 2014.

End Twilight is 15:54 + 1.5 hour = 17:23 Begin Twilight (following day) is 6:35 – 1.5 hour = 5:05 Moonset is 18:40 Next moonrise (following day) is 10:35	Measurements can be taken: From: November 25th at 18:40 To: November 26th at 5:05 *New moon date: Nov. 22nd*

November 2014

Schefferville, Québec, Canada

Latitude, Longitude: 54 48.0' N, 66 48.6' W Time zone: -5:00 (Eastern) DST observance: North America

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1 Twi: 6:51 Sunrise: 7:29 Sunset: 16:52 Twi: 17:31 Moonrise: 14:35 Moonset: 0:23 Day length: 9h 23m
2 DST Ends Twi: 5:53 Sunrise: 6:31 Sunset: 15:50 Twi: 16:29 Moonrise: 14:01 Moonset: 0:43 Day length: 9h 19m	3 Twi: 5:55 Sunrise: 6:33 Sunset: 15:48 Twi: 16:27 Moonrise: 14:26 Moonset: 2:03 Day length: 9h 15m	4 Twi: 5:57 Sunrise: 6:35 Sunset: 15:46 Twi: 16:25 Moonrise: 14:52 Moonset: 3:23 Day length: 9h 11m	5 Twi: 5:59 Sunrise: 6:37 Sunset: 15:44 Twi: 16:23 Moonrise: 15:19 Moonset: 4:43 Day length: 9h 7m	6 ○ Twi: 6:01 Sunrise: 6:40 Sunset: 15:42 Twi: 16:21 Moonrise: 15:50 Moonset: 6:01 Full Moon: 17:24 Day length: 9h 3m	7 Twi: 6:02 Sunrise: 6:42 Sunset: 15:40 Twi: 16:19 Moonrise: 16:26 Moonset: 7:16 Day length: 8h 59m	8 Twi: 6:04 Sunrise: 6:44 Sunset: 15:38 Twi: 16:18 Moonrise: 17:08 Moonset: 8:24 Day length: 8h 55m
9 Twi: 6:06 Sunrise: 6:46 Sunset: 15:37 Twi: 16:16 Moonrise: 17:57 Moonset: 9:25 Day length: 8h 51m	10 Twi: 6:08 Sunrise: 6:48 Sunset: 15:35 Twi: 16:14 Moonrise: 18:51 Moonset: 10:16 Day length: 8h 47m	11 Twi: 6:10 Sunrise: 6:50 Sunset: 15:33 Twi: 16:13 Moonrise: 19:51 Moonset: 10:58 Day length: 8h 43m	12 Twi: 6:12 Sunrise: 6:52 Sunset: 15:31 Twi: 16:11 Moonrise: 20:53 Moonset: 11:32 Day length: 8h 40m	13 Twi: 6:13 Sunrise: 6:54 Sunset: 15:29 Twi: 16:10 Moonrise: 21:57 Moonset: 12:01 Day length: 8h 36m	14 ◑ Twi: 6:15 Sunrise: 6:55 Sunset: 15:28 Twi: 16:08 Moonrise: 23:01 Moonset: 12:25 Last Qtr: 10:17 Day length: 8h 32m	15 Twi: 6:17 Sunrise: 6:57 Sunset: 15:26 Twi: 16:07 Moonrise: none Moonset: 12:47 Day length: 8h 29m
16 Twi: 6:19 Sunrise: 6:59 Sunset: 15:24 Twi: 16:05 Moonrise: 0:06 Moonset: 13:08 Day length: 8h 25m	17 Twi: 6:20 Sunrise: 7:01 Sunset: 15:23 Twi: 16:04 Moonrise: 1:12 Moonset: 13:28 Day length: 8h 22m	18 Twi: 6:22 Sunrise: 7:03 Sunset: 15:21 Twi: 16:02 Moonrise: 2:19 Moonset: 13:49 Day length: 8h 18m	19 Twi: 6:24 Sunrise: 7:05 Sunset: 15:20 Twi: 16:01 Moonrise: 3:28 Moonset: 14:12 Day length: 8h 15m	20 Twi: 6:26 Sunrise: 7:07 Sunset: 15:18 Twi: 16:00 Moonrise: 4:38 Moonset: 14:38 Day length: 8h 11m	21 Twi: 6:27 Sunrise: 7:09 Sunset: 15:17 Twi: 15:59 Moonrise: 5:49 Moonset: 15:09 Day length: 8h 8m	22 ● Twi: 6:29 Sunrise: 7:11 Sunset: 15:16 Twi: 15:57 Moonrise: 6:58 Moonset: 15:48 New Moon: 7:33 Day length: 8h 5m
23 Twi: 6:31 Sunrise: 7:13 Sunset: 15:14 Twi: 15:56 Moonrise: 8:04 Moonset: 16:35 Day length: 8h 2m	24 Twi: 6:32 Sunrise: 7:14 Sunset: 15:13 Twi: 15:55 Moonrise: 9:03 Moonset: 17:33 Day length: 7h 59m	25 Twi: 6:34 Sunrise: 7:16 Sunset: 15:12 Twi: 15:54 Moonrise: 9:53 Moonset: 18:40 Day length: 7h 56m	26 Twi: 6:35 Sunrise: 7:18 Sunset: 15:11 Twi: 15:53 Moonrise: 10:35 Moonset: 19:54 Day length: 7h 53m	27 Twi: 6:37 Sunrise: 7:20 Sunset: 15:10 Twi: 15:52 Moonrise: 11:10 Moonset: 21:12 Day length: 7h 50m	28 Twi: 6:39 Sunrise: 7:21 Sunset: 15:09 Twi: 15:51 Moonrise: 11:40 Moonset: 22:31 Day length: 7h 47m	29 ◐ Twi: 6:40 Sunrise: 7:23 Sunset: 15:08 Twi: 15:51 Moonrise: 12:07 Moonset: 23:50 First Qtr: 5:07 Day length: 7h 44m

Light Pollution Monitoring Data Format 1.0
URL: http://www.darksky.org/measurements
Number of header lines: 35+
This data is released under the following license: ODbL 1.0 http://opendatacommons.org/licenses/odbl/summary/
Device type: SQM-LU-DL
Instrument ID: TSMC_SQM
Data supplier: TSMC
Location name: Schefferville - Howse Project
Position (lat, lon, elev(m)): 54.799999, -66.833336, 549
Local timezone: America/Montreal
Time Synchronization:
Moving / Stationary position: STATIONARY
Moving / Fixed look direction: FIXED
Number of channels: 1
Filters per channel: HOYA CM-500
Measurement direction per channel: up - zenith
Field of view (degrees): 20
Number of fields per line: 5
SQM serial number: 2913
SQM firmware version: 4-6-32
SQM cover offset value:
SQM readout test ix: i,00000004,00000006,00000032,00002913
SQM readout test rx: r, 08.68m,0000030377Hz,0000000000c,0000000.000s, 004.5C
SQM readout test cx: c,00000019.88m,0000124.363s, 020.3C,00000008.71m, 020.9C
Comment: SQM purchased by AECOM on behlaf of TSMC
Comment: For HOWSE Env Impact Statement
Comment: November 2014
Comment:
Comment:
UDM version: 1.0.0.40
UDM setting: DL Retrieve All
blank line 32
UTC Date & Time, Local Date & Time, Temperature, Voltage, MSAS
YYYY-MM-DDTHH:mm:ss.fff YYYY-MM-DDTHH:mm:ss.fff Celsius Volts mag/arcsec^2
END OF HEADER

Dark point on Goodwood Rd.	**55° 00.7121' N**	**067° 14.7040' W**	**648 m**	**Prise avec Smartphone app**
	55° 00' 43.0" N	**067° 14' 41.6" W**	**651 m**	**Prise avec GPS Garmin**
	55.0118683°	**-067.2450667°**		**Conversion for use in Google Map**

# YYYY-MM-DDTHH:mm:ss.fff	YYYY-MM-DDTHH:mm:ss.fff	Celsius	Volts	mag/arcsec^2	
2014-11-27 at 20:39:08	2014-11-27 at 15:39:08	6.7	4.88	10.92	Dark spot
2014-11-27 at 20:44:08	2014-11-27 at 15:44:08	4.8	4.88	11.78	
2014-11-27 at 20:49:08	2014-11-27 at 15:49:08	1.6	4.88	12.66	
2014-11-27 at 20:54:08	2014-11-27 at 15:54:08	-1.7	4.88	13.53	Twilight 15:52
2014-11-27 at 20:59:08	2014-11-27 at 15:59:08	-4.6	4.88	14.38	
2014-11-27 at 21:04:08	2014-11-27 at 16:04:08	-7.1	4.88	15.15	
2014-11-27 at 21:09:08	2014-11-27 at 16:09:08	-9.4	4.88	15.91	
2014-11-27 at 21:14:08	2014-11-27 at 16:14:08	-11.3	4.88	16.66	
2014-11-27 at 21:19:08	2014-11-27 at 16:19:08	-12.9	4.88	17.29	
2014-11-27 at 21:24:07	2014-11-27 at 16:24:07	-14.2	4.88	17.9	
2014-11-27 at 21:29:07	2014-11-27 at 16:29:07	-15.5	4.88	18.47	
2014-11-27 at 21:34:07	2014-11-27 at 16:34:07	-16.5	4.88	18.91	
2014-11-27 at 21:39:07	2014-11-27 at 16:39:07	-17.5	4.88	19.31	
2014-11-27 at 21:44:07	2014-11-27 at 16:44:07	-18.1	4.88	19.6	
2014-11-27 at 21:49:07	2014-11-27 at 16:49:07	-18.7	4.88	19.94	
2014-11-27 at 21:54:07	2014-11-27 at 16:54:07	-19.1	4.88	20.2	
2014-11-27 at 21:59:07	2014-11-27 at 16:59:07	-19.4	4.88	20.19	
2014-11-27 at 22:04:07	2014-11-27 at 17:04:07	-19.7	4.88	20.14	
2014-11-27 at 22:09:07	2014-11-27 at 17:09:07	-19.7	4.88	19.7	
2014-11-27 at 22:14:07	2014-11-27 at 17:14:07	-19.7	4.88	19.9	
2014-11-27 at 22:19:07	2014-11-27 at 17:19:07	-19.7	4.88	20.13	
2014-11-27 at 22:24:07	2014-11-27 at 17:24:07	-19.7	4.88	19.38	Twilight 15:52 + 1.5 hours
2014-11-27 at 22:29:07	2014-11-27 at 17:29:07	-19.4	4.88	19.51	
2014-11-27 at 22:34:07	2014-11-27 at 17:34:07	-19.1	4.88	20.04	
2014-11-27 at 22:39:07	2014-11-27 at 17:39:07	-19.1	4.88	19.71	
2014-11-27 at 22:44:07	2014-11-27 at 17:44:07	-19.1	4.88	19.73	
2014-11-27 at 22:49:07	2014-11-27 at 17:49:07	-18.7	4.88	20.12	
2014-11-27 at 22:54:07	2014-11-27 at 17:54:07	-18.7	4.88	20.25	
2014-11-27 at 22:59:08	2014-11-27 at 17:59:08	-19.1	4.88	20.35	
2014-11-27 at 23:04:07	2014-11-27 at 18:04:07	-19.1	4.88	20.33	

2014-11-27 at 23:09:07	2014-11-27 at 18:09:07	-19.4	4.88	20.08	
2014-11-27 at 23:14:07	2014-11-27 at 18:14:07	-19.4	4.88	20.07	
2014-11-27 at 23:19:07	2014-11-27 at 18:19:07	-19.7	4.88	20.02	
2014-11-27 at 23:24:07	2014-11-27 at 18:24:07	-19.7	4.88	19.68	
2014-11-27 at 23:29:08	2014-11-27 at 18:29:08	-19.7	4.88	19.51	
2014-11-27 at 23:34:07	2014-11-27 at 18:34:07	-19.4	4.88	19.77	
2014-11-27 at 23:39:07	2014-11-27 at 18:39:07	-19.4	4.88	19.94	
2014-11-27 at 23:44:07	2014-11-27 at 18:44:07	-19.1	4.88	20.17	
2014-11-27 at 23:49:07	2014-11-27 at 18:49:07	-19.1	4.88	20.23	
2014-11-27 at 23:54:07	2014-11-27 at 18:54:07	-19.4	4.88	20.16	
2014-11-27 at 23:59:08	2014-11-27 at 18:59:08	-19.4	4.88	20.2	
2014-11-28 at 00:04:07	2014-11-27 at 19:04:07	-19.4	4.88	20.37	
2014-11-28 at 00:09:07	2014-11-27 at 19:09:07	-19.7	4.88	20.33	
2014-11-28 at 00:14:07	2014-11-27 at 19:14:07	-19.7	4.88	20.19	
2014-11-28 at 00:19:07	2014-11-27 at 19:19:07	-20	4.88	20.04	
2014-11-28 at 00:24:08	2014-11-27 at 19:24:08	-20	4.88	19.88	
2014-11-28 at 00:29:07	2014-11-27 at 19:29:07	-20	4.88	19.95	
2014-11-28 at 00:34:08	2014-11-27 at 19:34:08	-19.7	4.88	20.51	
2014-11-28 at 00:39:07	2014-11-27 at 19:39:07	-19.7	4.88	20.36	
2014-11-28 at 00:44:08	2014-11-27 at 19:44:08	-20	4.88	20.33	
2014-11-28 at 00:49:07	2014-11-27 at 19:49:07	-20	4.88	20.03	
2014-11-28 at 00:54:07	2014-11-27 at 19:54:07	-19.7	4.88	19.99	
2014-11-28 at 00:59:07	2014-11-27 at 19:59:07	-19.7	4.88	19.73	
2014-11-28 at 01:04:07	2014-11-27 at 20:04:07	-19.7	4.88	20.07	
2014-11-28 at 01:09:07	2014-11-27 at 20:09:07	-19.4	4.88	20.08	
2014-11-28 at 01:14:07	2014-11-27 at 20:14:07	-19.4	4.88	20.07	
2014-11-28 at 01:19:07	2014-11-27 at 20:19:07	-19.4	4.88	19.7	
2014-11-28 at 01:24:07	2014-11-27 at 20:24:07	-19.4	4.88	20.09	
2014-11-28 at 01:29:07	2014-11-27 at 20:29:07	-19.4	4.88	19.87	
2014-11-28 at 01:34:17	2014-11-27 at 20:34:17	-19.1	4.88	20.07	
2014-11-28 at 01:39:07	2014-11-27 at 20:39:07	-19.1	4.88	20.43	
2014-11-28 at 01:44:07	2014-11-27 at 20:44:07	-19.1	4.88	20.31	
2014-11-28 at 01:49:07	2014-11-27 at 20:49:07	-19.1	4.88	19.72	
2014-11-28 at 01:54:07	2014-11-27 at 20:54:07	-19.1	4.88	20.4	
2014-11-28 at 01:59:08	2014-11-27 at 20:59:08	-19.1	4.88	20.5	
2014-11-28 at 02:04:07	2014-11-27 at 21:04:07	-19.1	4.88	20.41	
2014-11-28 at 02:09:08	2014-11-27 at 21:09:08	-19.4	4.88	20.44	
2014-11-28 at 02:14:07	2014-11-27 at 21:14:07	-19.4	4.88	20.08	Moonset 21:12
2014-11-28 at 02:19:07	2014-11-27 at 21:19:07	-19.4	4.88	20.35	
2014-11-28 at 02:24:08	2014-11-27 at 21:24:08	-19.1	4.88	20.41	
2014-11-28 at 02:29:07	2014-11-27 at 21:29:07	-19.4	4.88	20.41	
2014-11-28 at 02:34:07	2014-11-27 at 21:34:07	-19.1	4.88	20.23	
2014-11-28 at 02:39:07	2014-11-27 at 21:39:07	-19.4	4.88	20.11	
2014-11-28 at 02:44:07	2014-11-27 at 21:44:07	-19.4	4.88	20.19	
2014-11-28 at 02:49:08	2014-11-27 at 21:49:08	-19.1	4.88	20.19	
2014-11-28 at 02:54:08	2014-11-27 at 21:54:08	-19.1	4.88	20.1	
2014-11-28 at 02:59:07	2014-11-27 at 21:59:07	-19.1	4.88	20.16	
2014-11-28 at 03:04:07	2014-11-27 at 22:04:07	-19.1	4.88	20.15	
2014-11-28 at 03:09:07	2014-11-27 at 22:09:07	-19.1	4.88	20.29	
2014-11-28 at 03:14:07	2014-11-27 at 22:14:07	-19.1	4.88	20.34	
2014-11-28 at 03:19:07	2014-11-27 at 22:19:07	-19.1	4.88	20.28	
2014-11-28 at 03:24:07	2014-11-27 at 22:24:07	-19.1	4.88	20.14	
2014-11-28 at 03:29:07	2014-11-27 at 22:29:07	-19.1	4.88	20.11	
2014-11-28 at 03:34:08	2014-11-27 at 22:34:08	-19.1	4.88	20.25	
2014-11-28 at 03:39:07	2014-11-27 at 22:39:07	-19.1	4.88	20.28	
2014-11-28 at 03:44:07	2014-11-27 at 22:44:07	-19.1	4.88	20.19	
2014-11-28 at 03:49:07	2014-11-27 at 22:49:07	-19.1	4.88	20.43	
2014-11-28 at 03:54:07	2014-11-27 at 22:54:07	-19.1	4.88	20.2	
2014-11-28 at 03:59:07	2014-11-27 at 22:59:07	-19.4	4.88	20.11	
2014-11-28 at 04:04:07	2014-11-27 at 23:04:07	-19.4	4.88	20.23	
2014-11-28 at 04:09:07	2014-11-27 at 23:09:07	-19.4	4.88	20.32	
2014-11-28 at 04:14:07	2014-11-27 at 23:14:07	-19.4	4.88	20.23	
2014-11-28 at 04:19:07	2014-11-27 at 23:19:07	-19.4	4.88	20.39	
2014-11-28 at 04:24:07	2014-11-27 at 23:24:07	-19.4	4.88	19.85	
2014-11-28 at 04:29:07	2014-11-27 at 23:29:07	-19.4	4.88	20.25	
2014-11-28 at 04:34:07	2014-11-27 at 23:34:07	-19.4	4.88	20.2	
2014-11-28 at 04:39:07	2014-11-27 at 23:39:07	-19.4	4.88	20.15	
2014-11-28 at 04:44:07	2014-11-27 at 23:44:07	-19.4	4.88	20.43	
2014-11-28 at 04:49:07	2014-11-27 at 23:49:07	-19.4	4.88	20.09	
2014-11-28 at 04:54:07	2014-11-27 at 23:54:07	-19.4	4.88	20.2	
2014-11-28 at 04:59:08	2014-11-27 at 23:59:08	-19.4	4.88	20.74	

2014-11-28 at 05:04:08	2014-11-28 at 00:04:08	-19.4	4.88	20.56	
2014-11-28 at 05:09:07	2014-11-28 at 00:09:07	-19.4	4.88	20.7	
2014-11-28 at 05:14:08	2014-11-28 at 00:14:08	-19.4	4.88	20.74	
2014-11-28 at 05:19:08	2014-11-28 at 00:19:08	-19.4	4.88	20.76	
2014-11-28 at 05:24:09	2014-11-28 at 00:24:09	-19.4	4.88	20.88	
2014-11-28 at 05:29:09	2014-11-28 at 00:29:09	-19.4	4.88	20.92	
2014-11-28 at 05:34:10	2014-11-28 at 00:34:10	-19.7	4.88	20.92	
2014-11-28 at 05:39:07	2014-11-28 at 00:39:07	-19.7	4.88	20.97	
2014-11-28 at 05:44:07	2014-11-28 at 00:44:07	-19.7	4.88	20.96	
2014-11-28 at 05:49:09	2014-11-28 at 00:49:09	-19.7	4.88	20.92	
2014-11-28 at 05:54:07	2014-11-28 at 00:54:07	-20	4.88	20.97	
2014-11-28 at 05:59:10	2014-11-28 at 00:59:10	-20	4.88	20.95	
2014-11-28 at 06:04:09	2014-11-28 at 01:04:09	-20	4.88	20.92	
2001-01-01 at 01:01:01	2000-12-31 at 20:01:01	-20	4.88	20.98	
2014-11-28 at 06:14:08	2014-11-28 at 01:14:08	-20	4.88	21.05	
2014-11-28 at 06:19:09	2014-11-28 at 01:19:09	-20	4.88	21.15	
2014-11-28 at 06:24:08	2014-11-28 at 01:24:08	-20	4.88	21.07	
2014-11-28 at 06:29:10	2014-11-28 at 01:29:10	-20.4	4.88	21.24	
2014-11-28 at 06:34:10	2014-11-28 at 01:34:10	-20.4	4.88	21.28	
2014-11-28 at 06:21:11	2014-11-28 at 01:21:11	-20.4	4.88	21.33	
2014-11-28 at 06:44:12	2014-11-28 at 01:44:12	-20.7	4.88	21.38	
2014-11-28 at 06:49:11	2014-11-28 at 01:49:11	-20.7	4.88	21.37	
2014-11-28 at 06:54:11	2014-11-28 at 01:54:11	-21	4.88	21.33	
2014-11-28 at 06:59:11	2014-11-28 at 01:59:11	-21	4.88	21.39	
2014-11-28 at 07:04:12	2014-11-28 at 02:04:12	-21.3	4.88	21.42	
2014-11-28 at 07:09:11	2014-11-28 at 02:09:11	-21.3	4.88	21.36	
2014-11-28 at 07:14:09	2014-11-28 at 02:14:09	-21.6	4.88	21.22	
2014-11-28 at 07:19:10	2014-11-28 at 02:19:10	-21.6	4.88	21.27	
2014-11-28 at 07:24:10	2014-11-28 at 02:24:10	-21.6	4.88	21.27	
2014-11-28 at 07:29:09	2014-11-28 at 02:29:09	-21.6	4.88	21.25	
2014-11-28 at 07:34:09	2014-11-28 at 02:34:09	-21.6	4.88	21.2	
2014-11-28 at 07:39:09	2014-11-28 at 02:39:09	-21.6	4.88	21.24	
2014-11-28 at 07:44:10	2014-11-28 at 02:44:10	-21.6	4.88	21.28	
2014-11-28 at 07:49:10	2014-11-28 at 02:49:10	-21.6	4.88	21.32	
2014-11-28 at 07:54:09	2014-11-28 at 02:54:09	-21.6	4.88	21.52	
2014-11-28 at 07:59:11	2014-11-28 at 02:59:11	-21.6	4.88	21.67	
2014-11-28 at 08:04:11	2014-11-28 at 03:04:11	-22	4.88	21.72	
2014-11-28 at 08:09:11	2014-11-28 at 03:09:11	-22.3	4.88	21.74	
2014-11-28 at 08:14:11	2014-11-28 at 03:14:11	-22.6	4.88	21.74	
2014-11-28 at 08:19:11	2014-11-28 at 03:19:11	-22.9	4.88	21.74	
2014-11-28 at 08:24:11	2014-11-28 at 03:24:11	-23.3	4.88	21.74	
2014-11-28 at 08:29:11	2014-11-28 at 03:29:11	-23.6	4.88	21.74	
2014-11-28 at 08:34:10	2014-11-28 at 03:34:10	-24.2	4.88	21.74	
2014-11-28 at 08:39:10	2014-11-28 at 03:39:10	-24.5	4.88	21.74	
2014-11-28 at 08:44:10	2014-11-28 at 03:44:10	-24.9	4.88	21.72	
2014-11-28 at 08:49:14	2014-11-28 at 03:49:14	-24.9	4.88	21.66	
2014-11-28 at 08:54:12	2014-11-28 at 03:54:12	-24.9	4.88	21.57	
2014-11-28 at 08:59:12	2014-11-28 at 03:59:12	-24.9	4.88	21.57	
2014-11-28 at 09:04:11	2014-11-28 at 04:04:11	-24.5	4.88	21.51	
2014-11-28 at 09:09:13	2014-11-28 at 04:09:13	-24.5	4.88	21.57	
2014-11-28 at 09:14:12	2014-11-28 at 04:14:12	-24.2	4.88	21.53	
2014-11-28 at 09:19:11	2014-11-28 at 04:19:11	-23.9	4.88	21.45	
2014-11-28 at 09:24:11	2014-11-28 at 04:24:11	-23.6	4.88	21.47	
2014-11-28 at 09:29:11	2014-11-28 at 04:29:11	-23.6	4.88	21.42	
2014-11-28 at 09:34:11	2014-11-28 at 04:34:11	-23.3	4.88	21.39	
2014-11-28 at 09:39:12	2014-11-28 at 04:39:12	-22.9	4.88	21.47	
2014-11-28 at 09:44:12	2014-11-28 at 04:44:12	-22.6	4.88	21.51	
2014-11-28 at 09:49:13	2014-11-28 at 04:49:13	-22.3	4.88	21.49	
2014-11-28 at 09:54:10	2014-11-28 at 04:54:10	-22.3	4.88	21.35	
2014-11-28 at 09:59:12	2014-11-28 at 04:59:12	-22	4.88	21.46	
2014-11-28 at 10:04:12	2014-11-28 at 05:04:12	-22	4.88	21.47	
2014-11-28 at 10:09:12	2014-11-28 at 05:09:12	-22	4.88	21.46	Twilight 6:39 - 1.5 hours
2014-11-28 at 10:14:12	2014-11-28 at 05:14:12	-22	4.88	21.44	
2014-11-28 at 10:19:12	2014-11-28 at 05:19:12	-21.6	4.88	21.43	
2014-11-28 at 10:24:11	2014-11-28 at 05:24:11	-21.6	4.88	21.35	
2014-11-28 at 10:29:10	2014-11-28 at 05:29:10	-21.6	4.88	21.33	
2014-11-28 at 10:34:09	2014-11-28 at 05:34:09	-21.6	4.88	21.16	
2014-11-28 at 10:39:09	2014-11-28 at 05:39:09	-21.6	4.88	20.95	
2014-11-28 at 10:44:07	2014-11-28 at 05:44:07	-21.6	4.88	20.69	
2014-11-28 at 10:49:07	2014-11-28 at 05:49:07	-21.6	4.88	20.28	
2014-11-28 at 10:54:07	2014-11-28 at 05:54:07	-21.6	4.88	19.83	

2014-11-28 at 10:59:07	2014-11-28 at 05:59:07	-21.6	4.88	19.28	
2014-11-28 at 11:04:07	2014-11-28 at 06:04:07	-21.6	4.88	18.71	
2014-11-28 at 11:09:07	2014-11-28 at 06:09:07	-21.6	4.88	18.05	
2014-11-28 at 11:14:07	2014-11-28 at 06:14:07	-22	4.88	17.38	
2014-11-28 at 11:19:07	2014-11-28 at 06:19:07	-22	4.88	16.66	
2014-11-28 at 11:24:07	2014-11-28 at 06:24:07	-22.3	4.88	15.92	
2014-11-28 at 11:29:07	2014-11-28 at 06:29:07	-22.3	4.88	15.16	
2014-11-28 at 11:34:07	2014-11-28 at 06:34:07	-22.3	4.88	14.38	
2014-11-28 at 11:39:07	2014-11-28 at 06:39:07	-22.3	4.88	13.58	Twilight 6:39
2014-11-28 at 11:44:07	2014-11-28 at 06:44:07	-22.3	4.88	12.76	
2014-11-28 at 11:49:07	2014-11-28 at 06:49:07	-22.6	4.88	11.92	
2014-11-28 at 11:54:07	2014-11-28 at 06:54:07	-22.6	4.88	11.12	
2014-11-28 at 11:59:07	2014-11-28 at 06:59:07	-22.9	4.88	10.35	
2014-11-28 at 12:04:07	2014-11-28 at 07:04:07	-22.9	4.88	9.63	
2014-11-28 at 12:09:07	2014-11-28 at 07:09:07	-22.9	4.88	9.01	
2014-11-28 at 12:14:07	2014-11-28 at 07:14:07	-22.9	4.88	8.46	
2014-11-28 at 12:19:07	2014-11-28 at 07:19:07	-22.6	4.88	7.99	Sunrise 7:21
2014-11-28 at 12:24:07	2014-11-28 at 07:24:07	-22.9	4.88	7.57	
2014-11-28 at 12:29:07	2014-11-28 at 07:29:07	-22.9	4.88	7.22	
2014-11-28 at 12:34:07	2014-11-28 at 07:34:07	-22.6	4.88	6.91	
2014-11-28 at 12:39:07	2014-11-28 at 07:39:07	-22.6	4.88	6.64	
2014-11-28 at 12:44:07	2014-11-28 at 07:44:07	-22.6	4.88	6.44	
2014-11-28 at 12:49:07	2014-11-28 at 07:49:07	-22.9	4.88	6.24	
2014-11-28 at 12:54:07	2014-11-28 at 07:54:07	-22.6	4.88	6.06	
2014-11-28 at 12:59:07	2014-11-28 at 07:59:07	-22.9	4.88	5.92	
2014-11-28 at 13:04:07	2014-11-28 at 08:04:07	-22.6	4.88	0	
2014-11-28 at 13:09:07	2014-11-28 at 08:09:07	-22.9	4.88	0	
2014-11-28 at 13:14:07	2014-11-28 at 08:14:07	-22.6	4.88	0	
2014-11-28 at 13:19:07	2014-11-28 at 08:19:07	-22.3	4.88	0	
2014-11-28 at 13:24:07	2014-11-28 at 08:24:07	-22.6	4.88	0	
2014-11-28 at 13:29:07	2014-11-28 at 08:29:07	-22.3	4.88	0	
2014-11-28 at 13:34:07	2014-11-28 at 08:34:07	-22	4.88	0	
2014-11-28 at 13:39:07	2014-11-28 at 08:39:07	-22.3	4.88	0	
2014-11-28 at 13:44:07	2014-11-28 at 08:44:07	-22.6	4.88	0	
2014-11-28 at 13:49:07	2014-11-28 at 08:49:07	-22	4.88	0	
2014-11-28 at 13:54:07	2014-11-28 at 08:54:07	-22	4.88	0	
2014-11-28 at 13:59:07	2014-11-28 at 08:59:07	-22	4.88	0	
2014-11-28 at 14:04:07	2014-11-28 at 09:04:07	-21.6	4.88	0	
2014-11-28 at 14:09:07	2014-11-28 at 09:09:07	-21	4.88	0	
2014-11-28 at 14:14:07	2014-11-28 at 09:14:07	-21.3	4.88	0	
2014-11-28 at 14:19:07	2014-11-28 at 09:19:07	-21.3	4.88	0	
2014-11-28 at 14:24:08	2014-11-28 at 09:24:08	-21	4.88	0	
2014-11-28 at 14:29:07	2014-11-28 at 09:29:07	-21.3	4.88	0	
2014-11-28 at 14:34:07	2014-11-28 at 09:34:07	-21.3	4.88	0	
2014-11-28 at 14:39:07	2014-11-28 at 09:39:07	-20.7	4.88	11.34	Back in the truck
2014-11-28 at 14:44:07	2014-11-28 at 09:44:07	-17.8	4.88	11.64	
2014-11-28 at 14:49:08	2014-11-28 at 09:49:08	-13.3	4.88	11.39	
2014-11-28 at 14:54:08	2014-11-28 at 09:54:08	-9.4	4.88	11.59	
2014-11-28 at 14:59:08	2014-11-28 at 09:59:08	-5.9	4.88	11.61	
2014-11-28 at 15:04:08	2014-11-28 at 10:04:08	-3	4.88	11.4	
2014-11-28 at 15:09:08	2014-11-28 at 10:09:08	-0.4	4.88	11.59	
2014-11-28 at 15:14:08	2014-11-28 at 10:14:08	1.2	4.88	10.52	
2014-11-28 at 15:19:08	2014-11-28 at 10:19:08	2.5	4.88	0	
2014-11-28 at 15:24:08	2014-11-28 at 10:24:08	3.2	4.88	6.75	
2014-11-28 at 15:27:41	2014-11-28 at 10:27:41	4.5	5.04	8.64	

SCHEFFERVILLE AT NIGHT 26-NOV-14

UNIMEDRON SKY QUALITY METER (GENERIC IMAGE)

SQM AT DARK POINT ON ol GOODWOOD RD. – 27/NOV/14

NIGHT PICTURE FROM HOUSE LOOKING TOWARDS MAIN PLANT – 26/NOV/14

HPP-RM-20141023

A14-08392

Acid-Base Accounting and Toxicity Characterization Leach Procedure Report

Prepared for: Tata Steel

Prepared by: Activation Laboratories Ltd.

A total of 52 samples were submitted in batches of 43 and 9 samples for Acid Base Accounting (modified Sobek) and Toxicity Characterization Leach Procedure (EPA 1311) for inorganic analytes.

Results of Acid-Base Accounting

Paste pH, measured in a mixture of deionized water and pulverized samples, ranged from 5.7 to 8.5. 62% of the samples prior to analysis are acidic, with a paste pH less than 7.0.

Classical acid-base accounting is based on the use of total sulphur to estimate acid generating potential (AP), results which ranged from below detection, <0.01% to 0.06%. Potential acidity for the samples is very low according to low total S concentrations.

Modified Sobek Neutralization Potential (NP) ranged from -1 kg CaCO3 equivalent/tonne to a maximum of 17 kg/t, with mean and median values of 0.8 and 0.2 kg/t.

The Acid Potential (AP) ranged from 0 to 2 kg CaCO3 equivalent/tonne, with mean and median values of 0.4 and 0.1 kg/t.

The Net Neutralization Potential (NNP) ranged from -2.6 to 15.6, and samples can be classified according to the following (ASTM E1915):

Table 1: Classifications

Classification	Specifications
Highly Acidic	NNP ≤ -10
Acidic	-10 < NNP ≤ -2
Slightly Acidic	-2 < NNP ≤ -0.2
Neutral	-0.2 < NNP ≤ 0.2 and AP ≤ -0.2 or NP ≥ 0.2
Inert	-0.2 < NNP ≤ 0.2 and AP > -0.2 or NP < 0.2
Slightly Basic	0.2 ≥ NNP < 2.0
Basic	2.0 ≥ NNP < 10
Highly Basic	NNP ≥ 10

Table 2: Sample Classification

Sample ID	Classification
HW-DD14-19 34.5 - 36	Basic
HW-DD14-19 52.5 - 54	Slightly Basic
HW-DD14-19 70.5 - 72	Neutral
HW-DD14-21 157.5 - 159	Slightly Basic
HW-DD14-23 69.41 - 69.52	Slightly Basic
HW-DD14-24 53.8 - 53.94	Slightly Basic
HW-DD14-24 81 - 82.5	Slightly Acidic
HW-DD14-25 30.6 - 30.76	Inert
HW-DD14-25 78.8 - 79	Slightly Acidic
HW-DD14-25 81.9 - 82	Slightly Basic
HW-DD14-26 43.8 - 43.96	Acidic
HW-DD14-26 57.1 - 57.24	Slightly Acidic
HW-DD14-27B 114.2 - 114.33	Slightly Basic
HW-DD14-28 35.28 - 35.4	Slightly Acidic
HW-DD14-28 67.5 - 67.64	Neutral
HW-DD14-29 12 - 13.5	Slightly Basic
HW-DD14-29 22.5 - 24	Neutral
HW-DD14-29 35.5 - 36	Slightly Basic
HW-DD14-29 45 - 46.5	Slightly Acidic
HW-DD14-29 69 - 70.5	Inert
HW-DD14-29 81 - 82.5	Slightly Acidic
HW-DD14-29 84 - 85.5	Slightly Acidic
HW-DD14-29 106.5 - 107	Slightly Acidic
HW-DD14-29 118.5 - 120	Slightly Basic
HW-DD14-30 31.6 - 31.71	Slightly Acidic
HW-DD14-30 50.2 - 50.32	Acidic
HW-DD14-31 15 - 16.6	Basic

Sample ID	Classification
HW-DD14-31 28.5 - 30	Slightly Acidic
HW-DD14-31 66 - 67.5	Slightly Basic
HW-DD14-31 70.5 - 72	Slightly Acidic
HW-DD14-31 109.5 - 111	Slightly Acidic
HW-DD14-32 52.5 - 54	Slightly Acidic
HW-DD14-32 84 - 85.5	Inert
HW-DD14-33 33 - 34.5	Inert
HW-DD14-33 48 - 49.5	Slightly Acidic
HW-DD14-34 18.3 - 18.46	Highly Basic
HW-DD14-34 64.5 - 64.67	Slightly Basic
HW-DD14-34 96.2 - 96.37	Inert
HW-DD14-35 31.13 - 31.29	Basic
HW-DD14-35 45.21 - 45.36	Inert
HW-DD14-35 69 - 69.16	Slightly Acidic
HW-DD14-35 90.77 - 90.99	Slightly Basic
HW-DD14-35 94 - 94.14	Inert
1345228 (1)	Inert
236522	Slightly Acidic
236537	Slightly Basic
236561	Slightly Basic
1329983	Inert
1330762+1330763	Slightly Basic
1330786+1330787	Slightly Basic
1345437	Slightly Acidic
1345306	Inert

Figure 1: Paste pH vs. Modified Sobek neutralization Potential

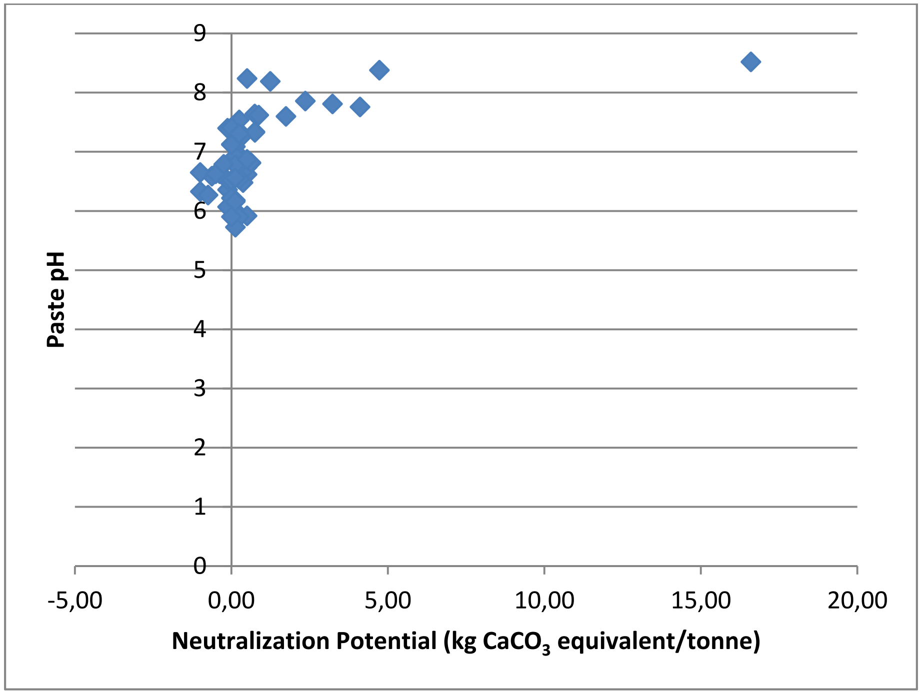


Figure 2 HCl-leachable sulphate vs total sulphur:

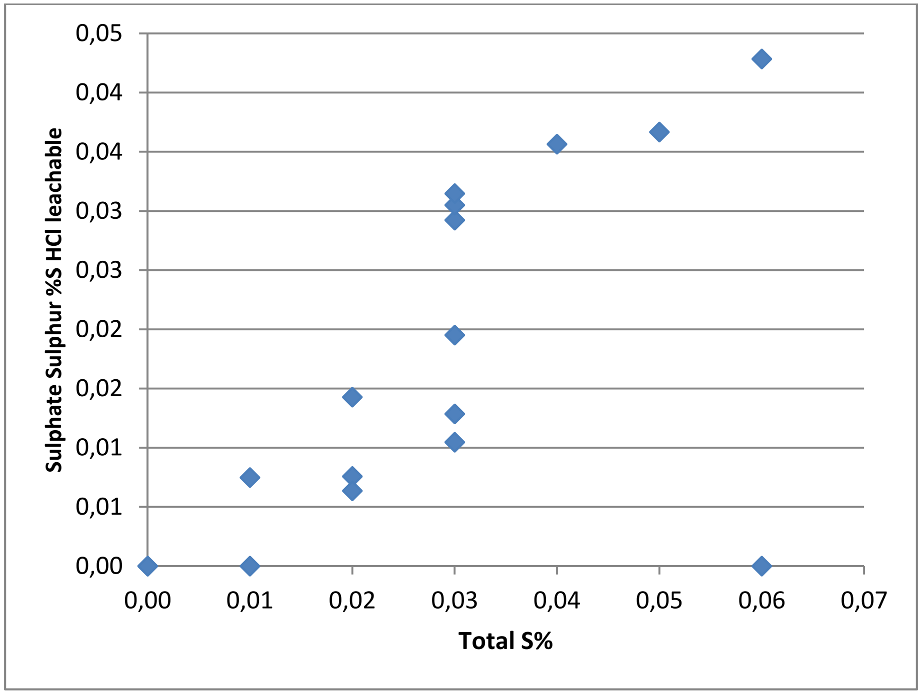


Table 3:

Acid-base accounting sample results (pH > 7 highlighted in green, pH<7 highlighted in red)

Analyte Symbol	AP	NNP	NP		Fizz Rating	Volume HCl	Volume NaOH
Analyte Name	Acid Potential	Net Neutralization Potential	Neutralization Potential	Paste pH		0.10 N	0.50 N
						(mL)	(mL)
Unit Symbol	kg CaCO3/t	no units	kg CaCO3/t	no units			
Total Samples				43			
Acidic Count				25			
% samples acidic				58%			
min	0	-2.620	-1.0	5.9			
max	2	15.600	16.6	8.5			
mean	0.4	0.467	0.9	7.0			
median	0.0	-0.063	0.2	6.8			
HW-DD14-19 34.5 - 36	0.625	4.1	4.73	8.38	None	4.40	0.50
HW-DD14-19 52.5 - 54	0	1.24	1.24	8.19	None	3.50	0.60
HW-DD14-19 70.5 - 72	0.625	0.121	0.746	7.64	None	2.30	0.40
HW-DD14-21 157.5 - 159	0	0.498	0.498	8.24	None	3.20	0.60
HW-DD14-23 69.41 - 69.52	0	1.74	1.74	7.60	None	3.20	0.50
HW-DD14-24 53.8 - 53.94	0	0.249	0.249	7.54	None	2.60	0.50
HW-DD14-24 81 - 82.5	0.938	-0.813	0.125	6.81	None	2.30	0.45
HW-DD14-25 30.6 - 30.76	0	-0.124	-0.124	7.40	None	2.20	0.45
HW-DD14-25 78.8 - 79	0.313	-0.437	-0.124	6.36	None	3.20	0.65
HW-DD14-25 81.9 - 82	0	0.498	0.498	6.62	None	3.20	0.60
HW-DD14-26 43.8 - 43.96	1.56	-2.19	-0.623	6.59	None	3.00	0.65
HW-DD14-26 57.1 - 57.24	0.938	-1.06	-0.125	6.52	None	3.20	0.65
HW-DD14-27B 114.2 - 114.33	0	0.374	0.374	6.48	None	2.40	0.45
HW-DD14-28 35.28 - 35.4	0.938	-0.813	0.125	7.09	None	1.80	0.35

Analyte Symbol	AP	NNP	NP		Fizz Rating	Volume HCl	Volume NaOH
Analyte Name	Acid Potential	Net Neutralization Potential	Neutralization Potential	Paste pH		0.10 N	0.50 N
						(mL)	(mL)
Unit Symbol	kg CaCO3/t	no units	kg CaCO3/t	no units			
Total Samples				43			
Acidic Count				25			
% samples acidic				58%			
min	0	-2.620	-1.0	5.9			
max	2	15.600	16.6	8.5			
mean	0.4	0.467	0.9	7.0			
median	0.0	-0.063	0.2	6.8			
HW-DD14-28 67.5 - 67.64	0.313	-0.063	0.25	5.94	None	5.10	1.00
HW-DD14-29 12 - 13.5	0.625	1.74	2.36	7.86	None	8.70	1.55
HW-DD14-29 22.5 - 24	0.938	-0.189	0.749	7.34	None	1.80	0.30
HW-DD14-29 35.5 - 36	0	0.249	0.249	6.94	None	2.10	0.40
HW-DD14-29 45 - 46.5	0	-0.999	-0.999	6.65	None	2.10	0.50
HW-DD14-29 69 - 70.5	0.313	-0.188	0.124	6.18	None	3.80	0.75
HW-DD14-29 81 - 82.5	1.25	-0.627	0.623	6.81	None	2.50	0.45
HW-DD14-29 84 - 85.5	0	-0.995	-0.995	6.33	None	2.60	0.60
HW-DD14-29 106.5 - 107	0.938	-0.688	0.249	6.54	None	2.60	0.50
HW-DD14-29 118.5 - 120	0	0.498	0.498	6.74	None	2.20	0.40
HW-DD14-30 31.6 - 31.71	0.938	-0.938	0	7.13	None	2.50	0.50
HW-DD14-30 50.2 - 50.32	1.88	-2.62	-0.747	6.27	None	2.70	0.60
HW-DD14-31 15 - 16.6	0.625	3.49	4.11	7.76	None	10.40	1.75
HW-DD14-31 28.5 - 30	0.625	-0.251	0.374	7.28	None	1.90	0.35
HW-DD14-31 66 - 67.5	0	0.748	0.748	7.33	None	1.80	0.30
HW-DD14-31 70.5 - 72	0.938	-0.563	0.374	6.84	None	1.90	0.35
HW-DD14-31 109.5 - 111	0	-0.374	-0.374	6.63	None	2.10	0.45
HW-DD14-32 52.5 - 54	0.625	-1.12	-0.5	6.63	None	2.80	0.60

Analyte Symbol	AP	NNP	NP		Fizz Rating	Volume HCl	Volume NaOH
Analyte Name	Acid Potential	Net Neutralization Potential	Neutralization Potential	Paste pH		0.10 N	0.50 N
						(mL)	(mL)
Unit Symbol	kg CaCO3/t	no units	kg CaCO3/t	no units			
Total Samples				43			
Acidic Count				25			
% samples acidic				58%			
min	0	-2.620	-1.0	5.9			
max	2	15.600	16.6	8.5			
mean	0.4	0.467	0.9	7.0			
median	0.0	-0.063	0.2	6.8			
HW-DD14-32 84 - 85.5	0	0.125	0.125	6.93	None	1.80	0.35
HW-DD14-33 33 - 34.5	0	0	0	7.41	None	2.00	0.40
HW-DD14-33 48 - 49.5	0.625	-0.501	0.124	6.78	None	2.30	0.45
HW-DD14-34 18.3 - 18.46	0.938	15.6	16.6	8.52	None	13.40	1.35
HW-DD14-34 64.5 - 64.67	0	0.623	0.623	6.82	None	1.50	0.25
HW-DD14-34 96.2 - 96.37	0	-0.125	-0.125	6.07	None	5.70	1.15
HW-DD14-35 31.13 - 31.29	0	3.23	3.23	7.81	None	8.80	1.50
HW-DD14-35 45.21 - 45.36	0	0	0	6.52	None	2.00	0.40
HW-DD14-35 69 - 69.16	0	-0.249	-0.249	6.79	None	1.90	0.40
HW-DD14-35 90.77 - 90.99	0	0.871	0.871	7.62	None	5.60	1.05
HW-DD14-35 94 - 94.14	0	0	0	6.22	None	5.00	1.00
1345228	0.25	-0.13	0.12	6.16	None	1.30	0.25
236522	0.66	-0.66	0.00	7.12	None	1.50	0.30
236537	0.19	0.31	0.50	6.87	None	1.20	0.20
236561	0.00	0.25	0.25	7.31	None	1.60	0.30
1329983	0.13	0.00	0.12	6.56	None	1.30	0.25
1330762+1330763	0.00	0.50	0.50	5.92	None	1.20	0.20
1330786+1330787	0.00	0.25	0.25	5.90	None	1.60	0.30

Analyte Symbol	AP	NNP	NP		Fizz Rating	Volume HCl	Volume NaOH
Analyte Name	Acid Potential	Net Neutralization Potential	Neutralization Potential	Paste pH		0.10 N	0.50 N
						(mL)	(mL)
Unit Symbol	kg CaCO3/t	no units	kg CaCO3/t	no units			
Total Samples				43			
Acidic Count				25			
% samples acidic				58%			
min	0	-2.620	-1.0	5.9			
max	2	15.600	16.6	8.5			
mean	0.4	0.467	0.9	7.0			
median	0.0	-0.063	0.2	6.8			
1345437	0.44	-0.31	0.12	5.73	None	1.30	0.25
1345306	0.00	0.00	0.00	5.90	None	3.00	0.60

Sulphur Speciation

Both total sulphur and acid soluble sulphate sulphur using HCl leach were performed with the following results.

There are very low concentrations of total sulphur, reporting limit is 0.01%, estimated error at this limit is ± 100%.

Table 4: Sulphur Speciation results

Analyte Symbol	Total S	S-SO4(HCl)
Analyte Name	Total Sulphur	Acid Soluble S
Unit Symbol	%	
HW-DD14-19 34.5 - 36	0.02	< 0.01
HW-DD14-19 52.5 - 54	< 0.01	< 0.01

Analyte Symbol	Total S	S-SO4(HCl)
Analyte Name	Total Sulphur	Acid Soluble S
Unit Symbol	%	
HW-DD14-19 70.5 - 72	0.02	0.01
HW-DD14-21 157.5 - 159	< 0.01	< 0.01
HW-DD14-23 69.41 - 69.52	< 0.01	0.01
HW-DD14-24 53.8 - 53.94	< 0.01	< 0.01
HW-DD14-24 81 - 82.5	0.03	0.03
HW-DD14-25 30.6 - 30.76	< 0.01	< 0.01
HW-DD14-25 78.8 - 79	0.01	0.01
HW-DD14-25 81.9 - 82	< 0.01	0.01
HW-DD14-26 43.8 - 43.96	0.05	0.04
HW-DD14-26 57.1 - 57.24	0.03	< 0.01
HW-DD14-27B 114.2 - 114.33	< 0.01	< 0.01
HW-DD14-28 35.28 - 35.4	0.03	0.03
HW-DD14-28 67.5 - 67.64	0.01	< 0.01
HW-DD14-29 12 - 13.5	0.02	< 0.01
HW-DD14-29 22.5 - 24	0.03	0.03
HW-DD14-29 35.5 - 36	< 0.01	< 0.01
HW-DD14-29 45 - 46.5	< 0.01	0.02
HW-DD14-29 69 - 70.5	0.01	< 0.01
HW-DD14-29 81 - 82.5	0.04	0.04
HW-DD14-29 84 - 85.5	< 0.01	< 0.01
HW-DD14-29 106.5 - 107	0.03	0.01
HW-DD14-29 118.5 - 120	< 0.01	< 0.01
HW-DD14-30 31.6 - 31.71	0.03	< 0.01
HW-DD14-30 50.2 - 50.32	0.06	0.04
HW-DD14-31 15 - 16.6	0.02	< 0.01
HW-DD14-31 28.5 - 30	0.02	0.01

Analyte Symbol	Total S	S-SO4(HCl)
Analyte Name	Total Sulphur	Acid Soluble S
Unit Symbol	%	
HW-DD14-31 66 - 67.5	< 0.01	< 0.01
HW-DD14-31 70.5 - 72	0.03	0.01
HW-DD14-31 109.5 - 111	< 0.01	< 0.01
HW-DD14-32 52.5 - 54	0.02	< 0.01
HW-DD14-32 84 - 85.5	< 0.01	< 0.01
HW-DD14-33 33 - 34.5	< 0.01	< 0.01
HW-DD14-33 48 - 49.5	0.02	0.01
HW-DD14-34 18.3 - 18.46	0.03	0.02
HW-DD14-34 64.5 - 64.67	< 0.01	0.01
HW-DD14-34 96.2 - 96.37	< 0.01	< 0.01
HW-DD14-35 31.13 - 31.29	< 0.01	< 0.01
HW-DD14-35 45.21 - 45.36	< 0.01	< 0.01
HW-DD14-35 69 - 69.16	< 0.01	< 0.01
HW-DD14-35 90.77 - 90.99	< 0.01	< 0.01
HW-DD14-35 94 - 94.14	< 0.01	< 0.01
1345228	< 0.01	< 0.01
236522	0.02	< 0.01
236537	< 0.01	< 0.01
236561	< 0.01	< 0.01
1329983	< 0.01	< 0.01
1330762+1330763	< 0.01	< 0.01
1330786+1330787	< 0.01	< 0.01
1345437	0.01	< 0.01
1345306	< 0.01	< 0.01

Results of TCLP

Table 5: TCLP Results

Analysis for Hg performed using cold-vapour AA, Fluoride, nitrite and nitrate using ion chromatography, and all other results using ICP-OES.

Estimated error at reporting limit is ± 100%.

Other than nitrate/nitrite, no significant concentrations were detected.

	Ag	As	B	Ba	Cd	Cr	Hg	Pb	Se	U	F	NO2 (as N)	NO3 (as N)
	Silver	Arsenic	Boron	Barium	Cadmium	Chromium	Mercury	Lead	Selenium	Uranium	Fluoride	Nitrite	Nitrate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ng/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
HW-DD14-19 34.5 - 36	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-19 52.5 - 54	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	10.2
HW-DD14-19 70.5 - 72	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-21 157.5 - 159	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-23 69.41 - 69.52	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-24 53.8 - 53.94	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-24 81 - 82.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-25 30.6 - 30.76	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-25 78.8 - 79	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-25 81.9 - 82	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-26 43.8 - 43.96	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-26 57.1 - 57.24	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-27B 114.2 - 114.33	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-28 35.28 - 35.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-28 67.5 - 67.64	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1

	Ag	As	B	Ba	Cd	Cr	Hg	Pb	Se	U	F	NO2 (as N)	NO3 (as N)
	Silver	Arsenic	Boron	Barium	Cadmium	Chromium	Mercury	Lead	Selenium	Uranium	Fluoride	Nitrite	Nitrate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ng/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
HW-DD14-29 12 - 13.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-29 22.5 - 24	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-29 35.5 - 36	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-29 45 - 46.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-29 69 - 70.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-29 81 - 82.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-29 84 - 85.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-29 106.5 - 107	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-29 118.5 - 120	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-30 31.6 - 31.71	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-30 50.2 - 50.32	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-31 15 - 16.6	< 0.1	< 0.1	< 0.1	0.7	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-31 28.5 - 30	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-31 66 - 67.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-31 70.5 - 72	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-31 109.5 - 111	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-32 52.5 - 54	< 0.1	< 0.1	0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-32 84 - 85.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-33 33 - 34.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-33 48 - 49.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-34 18.3 - 18.46	< 0.1	< 0.1	< 0.1	0.5	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-34 64.5 - 64.67	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-34 96.2 - 96.37	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-35 31.13 - 31.29	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-35 45.21 - 45.36	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1

	Ag	As	B	Ba	Cd	Cr	Hg	Pb	Se	U	F	NO2 (as N)	NO3 (as N)
	Silver	Arsenic	Boron	Barium	Cadmium	Chromium	Mercury	Lead	Selenium	Uranium	Fluoride	Nitrite	Nitrate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ng/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
HW-DD14-35 69 - 69.16	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	16.7
HW-DD14-35 90.77 - 90.99	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
HW-DD14-35 94 - 94.14	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
1345228	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	1.1	28.8
236522	< 0.1	< 0.1	0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	1.48	14.8
236537	< 0.1	< 0.1	0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	1.14	23.1
236561	< 0.1	< 0.1	0.1	0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	30.5
1329983	< 0.1	< 0.1	0.2	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	1.56	13.6
1330762+1330763	< 0.1	< 0.1	0.2	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	30.7
1330786+1330787	< 0.1	< 0.1	0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	< 1
1345437	< 0.1	< 0.1	0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	2.56	31.6
1345306	< 0.1	< 0.1	0.1	< 0.1	< 0.01	< 0.1	< 6	< 0.1	< 0.1	< 1	< 1	< 1	30.5

Conclusions

From the ABA analysis, the maximum acid potential result was 2 kg $CaCO_3$/t, indicating the samples are not acid generating.

From the sample classifications, 4% of the samples are acidic, 33% are slightly acidic, 6% are neutral, 19% are inert, 31% are slightly basic, 6% are basic, and 2% are highly basic.

From the TCLP analysis, other than nitrate/nitrite, no significant concentrations were detected.

GroupeHemispheres

October 3rd, 2014

Mr. Loic Didillon
Howse Minerals Limited (HML)
c/o Tata Steel Minerals Canada Ltd.
1000 Sherbrooke Street, Suite 1120
Montréal, Quebec H3A 3G4

Re: **2013-2014 HYDROLOGICAL CAMPAIGN FOR THE HOWSE PROPERTY**
Field Report for Howse Minerals Limited
Our file: PR185-18-13
Your order: HPP-LD-20140813-1

Dear Mr. Didillon,

The Howse Property Project site is located in the Province of Newfoundland and Labrador, approximately 24 km northwest of Schefferville, Quebec. Between August 2013 and September 2014, Groupe Hémisphères installed and took stream gauge measurements at four instantaneous hydrometric stations in the Howse Property Project for Howse Minerals Limited (HML), with the goal of recording the instantaneous flow of all the watercourses flowing within the project footprint. The team also visited and took stream gauge measurements at an existing hydrometric station downstream from one of these watercourses. This field report presents the methodology used to install the hydrometric stations and take the stream gauging measurements, as well as the data gathered during fieldwork.

Please feel free to contact our office if you have any comments or questions regarding this document.

1 INSTALLATION OF STATIONS AND MEASUREMENTS

1.1 Field Program Chronology

Field logistics for the different field campaigns were jointly managed by Groupe Hémisphères and HML.

The first fieldwork was conducted by Hugo Robitaille and Corey Einish, a Naskapi assistant from Kawawachikamach, from August 13 to August 31, 2013. The work included setting up the stations, measuring the flow, visiting the watershed and validating the local hydrography. A total of three hydrometric stations were installed.

A lot of rain fell in the region during the month of August, more than twice the monthly average. During the site visits, the mean daily temperature diminished gradually from +14 °C to +5 °C. Light rain came down every day during the fieldwork, reaching a maximum of 42.9 mm according to the Schefferville airport weather station. The 1971-2000 climate normals and daily records from this government station can be found in Appendix I.

A second field campaign was conducted by Loic Didillon and Jean-François Dion on April 10, 2014. This time, the goals were to define the extent of watercourse dryness and to take stream gauging measurements at lower water levels, if possible. This survey was conducted in snowshoes over a thick layer of snow.

A third field campaign was conducted by Simon Barrette and Grégory Tison on July 4 and July 5, 2014.

The last field campaign was conducted by Daniel Néron and Jean-François Dion, on September 11, 2014, in order to take stream gauging measurements and add an additional station midcourse in Burnetta Creek, to better understand its contribution to the system.

1.2 Methodology

The surface water flow investigation involved the installation of temporary stations designed for the instantaneous measurement of the watercourses during one or more site visits. The main parameters measured at the hydrometric stations were water elevation and velocity.

The location of all hydrometric stations is shown in Figure 1, and detailed information for each station is presented in Table 1.

1.2.1 Hydrometric Station Installation

Previous studies have demonstrated that streams in the region are characterized by high flow variability, for which standard methods of measurement, such as flumes and weirs, are unsuitable, especially in remote areas with limited mobility and access to construction materials. It was therefore decided that a natural cross-section of the stream would be used for flow monitoring.

Each hydrometric station was installed in the most uniform, straight section of the stream that could be found, where a detailed cross-sectional area could be measured. Whenever possible, a uniform bed with laminar flow, in which there was mean velocity of at least 0.1 m/s, was favoured. Accessibility was also taken into account. The relationship between depth (from the free surface) and velocity in the stream section was established through stream gauging under various flow conditions, using two velocity meter models: the Swoffer 2100 and the GlobalWater FP111. Velocity readings were taken by slowly moving the propeller up and down at least three times over the height of the water column. The flow rate was obtained by multiplying the wetted area by the average velocity of the stream. This procedure, although time consuming, produces very accurate results (Patra, 2010).

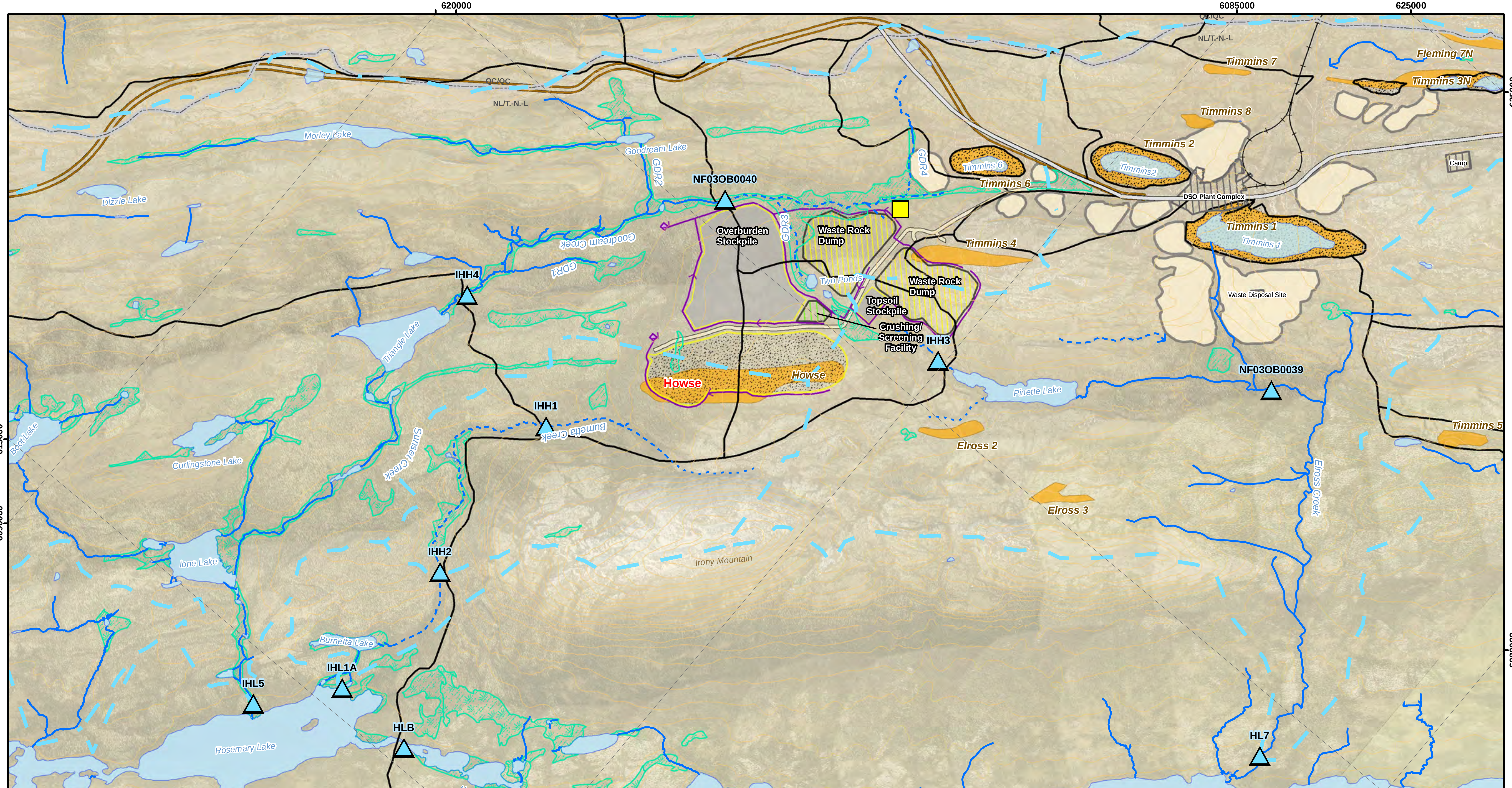
A graduated rope was attached from one bank of the stream to the other to ensure the repeatability of measurements at the same location and to allow for accurate data comparisons within a given time frame, such as data at high and low flow periods. Column interval varies with the width of the watercourse. A minimum of eight columns is preferable for optimal measurements over the wet cross-section.

1.2.2 Flow Estimation

The flow rate was calculated using the relationship between the average water velocity and the wetted area, according to the following general formula:

$$Q = VA$$

Where Q = water flow rate through a cross-section perpendicular to the watercourse (m^3/s)
V = water average velocity through a cross-section perpendicular to the watercourse (m/s)
A = the wetted area of the cross-section perpendicular to the watercourse (m^2)



LEGEND

Surveys

- Hydrometric Station
- Timmins 4 Sedimentation Pond-3

Basemap

- Permanent Watercourse
- Intermittent Watercourse
- Storm Runoff
- Disappearing Stream
- Artesian Spring
- Water Body
- Wetland
- Watershed Boundary
- Contour Line (50 pi)
- Provincial Border
- Existing Road
- Main Access Road

Infrastructure And Mining Components

- Proposed Howse Pit
- Proposed Topsoil/Overburden Stockpile
- Proposed Crushing/Screening Facility
- Proposed Waste Rock Dump
- Proposed Sedimentation Pond
- Mine Haul Road
- Proposed Ditch
- Potential Road To DSO Area 4
- Proposed Railroad
- Existing Dump
- Existing Pit
- Deposit
- Elross Lake Area Iron Ore Mine (ELAIOM) Plant Infrastructure footprint

*Hydronyms are oriented along the direction of water flow

FILE, VERSION, DATE, AUTHOR:
GH-0476b-01, 2014-09-22, E.D., J.T.

0 500 1 000 2 000

SCALE: 1:30 000 Meters UTM 19N NAD 83

SOURCES:
Basemap
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and Government of Quebec, Boundary used for claims
SLE, AMEC and GHI (October 2012). LabMag and Kémag Iron Ore Projects 2012 Mine Site Aquatic Program Field Report.
Groupe Hémisphères, Hydrology, Wetland, 2013.

Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
TATA Steel Minerals Canada Limited/
MET-CHEM, Howse Deposit Design for General Layout, 2013

Surveys
SNC-Lavalin (May 2013) Taconite Project LabMag Mine Site 2012 Hydrology Field Report. Final Report done in collaboration with Groupe Hémisphères and AMEC for New Millennium Iron/TATA Steel, 25 pages and 5 appendices.

Hydrometric Stations

Howse Minerals Limited

GroupeHemispheres

Figure 1

For stations using a culvert, the flow rate is calculated using the California pipe method, based on the following formula (in U.S. units):

$$Q = 8.69\ (1- a/d)^{1.88}\ d^{2.48} \qquad (1)$$

Where
- Q = flow rate in cubic feet per second
- d = pipe diameter in feet
- a = distance from the top of the inside surface of the pipe to the liquid surface, in feet

Flow rate was then converted from feet to metres.

1.2.3 Extent of Watercourse Drying

Low water levels occur at the end of the winter season in Labrador (Rollings 1997), meaning in late March or early April at this latitude. In order to define the extent of watercourse drying, the team travelled the watercourses during this period and regularly verified the presence of running water with a pole and an axe. The exact location of these observations was determined using a GPS apparatus.

1.3 Station Location and Summary

Table 1 shows the location and metadata of the three recently-installed stations and the one reclaimed from the nearby Taconite project (in progress). The new stations stand at an elevation of between 555 and 637 m a.s.l., while the old one, IHL1A, sits at 520 m a.s.l.

Table 1. Station Location and Metadata

STATION NO.	WATERCOURSE / SECTION NAME	COORDINATE (NAD83)	STARTING DATE	DRAINAGE AREA (KM²)	COMMENT
IHH1	Burnetta Creek Upstream	54.91743 N, -67.16064 W	2013-08-30	2.716	
IHH2	Burnetta Creek Midcourse	54.91797 N, -67.17927 W	2014-09-07	4.645	
IHH3	Lake Pinette Inflow	54.89796 N, -67.12312 W	2013-08-31	0.660	Stream crossing 93 cm Ø culvert
IHH4	End of Goodream Creek before Triangle Lake	54.92791 N, -67.15383 W	2013-08-31	13.653	
IHL1A	Burnetta Lake Outflow	54.91717 N, -67.20282 W	2011-09-13	5.812	Nearby station from LabMag Project

2 RESULTS

Raw data from the flow measurements, including upstream and downstream photographs, is found in Appendix II. Instant flow estimates for each station are found in Table 2. Some visits showed that Burnetta Creek (IHH1 and IHH2) can dry up from midcourse to upstream in both winter and summer. It should be noted that very low flow rates were recorded at the IHH3 station, even though highly saturated soil conditions were generally expected because of abundant precipitation.

Table 2. Morphology and Instant Flow Rates

STATION NO.	OBSERVATION DATE	WETTED WIDTH (CM)	MEAN DEPTH (CM)	WETTED AREA (M^2)	FLOW RATE (M^3/S)
IHH1	2013-08-30	225	9.7	0.218	0.011
IHH1	2013-04-10	dry	dry	dry	dry
IHH1	2014-07-04	215	8.4	0.210	0.005
IHH1	2014-09-11	200	7.3	0.145	0.001
IHH2	2013-08-29*	dry	dry	dry	dry
IHH2	2014-09-11	97	5.6	0.048	0.001
IHH3	2013-08-31	32	2.1	0.007	0.003
IHH3	2014-07-04	6	0.2	<0.001	<0.001
IHH3	2014-09-07	dry	dry	dry	dry
IHH4	2013-08-31	361	23.6	0.851	0.703
IHH4	2014-07-04	360	15.7	0.565	0.397
IHL1A	2011-09-13	1033	12.2	1.259	0.257
IHL1A	2012-06-16	1053	11.2	1.177	0.285
IHL1A	2013-08-31	1150	15.8	1.820	0.855
IHL1A	2014-07-05	1096	16.5	1.812	0.663

*Observation by the aquatic fauna team

Surface runoff is affected by many factors, the most relevant being climate, physiography, land cover and geology. These factors exhibit local coherence, as does runoff. However, in a gauging network, the principal cause of flow rate (Q) variability is the varying size of the gauged drainage area (Da) (Church, 1997). Specific runoff (Q/Da) is a method for examining true local hydrology by discounting the effect of drainage basin area. Specific runoff for each station is found in Table 3. Compared to a mean annual regionally-specific runoff of 20.5 L/s/km^2 (NML and PFWA, 2009), it can be said that the first three stations show very low flow rates, while the IHH4 and IHL1A downstream stations experience higher flow rates.

Table 3. Specific Runoff

STATION NO.	WATERCOURSE / SECTION NAME	AVERAGE FLOW RATE (M^3/S)	SPECIFIC RUNOFF ($L/S/KM^2$)
IHH1	Burnetta Creek Upstream	0.006	2.08
IHH2	Burnetta Creek Midcourse	0.001*	0.22*
IHH3	Lake Pinette Inflow	0.001	1.77
IHH4	End of Goodream Creek before Triangle Lake	0.550	40.29
IHL1A	Burnetta Lake Outflow	0.515	88.64

*Based on the only measurement available

3 CONCLUSION

The installation of four instantaneous stations allowed the size and flow rate of the watercourses within the Howse Project footprint to be assessed. The watercourse flow rate monitored for one of these stations, Lake Pinette Inflow (IHH3), was quite low. When taking the drainage area into account, the same can be said about upstream stations IHH1 and IHH2. Specific runoff analysis reveals a high flow rate for downstream stations compared to hydrometric reference stations. The measured flow rates represent instantaneous values for the summer period only.

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TECHNOLOGUE PROFESSIONNEL

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Appendix I

Meteorological Data from Schefferville Airport

and

Detailed Data from the Hydrometric Stations

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Daily Data

Daily Data Report for August 2013

Metadata including Station Name, Province, Latitude, Longitude, Elevation, Climate ID, WMO ID, TC ID

SCHEFFERVILLE A QUEBEC					
Latitude:	54°48'00.000" N	Longitude:	66°48'00.000" W	Elevation:	517.20 m
Climate ID:	7117827	WMO ID:	71828	TC ID:	GKL

Daily Data Report for August 2013

	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days	Cool Deg Days	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's deg	Spd of Max Gust km/h
DAY											
01 †	23.7	8.4	16.1	1.9	0.0	M	M	M			<31
02 †	23.1	12.3	17.7	0.3	0.0	M	M	M			<31
03 †	17.1	12.9	15.0	3.0	0.0	M	M	M			<31
04 †	14.4	10.5	12.5	5.5	0.0	M	M	29.0			<31
05 †	15.5	9.9	12.7	5.3	0.0	M	M	M			<31
06 †	15.2	10.5	12.9	5.1	0.0	M	M	M			<31
07 †	19.5	11.4	15.5	2.5	0.0	M	M	0.0			<31
08 †	23.3	10.9	17.1	0.9	0.0	M	M	2.9		18	44
09 †	17.6	11.6	14.6	3.4	0.0	M	M	M			<31
10 †	14.1	9.5	11.8	6.2	0.0	M	M	48.3		34	50
11 †	10.1	7.2	8.7	9.3	0.0	M	M	12.4		33	52
12 †	9.1	4.8	7.0	11.0	0.0	M	M	13.9		34	50
13 †	15.0	6.4	10.7	7.3	0.0	M	M	M			<31
14 †	16.7E	5.8E	11.3E	6.7E	0.0E	M	M	M			<31
15 †	16.8	6.6	11.7	6.3	0.0	M	M	0.0		1	39
16 †	19.5	6.8	13.2	4.8	0.0	M	M	0.4			<31
17											
18 †	19.8	8.8	14.3	3.7	0.0	M	M	4.4		32	39
19 †	11.3	1.6	6.5	11.5	0.0	M	M	0.8		35	41
20 †	15.2	0.4	7.8	10.2	0.0	M	M	5.4		18	41
21 †	21.1	14.3	17.7	0.3	0.0	M	M	19.0		25	37
22 †	14.6	7.0	10.8	7.2	0.0	M	M	42.9		31	48
23 †	11.5	1.9	6.7	11.3	0.0	M	M	0.4		31	46
24 †	13.1	2.0	7.6	10.4	0.0	M	M	0.0		25	52
25 †	19.8	5.6	12.7	5.3	0.0	M	M	0.3		24	39
26 †	16.1	10.8	13.5	4.5	0.0	M	M	3.1			<31
27 †	12.0	2.0	7.0	11.0	0.0	M	M	4.2		34	37
28 †	M	-1.1E	M	M	M	M	M	M			<31
29 †	17.5	2.3	9.9	8.1	0.0	M	M	4.6		22	56
30 †	13.0	2.3	7.7	10.3	0.0	M	M	M			<31
31 †	7.7	-0.4	3.7	14.3	0.0	M	M	0.0		32E	43E
Sum				187.6*	0.0*	0.0*	0.0*	192.0*			
Avg	16.0*	6.8*	11.5*								
Xtrm	23.7*	-1.1*								22*	56*

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Daily Data Report for September 2013

SCHEFFERVILLE A QUEBEC					
Latitude:	54°48'19.000" N	**Longitude:**	66°48'19.000" W	**Elevation:**	520.90 m
Climate ID:	7117823	**WMO ID:**	71921	**TC ID:**	YKL

DAY	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days	Cool Deg Days	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's deg	Spd of Max Gust km/h
01 ‡	9.5	-0.6	4.5	13.5	0.0	M	M	0.0		32	32
02 ‡	14.2	-0.4	6.9	11.1	0.0	M	M	0.0		14	33
03 ‡	12.2	4.0	8.1	9.9	0.0	M	M	3.6		16	43
04 ‡	14.4	1.7	8.1	9.9	0.0	M	M	4.8		25	63
05 ‡	6.9	0.7	3.8	14.2	0.0	M	M	2.5		23	69
06 ‡	10.7	0.4	5.6	12.4	0.0	M	M	3.3		26	48
07 ‡	7.5	1.0	4.3	13.7	0.0	M	M	0.3			<31
08 ‡	6.0	-1.7	2.2	15.8	0.0	M	M	0.0		33	32
09 ‡	8.0	0.2	4.1	13.9	0.0	M	M	5.3		29	61
10 ‡	3.8	-2.1	0.9	17.1	0.0	M	M	0.0		32	46
11 ‡	11.8	-3.5	4.2	13.8	0.0	M	M	0.0		19	43
12 ‡	8.1	3.1	5.6	12.4	0.0	M	M	10.1		36	33
13 ‡	3.1	-2.0	0.6	17.4	0.0	M	M	0.0		1	43
14 ‡	8.7	-4.2	2.3	15.7	0.0	M	M	4.0		17	39
15 ‡	8.8	0.5	4.7	13.3	0.0	M	M	2.9		28	57
16 ‡	2.5	-1.9	0.3	17.7	0.0	M	M	0.3		29	59
17 ‡	9.4	-2.1	3.7	14.3	0.0	M	M	15.8		26	69
18 ‡	4.4	-2.0	1.2	16.8	0.0	M	M	4.3		34	50
19 ‡	0.3	-2.0	-0.9	18.9	0.0	M	M	0.0		30	33
20 ‡	4.6	-2.5	1.1	16.9	0.0	M	M	6.3		15	46
21 ‡	13.2	2.4	7.8	10.2	0.0	M	M	19.0		16	46
22 ‡	8.7	1.1	4.9	13.1	0.0	M	M	0.3		34	43
23 ‡	5.9	-1.4	2.3	15.7	0.0	M	M	0.0		1	44
24 ‡	8.7	-3.4	2.7	15.3	0.0	M	M	0.0			<31
25 ‡	12.4	2.1	7.3	10.7	0.0	M	M	0.0			<31
26 ‡	17.4	1.6	9.5	8.5	0.0	M	M	0.0			<31
27 ‡	19.7	1.7	10.7	7.3	0.0	M	M	0.0		26	32
28 ‡	22.2	7.1	14.7	3.3	0.0	M	M	0.0		26	63
29 ‡	22.1	13.6	17.9	0.1	0.0	M	M	0.0		23	57
30 ‡	13.7	7.6	10.7	7.3	0.0	M	M	0.0		28	46
Sum				380.2	0.0	0.0^	0.0^	82.8			
Avg	10.0	0.6	5.3								
Xtrm	22.2	-4.2								26	69S

Summary, average and extreme values are based on the data above.

Daily Data Report for July 2014 http://climate.weather.gc.ca/climateData/dailydata_e.html?timeframe=2...

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SCHEFFERVILLE A QUEBEC					
Latitude:	54°48'19.000" N	Longitude:	66°48'19.000" W	Elevation:	520.90 m
Climate ID:	7117823	WMO ID:	71921	TC ID:	YKL

DAY	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days	Cool Deg Days	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's deg	Spd of Max Gust km/h
01 ‡	25.2	15.0	20.1	0.0	2.1	M	M	4.1		30	46
02 ‡	22.9	15.4	19.2	0.0	1.2	M	M	4.6		22	43
03 ‡	15.6	6.7	11.2	6.8	0.0	M	M	1.1		24	65
04 ‡	12.5	5.6	9.1	8.9	0.0	M	M	0.8		29	56
05 ‡	18.1	5.5	11.8	6.2	0.0	M	M	0.0			<31
06 ‡	18.4	7.9	13.2	4.8	0.0	M	M	0.8		33	44
07 ‡	15.0	3.4	9.2	8.8	0.0	M	M	0.5		31	52
08 ‡	18.1	3.1	10.6	7.4	0.0	M	M	0.0			<31
09 ‡	13.8	7.4	10.6	7.4	0.0	M	M	12.1		10	44
10 ‡	14.7	8.6	11.7	6.3	0.0	M	M	4.1		29	67
11 ‡	13.2	8.1	10.7	7.3	0.0	M	M	1.3		32	43
12 ‡	19.4	8.0	13.7	4.3	0.0	M	M	1.0		27	32
13 ‡	18.8	11.6	15.2	2.8	0.0	M	M	0.3		11	33
14 ‡	11.5	9.3	10.4	7.6	0.0	M	M	13.6		11	44
15 ‡	17.2	10.1	13.7	4.3	0.0	M	M	3.3			<31
16 ‡	20.2	11.4	15.8	2.2	0.0	M	M	5.1		36	32
17 ‡	14.5	6.2	10.4	7.6	0.0	M	M	0.3			<31
18 ‡	20.5	4.8	12.7	5.3	0.0	M	M	0.0		30	35
19 ‡	25.7	11.4	18.6	0.0	0.6	M	M	M		26	33
20 ‡	27.9	13.2	20.6	0.0	2.6	M	M	0.0		25	37
21 ‡	27.8	12.1	20.0	0.0	2.0	M	M	0.0		26	44
22 ‡	21.8	12.9	17.4	0.6	0.0	M	M	5.3		27	57
23 ‡	13.5	7.7	10.6	7.4	0.0	M	M	13.3		33	44
24 ‡	14.9	5.9	10.4	7.6	0.0	M	M	0.0		27	43
25 ‡	16.1	9.6	12.9	5.1	0.0	M	M	0.6		26	43
26 ‡	14.8	8.2	11.5	6.5	0.0	M	M	12.5		14	37
27 ‡	17.3	8.2	12.8	5.2	0.0	M	M	2.4		16	32
28 ‡	16.6	8.9	12.8	5.2	0.0	M	M	13.6		24	33
29 ‡	18.4	8.4	13.4	4.6	0.0	M	M	28.1		25	39
30 ‡	19.6	8.0	13.8	4.2	0.0	M	M	0.0		28	56
31 ‡	22.1	7.3	14.7	3.3	0.0	M	M	0.0			<31
Sum				147.7	8.5	0.0^	0.0^	128.8^			
Avg	18.3	8.7	13.5								
Xtrm	27.9	3.1								29	67

Summary, average and extreme values are based on the data above.

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Daily Data Report for September 2014

SCHEFFERVILLE A QUEBEC					
Latitude:	54°48'19.000" N	**Longitude:**	66°48'19.000" W	**Elevation:**	520.90 m
Climate ID:	7117823	**WMO ID:**	71921	**TC ID:**	YKL

DAY	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days	Cool Deg Days	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's deg	Spd of Max Gust km/h
01 ‡	16.9	6.3	11.6	6.4	0.0	M	M	0.0		22	33
02 ‡	18.7	8.0	13.4	4.6	0.0	M	M	2.3		21	57
03 ‡	13.8	6.5	10.2	7.8	0.0	M	M	0.0		28	56
04 ‡	13.9	5.6	9.8	8.2	0.0	M	M	0.3		30	57
05 ‡	12.4	4.8	8.6	9.4	0.0	M	M	10.6		11	56
06 ‡	12.7	2.3	7.5	10.5	0.0	M	M	1.9		26	56
07 ‡	10.5	3.8	7.2	10.8	0.0	M	M	M		34	37
08 ‡	11.0	3.6	7.3	10.7	0.0	M	M	1.0		27	37
09 ‡	M	3.6E	M	M	M	M	M	M		23	70
10 ‡	7.7	1.5	4.6	13.4	0.0	M	M	M		30	46
11 ‡	5.5	-0.3	2.6	15.4	0.0	M	M	15.3		2	48
12 ‡	5.5	-0.1	2.7	15.3	0.0	M	M	10.3		34	54
13 ‡	M	M	M	M	M	M	M	M		25	39
14 ‡	8.2	3.6	5.9	12.1	0.0	M	M	0.0			<31
15 ‡	9.9	1.3	5.6	12.4	0.0	M	M	0.0		25	33
16 ‡	10.5	0.6	5.6	12.4	0.0	M	M	0.5		25	39
17 ‡	4.8	-2.0	1.4	16.6	0.0	M	M	M		28	67
18 ‡	4.8	-2.9	1.0	17.0	0.0	M	M	0.0		28	44
19 ‡	5.1	-1.0	2.1	15.9	0.0	M	M	0.0		30	46
20 ‡	7.6	0.3	4.0	14.0	0.0	M	M	5.1		23	44
21 ‡	7.2	2.2	4.7	13.3	0.0	M	M	0.3			<31
22 ‡	2.6	-0.9	0.9	17.1	0.0	M	M	2.1		35	54
23 ‡	0.3	-2.7	-1.2	19.2	0.0	M	M	3.1		32	52
24 ‡	12.3	-1.2	5.6	12.4	0.0	M	M	18.5		28	52
25 ‡	12.5	1.7	7.1	10.9	0.0	M	M	12.8		31	61
26 ‡	8.6	1.6	5.1	12.9	0.0	M	M	9.8		34	46
27 ‡	M	1.1E	M	M	M	M	M	M		33	41
28 ‡	3.4	-3.5	-0.1	18.1	0.0	M	M	0.8		33	52
29 ‡	-0.6	-4.1	-2.4	20.4	0.0	M	M	0.0		33	52
30 ‡	3.1	-5.0	-1.0	19.0	0.0	M	M	0.3		28	61
Sum				356.2^	0.0^	0.0^	0.0^	95.0^			
Avg	8.5^	1.2^	4.8^								
Xtrm	18.7^	-5.0^								23	70

Summary, average and extreme values are based on the data above.

Notes on Data Quality.

Legend

- [empty] = No data available
- M = Missing
- E = Estimated
- A = Accumulated
- C = Precipitation occurred, amount uncertain
- L = Precipitation may or may not have occurred
- F = Accumulated and estimated
- N = Temperature missing but known to be > 0
- Y = Temperature missing but known to be < 0
- S = More than one occurrence
- T = Trace
- * = The value displayed is based on incomplete data
- † = Data for this day has undergone only preliminary quality checking
- ‡ = Partner data that is not subject to review by the National Climate Archives

Date modified: 2013-11-12

Canadian Climate Normals 1971-2000 Station Data

The minimum number of years used to calculate these Normals is indicated by a code for each element. A "+" beside an extreme date indicates that this date is the first occurrence of the extreme value. Values and dates in bold indicate all-time extremes for the location.

Data used in the calculation of these Normals may be subject to further quality assurance checks. This may result in minor changes to some values presented here.

Metadata including Station Name, Province, Latitude, Longitude, Elevation, Climate ID, WMO ID, TC ID

SCHEFFERVILLE A QUEBEC					
Latitude:	54°48'00.000" N	**Longitude:**	66°49'00.000" W	**Elevation:**	521.80 m
Climate ID:	7117825	**WMO ID:**	71828	**TC ID:**	YKL

1971 to 2000 Canadian Climate Normals station data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Temperature:														
Daily Average (°C)	-24.1	-22.6	-16	-7.3	1.2	8.5	12.4	11.2	5.4	-1.7	-9.8	-20.6	-5.3	C
Standard Deviation	3	3.5	3.3	2.6	1.8	1.8	1	1.2	1.5	1.7	2.3	3	1.2	C
Daily Maximum (°C)	-19	-16.9	-9.8	-1.5	6	13.7	17.2	15.8	8.9	1.3	-6.1	-15.9	-0.5	C
Daily Minimum (°C)	-29.2	-28.1	-22.2	-13.1	-3.6	3.3	7.6	6.5	1.7	-4.6	-13.5	-25.2	-10	C
Extreme Maximum (°C)	5.1	5.1	9.4	13.1	28.3	**34.3**	31.7	28.7	26.7	20.6	9.8	5		
Extreme Minimum (°C)	-48.3	**-50.6**	-45	-36.1	-23.3	-7.8	0	-3.3	-9.4	-19.4	-35.6	-47.2		
Precipitation:														
Rainfall (mm)	0.2	0.2	1.6	8.4	27.7	65.4	106.8	82.8	85.3	24.4	4.5	0.9	408.1	C
Snowfall (cm)	57.4	42.6	56.6	54.8	22.9	8	0.5	1.7	12.7	57.2	70.7	55.4	440.5	C
Precipitation (mm)	53.2	38.7	53.3	61.4	52.1	73.7	107.2	84.5	98.4	80.5	69.4	50.7	822.9	C
Average Snow Depth (cm)	62	70	71	69	18	0	0	0	0	7	26	49	31	C
Median Snow Depth (cm)	60	70	70	71	12	0	0	0	0	5	26	48	30	C
Snow Depth at Month-end (cm)	71	71	76	49	2	0	0	0	1	12	41	53	31	C
Extreme Daily Rainfall (mm)	24.6	2.8	10.6	23.4	29.5	51.3	**54.4**	48.5	45.2	34.3	34.8	5.8		
Extreme Daily Snowfall (cm)	30.6	29	**36.4**	30.2	33.2	23.7	9	23.9	28.4	35.6	29	25.4		
Extreme Daily Precipitation (mm)	29	29	36.8	32.8	33.8	51.3	**54.4**	48.5	49	41.2	35.8	24.6		
Extreme Snow Depth (cm)	163	188	**190**	163	132	38	0	18	18	53	89	115		
Days with Maximum Temperature:														
<= 0 °C	30.6	27.6	27.6	17.5	3.8	0.13	0	0	0.52	12.2	26	30.5	176.4	C
> 0 °C	0.41	0.65	3.4	12.5	27.2	29.9	31	31	29.5	18.9	4	0.55	188.9	C
> 10 °C	0	0	0	0.39	6.6	20.8	29.1	27.3	11.2	0.80	0	0	96.1	C
> 20 °C	0	0	0	0	0.39	4.6	9.2	6.5	0.43	0	0	0	21.1	C
> 30 °C	0	0	0	0	0	0.22	0	0	0	0	0	0	0.22	C
> 35 °C	0	0	0	0	0	0	0	0	0	0	0	0	0	C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Days with Minimum Temperature:														
> 0 °C	0	0	0	0.91	6.4	23	31	30.7	19.6	3.5	0.43	0.05	115.5	C
<= 2 °C	31	28.3	31	29.9	28.4	13.1	0.52	2.2	17.3	29.5	29.8	31	271.9	C
<= 0 °C	31	28.3	31	29.1	24.6	7	0	0.33	10.5	27.6	29.6	31	249.8	C
< -2 °C	31	28.1	30.6	27.2	18.9	2.1	0	0	3.6	21.7	29	30.9	222.9	C
< -10 °C	30.3	27.5	27.4	18.8	2.3	0	0	0	0	3.7	19.6	29.8	159.3	C
< -20 °C	27.3	23.9	19	6	0.04	0	0	0	0	0	5.3	22.6	104.1	C
< - 30 °C	16.1	12.8	6.4	0.22	0	0	0	0	0	0	0.29	9.6	45.3	C
Days with Rainfall:														
>= 0.2 mm	0.30	0.30	1	2.9	8.6	14.7	19	18.4	17.2	7.3	1.8	0.64	92.2	C
>= 5 mm	0	0	0.09	0.52	1.7	4.3	6.7	5.2	5.4	1.6	0.29	0.05	25.7	C
>= 10 mm	0	0	0.04	0.13	0.48	2	3.3	2.7	2.4	0.76	0.10	0	11.9	C
>= 25 mm	0	0	0	0	0	0.13	0.48	0.19	0.48	0	0	0	1.3	C
Days With Snowfall:														
>= 0.2 cm	17.4	14.3	16.6	14.6	10.3	3.4	0.17	0.33	6.4	19	21.3	19.2	142.9	C
>= 5 cm	3.8	2.4	3.2	3.3	1	0.35	0.04	0.10	0.78	3.7	4.6	3.2	26.5	C
>= 10 cm	1.4	0.91	1.4	1.4	0.39	0.13	0	0.05	0	1.1	1.9	1.4	9.9	C
>= 25 cm	0.09	0.04	0.14	0.30	0.04	0	0	0	0	0.14	0.14	0.05	0.94	C
Days with Precipitation:														
>= 0.2 mm	17.1	14.3	16.4	16.2	15.8	16.1	19	18.4	20.4	21.8	21.3	19	215.9	C
>= 5 mm	3.4	2.3	3.1	3.8	3.2	4.7	6.7	5.3	6.3	5.4	4.4	3	51.5	C
>= 10 mm	1.3	0.74	1.1	1.5	1.3	2.2	3.3	2.8	2.7	2	1.7	1.4	21.9	C
>= 25 mm	0.09	0.04	0.13	0.30	0.09	0.22	0.48	0.24	0.52	0.14	0.10	0	2.4	C
Days with Snow Depth:														
>= 1 cm	31	28.3	31	30	21.7	1.1	0	0.09	0.74	17.4	28.5	31	220.7	C
>= 5 cm	31	28.3	31	29	16.8	0.70	0	0.05	0.13	11.3	25.9	31	205.1	C
>= 10 cm	31	28.3	31	28.5	13.8	0.52	0	0	0.04	7.6	23.5	31	195.3	C
>= 20 cm	30.8	28.3	31	27.9	10.3	0.22	0	0	0	3.3	17.2	29.2	178.1	C
Wind:														
Speed (km/h)	16.4	16.8	17.4	16.5	16	16.2	15.1	15.6	16.9	17.8	17.3	16	16.5	A
Most Frequent Direction	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	A
Maximum Hourly Speed (km/h)	85	**97**	83	77	66	97	65	61	80	89	84	80		
Maximum Gust Speed (km/h)	134	148	148	130	101	126	103	117	137	137	142	**153**		
Direction of Maximum Gust	W	W	SW	W	W	W	W	W	SW	SW	SW	SW	SW	
Days with Winds >= 52 km/h	1.7	1.4	1.9	1.1	0.9	0.4	0.6	0.4	0.8	1.1	1.8	2.1	13.9	C
Days with Winds >= 63 km/h	0.7	0.5	0.4	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.3	0.6	3.3	C
Degree Days:														
Above 24 °C	0	0	0	0	0	0.2	0	0	0	0	0	0	0.2	C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Above 18 °C	0	0	0	0	0	2.8	2.9	1.4	0.1	0	0	0	7.2	C
Above 15 °C	0	0	0	0	0	8.9	15.4	10.6	0.7	0	0	0	35.7	C
Above 10 °C	0	0	0	0	1.7	40.4	89.3	66	8.9	0	0	0	206.4	C
Above 5 °C	0	0	0	0.3	15.7	123.3	230.3	192.4	51.3	2.6	0.2	0	615.9	C
Above 0 °C	0	0.1	0.6	9.5	77.7	256.5	385.1	345.9	163.1	28.9	2.6	0.1	1270.1	C
Below 0 °C	741.7	637.9	497.1	228.5	39.5	0.7	0	0	2.7	81.5	296.3	637.6	3163.6	C
Below 5 °C	896.7	779.2	651.5	369.3	132.6	17.5	0.2	1.5	40.9	210.2	443.8	792.5	4335.8	C
Below 10 °C	1051.7	920.5	806.5	519	273.6	84.7	14.2	30.1	148.5	362.6	593.6	947.5	5752.6	C
Below 15 °C	1206.7	1061.8	961.5	669	426.9	203.1	95.3	129.7	290.4	517.6	743.6	1102.5	7408.1	C
Below 18 °C	1299.7	1146.5	1054.5	759	519.9	287	175.8	213.5	379.7	610.6	833.6	1195.5	8475.5	C
Bright Sunshine:														
Total Hours	80.4	116.3	156.4	173	187.4	179.9	188.1	173.3	91.7	61.5	47.8	58.2	1513.9	D
Days with measureable	20.6	22.3	24.7	24.3	26.4	25.5	27.7	27.2	22.3	20.8	16.4	18.1	276.1	D
% of possible daylight hours	32.9	42.6	42.7	41	37.6	34.8	36.3	37.4	24	18.8	18.8	25.6	32.7	D
Extreme Daily	8	10.5	11.9	14.7	16.5	**17**	16.8	15.1	12.2	11.4	8.4	7.6		C
Humidex:														
Extreme Humidex	5.5	4.6	10.2	12.8	26.8	35.7	**37.3**	32	30.5	21	10.6	5		
Days with Humidex >= 30	0	0	0	0	0	0.3	0.2	0.1	0	0	0	0	0.7	A
Days with Humidex >= 35	0	0	0	0	0	0	0	0	0	0	0	0	0	A
Days with Humidex >= 40	0	0	0	0	0	0	0	0	0	0	0	0	0	A
Wind Chill:														
Extreme Wind Chill	**-66.2**	-60.2	-56.9	-43.6	-36.6	-14	-7.1	-8.1	-14.8	-31.6	-44.1	-58.5		
Days with Wind Chill < -20	29.7	26.7	24.9	13.5	0.8	0	0	0	0	1	14.3	27.2	138	A
Days with Wind Chill < -30	26.6	22.6	17	3.4	0.1	0	0	0	0	0.1	2.8	19.3	92	A
Days with Wind Chill < -40	16.6	13.2	5.9	0.2	0	0	0	0	0	0	0.2	8.8	44.8	A
Humidity:														
Average Vapour Pressure (kPa)	0.1	0.1	0.2	0.3	0.5	0.8	1	1	0.7	0.5	0.3	0.1	0.5	A
Average Relative Humidity - 0600LST (%)	65.1	65.6	69	76.9	77.2	76	79.2	81	84.8	82.3	80.3	70.8	75.7	A
Average Relative Humidity - 1500LST (%)	63.7	60.3	59.8	62.2	60.3	56.6	59.2	59.4	67.7	72.7	76.2	70.2	64	A
Pressure:														
Average Station Pressure (kPa)	94.4	94.6	94.8	95.1	95.1	94.9	94.9	95	94.9	95	94.7	94.6	94.8	A
Average Sea Level Pressure (kPa)	101.1	101.3	101.4	101.6	101.5	101.2	101.1	101.3	101.2	101.4	101.2	101.3	101.3	A
Radiation:														

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Extreme Global - RF1 (MJ/m2)	6.6	13.5	21.8	27.4	29.7	**33.7**	32.1	27.7	20.4	12.9	7.6	4.5		
Extreme Net - RF4 (MJ/m2)	0.6	2.3	1.7	13.9	17.2	**18.2**	16	15	10.5	5.2	0.8	-0.6		
Visibility (hours with):														
< 1 km	25.8	20.6	17.8	19.8	13.4	7.9	2.7	1.7	6.2	15.3	23.4	18.6	173	D
1 to 9 km	171.9	137.5	134.7	117.3	90.3	70.4	60.2	47.7	85.3	135.9	158.1	169.7	1378.8	D
> 9 km	546.4	520.8	591.6	583	640.3	641.7	681.2	694.6	628.6	592.9	538.4	555.8	7215.2	D
Cloud Amount (hours with):														
0 to 2 tenths	237.4	223.2	215.3	172.5	132	84.6	79.5	94.2	71	58.6	95.5	223.9	1687.6	D
3 to 7 tenths	151.5	138.9	133	121.6	127.5	156	172.4	180.5	130.2	101.9	110.9	133.5	1657.6	D
8 to 10 tenths	355.1	316.2	395.8	425.9	484.5	479.5	492	469.4	518.9	583.5	513.6	386.7	5421	D

Legend

- A = WMO "3 and 5 rule" (i.e. no more than 3 consecutive and no more than 5 total missing for **either** temperature **or** precipitation)
- B = At least 25 years
- C = At least 20 years
- D = At least 15 years

Date modified: 2014-02-13

Appendix II

Detailed Data and Photos from the Hydrometric Stations

Project: Howse

Hydrometric station no: **IHH1**

Burnetta Creek, upstream

General information

Type: **Instant**

Geographical information

Latitude (Nad83): 54.91743

Longitude (Nad83): -67.16064

Altitude: 588 **m**

Drainage area: 2.716 **km²**

Weather connection

Rain station:

Barometric station:

Probe information

Probe dealer:

Probe serial:

Probe unit:

High water mark: 33 **cm**

Probe elevation: **cm**

Cross-section invert: **cm**

Probe offset: **cm**

Startup date: 30-08-2013

Last record date:

Gauging information

Calibration curve type:

$$Q = aH^b$$

Constante 'a':

Constante 'b':

R^2:

extrapolation: **cm**

Calculated Flow and Precipitation, per day

Project: Howse

Hydrometric station no: **IHH1**

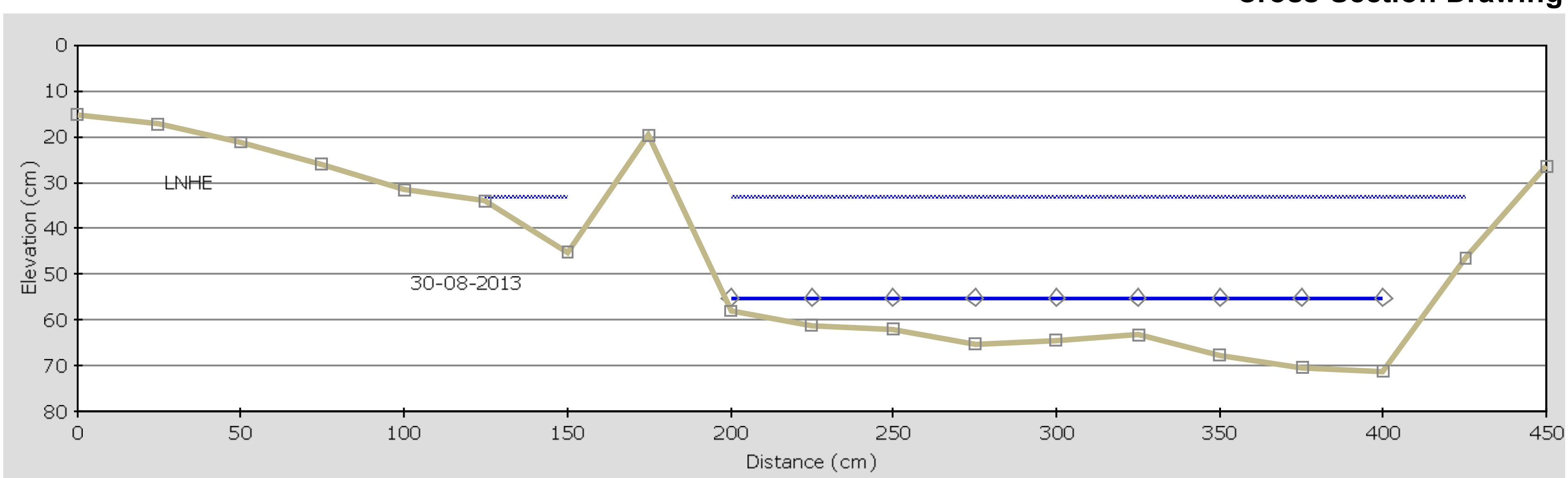
Burnetta Creek, upstream

Cross-Section Surveying and Gauging

	Distance* (cm):	0	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450											
	Topo (cm):**	15	17	21	26	31,5	34	45	19,5	58	61	62	65	64,5	63	67,5	70,5	71	46,5	26,5											
Date: 30-08-2013	**Depth (cm):**									3	6.5	7	10	9.5	8	12	15	16													
Head: cm	**Speed (m/s):**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.03	0.12	0.09	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tech.: HR & CE																															
Date: 04-07-2014	**Depth (cm):**									1	5.5	6.4	9.3	11.6	12.1	12.7	12.2	13	0	0											
Head: cm	**Speed (m/s):**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.09	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tech.: SB																															
Date: 11-09-2014	**Depth (cm):**										2	5	6	10	9	7.5	6.5	12													
Head: cm	**Speed (m/s):**										0.00	0.00	0.00	0.01	0.01	0.03	0.01	0.00													
Tech.: DN																															

* The vertical distance from a defined zero point on the left bank
** Depth of the vertical, from the rope to the bed of the stream

Cross-Section Drawing



Project: Howse

Hydrometric station no: **IHH1**

Instant

Upstream

Downstream

Probe (if applicable)

Box (if applicable)

Project: Howse

Hydrometric station no: **IHH2**

Burnetta Creek, midcourse

General information

Type: **Instant**

Geographical information

Latitude (Nad83): 54.91797

Longitude (Nad83): -67.17927

Altitude: 555 **m**

Drainage area: ______ **km²**

Weather connection

Rain station: ______

Barometric station: ______

Probe information

Probe dealer: ______

Probe serial: ______

Probe unit: ______

High water mark: 0 **cm**

Probe elevation: ______ **cm**

Cross-section invert: ______ **cm**

Probe offset: ______ **cm**

Startup date: 11-09-2014

Last record date: ______

Gauging information

Calibration curve type:

$$Q = aH^b$$

Constante 'a':

Constante 'b':

R²:

extrapolation: ______ **cm**

Calculated Flow and Precipitation, per day

Project: Howse

Hydrometric station no: **IHH2**

Burnetta Creek, midcourse

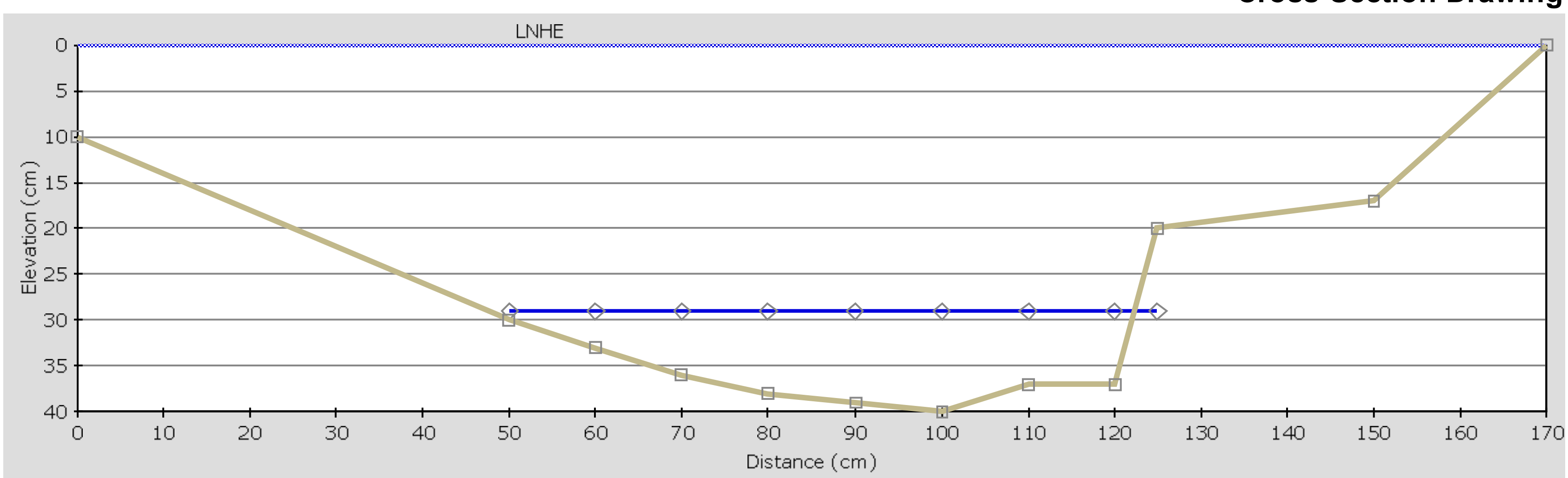
Cross-Section Surveying and Gauging

Distance* (cm):	0	50	60	70	80	90	100	110	120	125	150	170	
Topo (cm):**	10	30	33	36	38	39	40	37	37	20	17	0	0
Depth (cm):		0	3	6	8	9	10	7	7	0			
Speed (m/s):		0.00	0.01	0.02	0.04	0.04	0.05	0.02	0.01	0.00			

Date: 11-09-2014
Head: cm
Tech.: DN

* The vertical distance from a defined zero point on the left bank
** Depth of the vertical, from the rope to the bed of the stream

Cross-Section Drawing



Project: Howse

Hydrometric station no: **IHH2**

Instant

Upstream

Downstream

Probe (if applicable)

Box (if applicable)

Project: Howse

Hydrometric station no: **IHH3**

Lake Pinette Inflow

General information

Type: **Instant**

Geographical information

Latitude (Nad83): 54.89796

Longitude (Nad83): -67.12312

Altitude: 637 **m**

Drainage area: 0.66 **km²**

Weather connection

Rain station: ______

Barometric station: ______

Probe information

Probe dealer: ______

Probe serial: ______

Probe unit: ______

High water mark: ______ **cm**

Probe elevation: ______ **cm**

Cross-section invert: ______ **cm**

Probe offset: ______ **cm**

Startup date: 31-08-2013

Last record date: ______

Gauging information

Calibration curve type:

$$Q = aH^b$$

Constante 'a':

Constante 'b':

R^2:

extrapolation: ______ **cm**

Calculated Flow and Precipitation, per day

Project: Howse

Hydrometric station no: **IHH3**

Lake Pinette Inflow

Cross-Section Surveying and Gauging

Distance* (cm):

Topo (cm):**

Date: 31-08-2013 **Depth (cm):**
Head: 1,5 **cm** **Speed (m/s):**
Tech.: HR & CE

Date: 04-07-2014 **Depth (cm):**
Head: 0,2 **cm** **Speed (m/s):**
Tech.: SB

Date: 07-09-2014 **Depth (cm):**
Head: 0 **cm** **Speed (m/s):**
Tech.: DN & GF

* The vertical distance from a defined zero point on the left bank
** Depth of the vertical, from the rope to the bed of the stream

Cross-Section Drawing

ChartData(): Invalid value.
Series 1

Project: Howse

Hydrometric station no: **IHH3**

Instant

Upstream

Downstream

Probe (if applicable)

Box (if applicable)

Project: Howse

Hydrometric station no: **IHH4**

End of Goodream Creek before Triangle Lake

General information

Type: **Instant**

Geographical information

Latitude (Nad83): 54.92791

Longitude (Nad83): -67.15383

Altitude: 590 m

Drainage area: 13.653 km²

Weather connection

Rain station:

Barometric station:

Probe information

Probe dealer:

Probe serial:

Probe unit:

High water mark: -50 cm

Probe elevation: cm

Cross-section invert: cm

Probe offset: cm

Startup date: 31-08-2013

Last record date:

Gauging information

Calibration curve type:

$$Q = aH^b$$

Constante 'a':

Constante 'b':

R^2:

extrapolation: cm

Calculated Flow and Precipitation, per day

Project: Howse

Hydrometric station no: **IHH4**

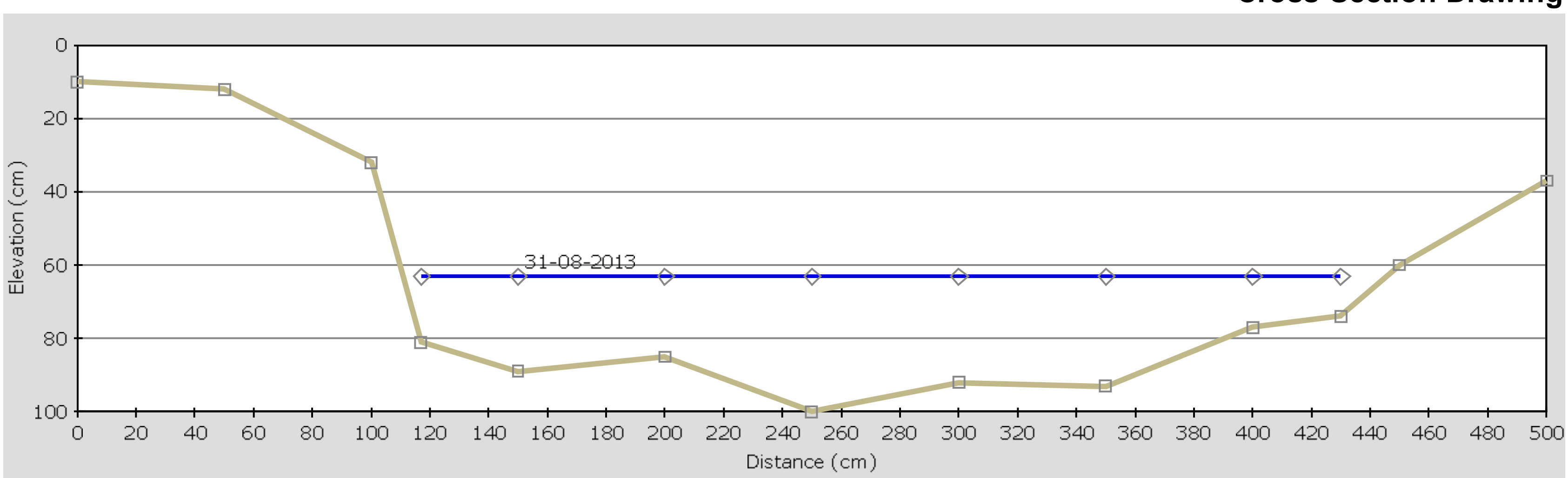
End of Goodream Creek before Triangle Lake

Cross-Section Surveying and Gauging

	Distance* (cm):	0	50	100	117	150	200	250	300	350	400	430	450	500																	
	Topo (cm):**	10	12	32	81	89	85	100	92	93	77	74	60	37																	
Date: 31-08-2013	**Depth (cm):**				16	24	24.5	43	32	28	14	7																			
Head: cm	**Speed (m/s):**	0.00	0.00	0.00	0.06	0.06	0.98	1.34	1.10	0.46	0.76	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tech.: HR & CE																															
Date: 04-07-2014	**Depth (cm):**				10	20.5	13	27	19	23	8	5																			
Head: cm	**Speed (m/s):**	0.00	0.00	0.00	0.21	0.37	0.98	1.13	1.34	0.03	0.09	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tech.: SB																															
Date:	**Depth (cm):**																														
Head: cm	**Speed (m/s):**																														
Tech.: DN																															

* The vertical distance from a defined zero point on the left bank
** Depth of the vertical, from the rope to the bed of the stream

Cross-Section Drawing



Project: Howse

Hydrometric station no: **IHH4**

Instant

Upstream

Downstream

Probe (if applicable)

Box (if applicable)

PERMAFROST CONDITION AT TSMC HOWSE DEPOSIT

SCHEFFERVILLE, QUEBEC

Report No. L-15-1802

October 22th, 2015

TATA

JOURNEAUX ASSOC
Division LAB JOURNEAUX INC.
801 Bancroft Pointe-Claire, QC H9R 4L6
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1 INTRODUCTION

Tata Steel Minerals Canada Limited (TSMC) is presently mining several open pits in the direct shipping ore, some up to 35 km from its plant site and in frozen ground conditions. It is planning to begin mining the nearby Howse DSO iron ore deposit located 4 km from the plant site.

The Howse deposit is located in the province of Newfoundland and Labrador approximately 25 km north of Schefferville, which is 570 km north of Sept-Îles, Québec. The Howse DSO deposit is confined in license 021315M, and covers a surface area of 24 hectares. Howse Mineral Limited (HML) owns 100% interest in the Howse property and it is wholly-owned subsidiary of TSMC.

Although large-scale occurrences of melting permafrost in northern environments are common (e.g. see Figure 1-1), these occurrences are mainly related to presence of ice-rich saline clays and silt which were deposited during the marine invasion which flooded far in land from the coast line following primary the wide river valley (see Figure 1-2). Such saline permafrost can melt at -2ºC, depending on the salt content. As clearly demonstrated in Figures 1-2, these easily-disturbed regions of saline permafrost occurred at elevations below 120 m, which is not the case for the Howse deposit, located at 680 m asl. Therefore it is important to situate the Howse site with respect to the many occurrences of melting permafrost.

Figure 1-1: Melting ice rich fine grain permafrost

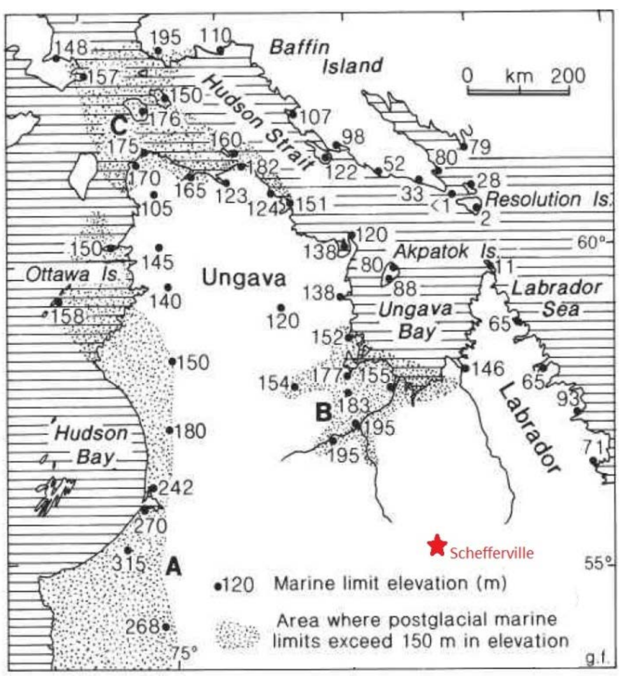


Figure 1-2: Postglacial Marine Limits in Northern Quebec, Relative to Schefferville (Adapted from Gray et al., 1993).

2 SCOPE OF WORK

Howse Mineral Limited (HML) retained the services of Journeaux Assoc, a division of LAB JOURNEAUX INC., to assess the presence of permafrost at the Howse deposit. Journeaux Assoc's mandate was twofold.

First, a thorough review of all available past and present information on permafrost occurrences in the area was completed. We assessed previous work related to ground temperature as recorded by McGill researchers (Granberg et al., 1983) during the Iron Ore Company of Canada (IOC)'s mining activities, commencing in the 1950s. These reports focus specifically on frozen ground conditions.

Second, Journeaux Assoc conducted two visits of the Howse Site. The first visit was carried out in June 2015 to evaluate the presence of permafrost in the Howse deposit by taking measurements of ground water level and temperature within a thermistor installed by Golder Associates in 2013. During the second visit in July 2015, existing thermistors which were installed in the 1980s by McGill University researchers in Howse deposit during IOC mining operations were located. Since the shutdown of IOC in the 1980s, no further readings were taken from those installed thermistors.

Figure 2-1 below shows the location of the various pits in the Millennium Iron Ore Range.

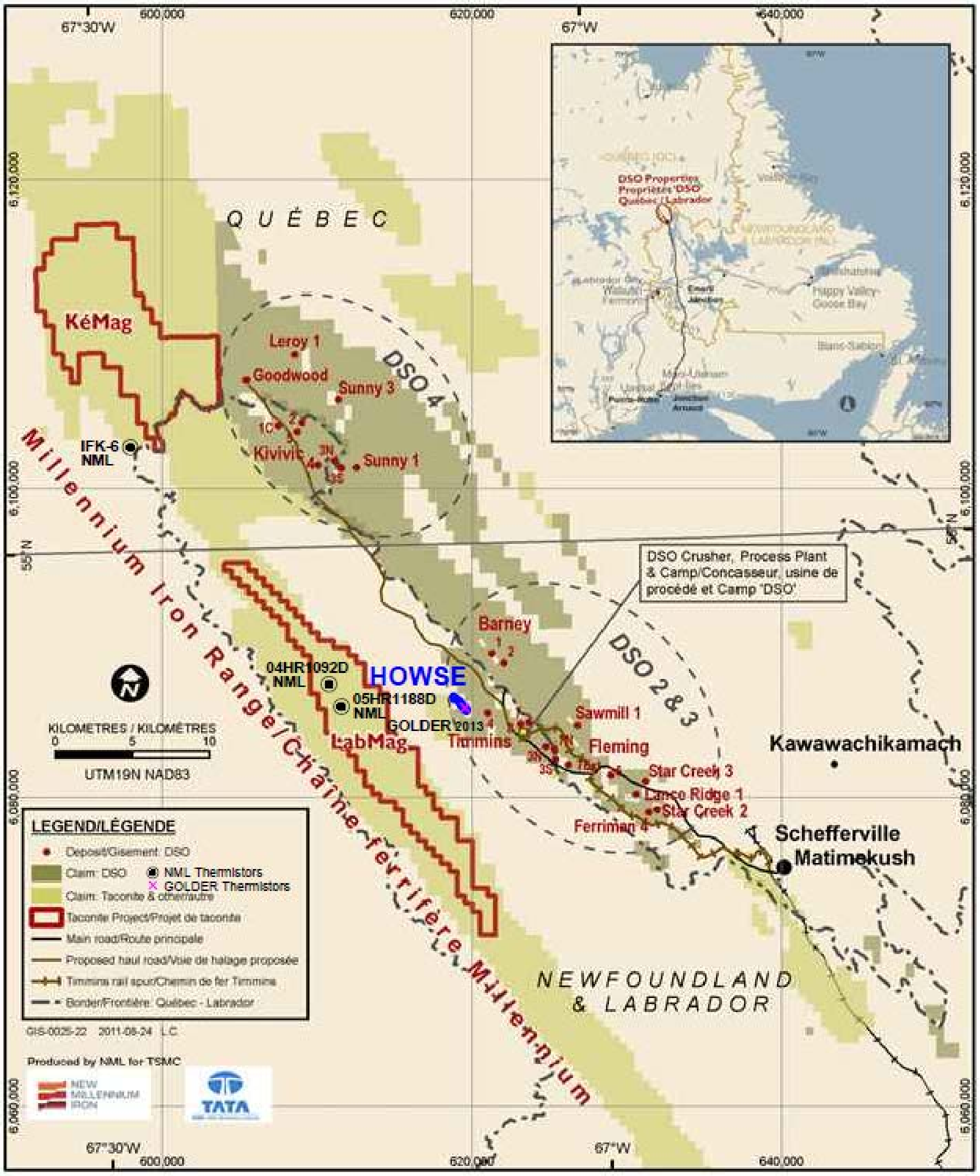


Figure 2-1: Location Plan for Howse Ore Body and DSO Iron ore Pits

Additional sources of information

- Journeaux Assoc. also reviewed information provided by Geofor Environment (Geofor), who has considerable hydrogeological information on the iron ore range, particularly in the Howse area but also on other pits in the surrounding region. This information was to be reviewed to obtain any useful input on frozen ground conditions in the Howse area.

- In 2013, Golder Associates (Golder) installed one thermistor and two (2) temperature gauges. These temperature gauges were destroyed after one year of installation.

- Palmer Environmental Consulting Group (PECG) reviewed the permafrost articles published mainly by McGill research station and produced a permafrost assessment memorandum.

The present report contains all the information gathered from different sources. It has been assembled in charts and tables for simplicity, with some photographs for clarity. Data is presented on daily temperatures, freezing and thawing indices, precipitation records and groundwater levels.

Known permanently frozen ground conditions in the area are reported according to elevations; this information that is absent in most data found in McGill and IOCC published reports. Finally the report comments on the relationship between permafrost and Howse mining operations.

3 BACKGROUND

Figure 3-1 presents the distribution of permafrost in the northern hemisphere.

Figure 3-1: Permafrost Distribution in the Northern Hemisphere

This permanent ground temperature below 0°C is controlled by mean annual air temperature, snow cover, vegetation and terrain topography. Attempts have been made to present permafrost distribution in Canada. Figure 3-2 presents permafrost distribution in Canada.

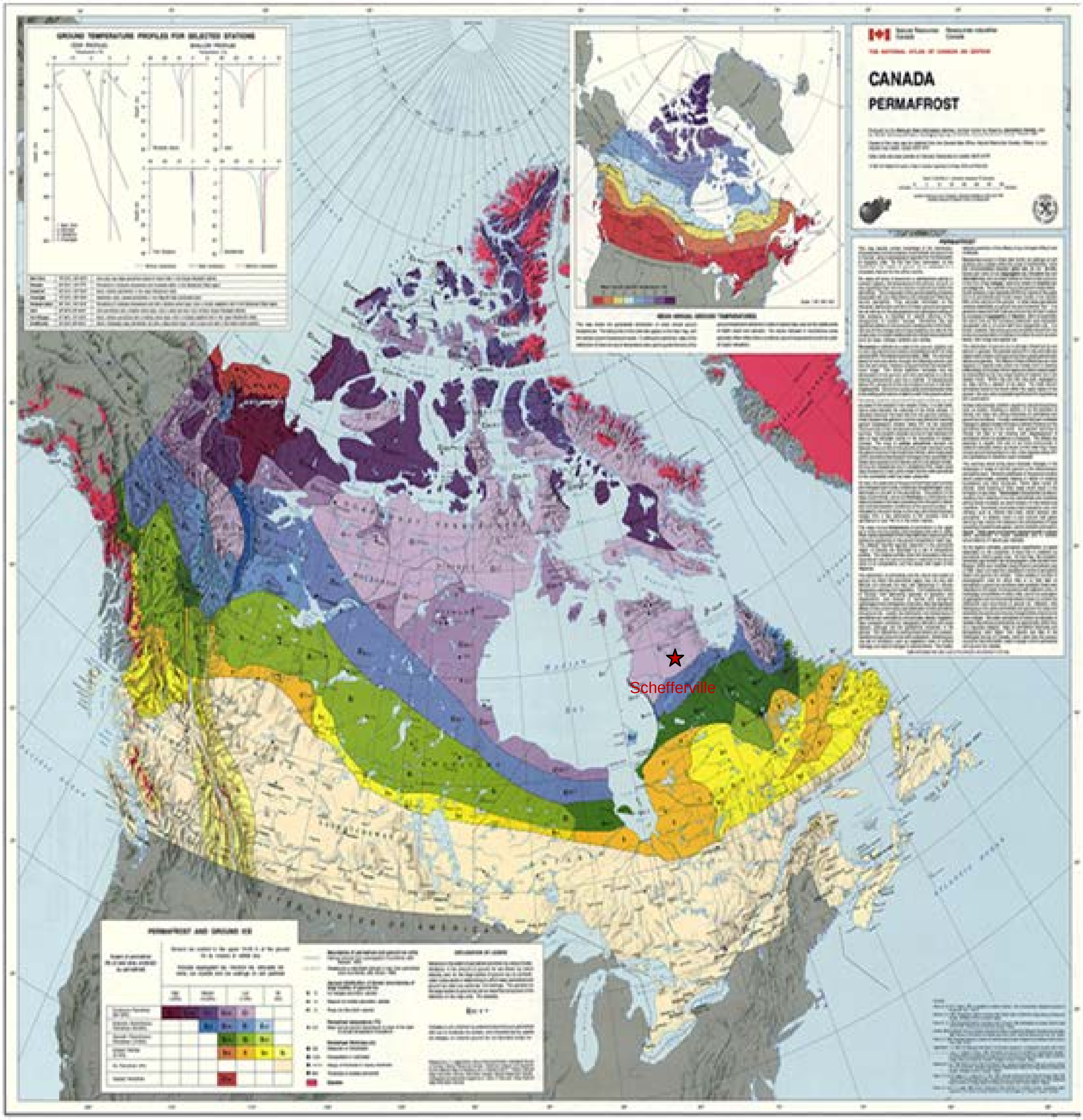


Figure 3-2 : Permafrost Distribution in Canada (Natural Resources Canada)

The Howse Project is located in the discontinuous or sporadic permafrost zone between the extensive continuous permafrost of Nunavik to the north and the permafrost free southern territory (Figure 3-3).

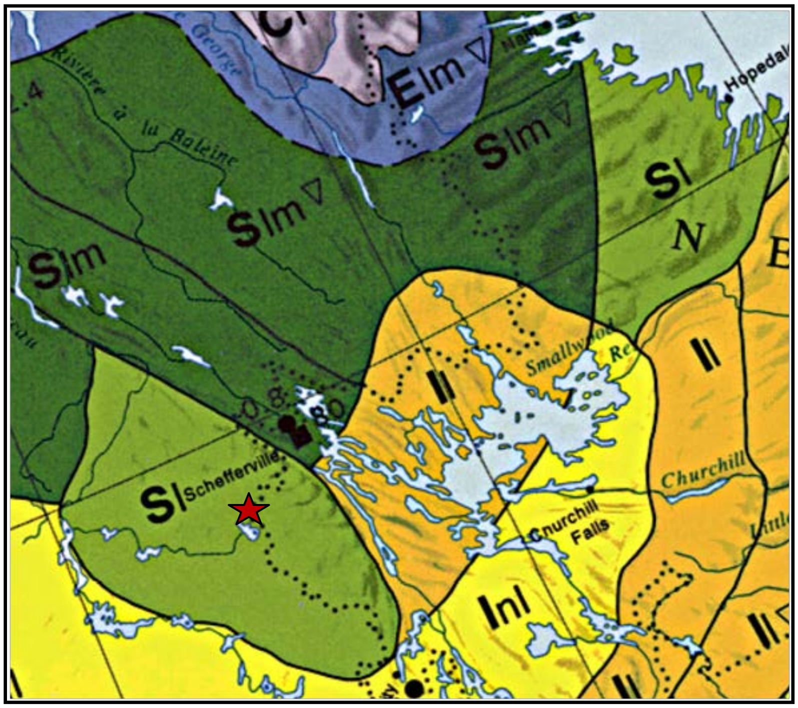


Figure 3-3: Schefferville on Canada Permafrost Map

Permafrost occurrence is related to ground elevation; it is more extensive on the treeless and exposed iron ore ridges above 660 m asl. These areas are subjected to extreme low temperatures and harsh winter winds where freezing indices (cumulative number of days of air temperatures below $0^{o}C$) have been calculated at about $5{,}000^{o}C$ days yearly since 1970 to today. The topography of the Howse property is generally controlled by the synclinal geology of the Labrador trough and consists of flat to gently rolling terrain. The highest point around the Howse area is the Irony Mountain, west of the deposit, outside the limits of the property. The ground elevation slopes northward from 680 m at the highest southern end of the property, to almost 580 m at Triangle Lake on the north. The area is characterized by thick overburden covering the mineralized iron formation. The overburden thickness averages 28 m (range: 12 - 52 m).

4 RELATIONSHIP BETWEEN PERMAFROST AND ELEVATION

Table 4-1 summarises observations of frozen ground reported by personnel working in the old and existing mining pits. These are all referenced to ground elevations.

Table 4-1 : Table of Frozen Ground Occurrences

PIT NAME	GROUND Elev. (m)	WATER Elev. (m)	SHAPE OF PERMAFROST	NOTES
Leroy 1	660		Massive frozen soil	
Timmins 3N	693	676		Artesian water encountered under permafrost at 60 m depth; froze at 17 m depth
Timmins 7	715			Artesian water encountered under permafrost at 44.1 m depth; froze at 42.3 m depth
Kivivic 1C	740	697.7	Ice lenses in yellow ore	
Kivivic 5	742	736		Water froze in observation well
Sunny 3	750		Massive frozen soil	
Goodwood	750		Massive frozen soil in yellow ore	Frozen drill bit while drilling exploration holes
Kivivic 3S	775		Massive frozen soil	
Kivivic 2	775	754.5	Massive frozen soil	Artesian water encountered under permafrost at 26.3 m depth; froze at 20.5 m depth
Kivivic 3N	780		Massive frozen soil	
Sunny 1	800		Massive frozen soil	

This table illustrates, as expected, that permafrost occurrences are more extensive in the high bedrock hills above El. 660 m. This includes the Fleming Pit in the southern part of the territory and also the Kivivic and Goodwood ore bodies which are located in the northern extremity of the iron ore belt, some 35 km from the Howse deposit.

The Howse area is composed mainly of blue ore which has low moisture content. In most of the areas described in table 4-1, costly drilling and blasting of cold temperature frozen ground was necessary and is presently used to allow mining to proceed. Alternatively, Figure 4-1 shows the excavation slopes at Timmins 4, located adjacent to the Howse deposit, in softer ground which has temperatures approaching zero. Some frozen ground was also noted in the greyish till-like overburden; both these occurrences in warm frozen ground conditions (Figure 4-1). These conditions did not require blasting as the ore could be excavated with powerful shovels, assisted by a "ripper" in some areas.

Figure 4-1: Photo showing excavator teeth marks in pockets of warm permafrost in Timmins 4N

Further, Table 4-2 indicates that there was no evidence of permafrost in Kivivic 4 even though it was above El. 740 m. In the Kivivic 1C and Kivivic 2 (El. 740 to 775 m respectively), ice lenses were noted between the finer grained, high water content yellow ore and the porous blue ore.

Table 4-2 : Table of Unfrozen Ground Occurrences

PIT NAME	GROUND EL. (m)
Ferriman	540
Star Creek 2	540
Star Creek 3	550
Lance Ridge 1	560
Sawmill 1	560
LabMag	580
Barney 1	640
Barney 2	640
Howse	682
Timmins 8	690
Timmins 4	700
KeMag	705
Timmins 3S	725
Kivivic 4	775

It should be noted that no frozen ground occurrences were reported for the pits below El. 682 m. At higher elevations, the effects of thawing of the frozen ground can be seen on photographs in Figures 4-2 and 4-3 below.

Figure 4-2: Photos of Recent Thawing of Frozen Ground – Active Layer or Permafrost Degradation

Figure 4-3: Photos of Degradation of Permafrost over 50 Years on old Fleming Haul Roads

4.1 Freezing and Thawing Indices for Schefferville Area

Typical temperature profiles are given in Figure 4-4 below from which the freezing and thawing indices can be calculated for the Schefferville area.

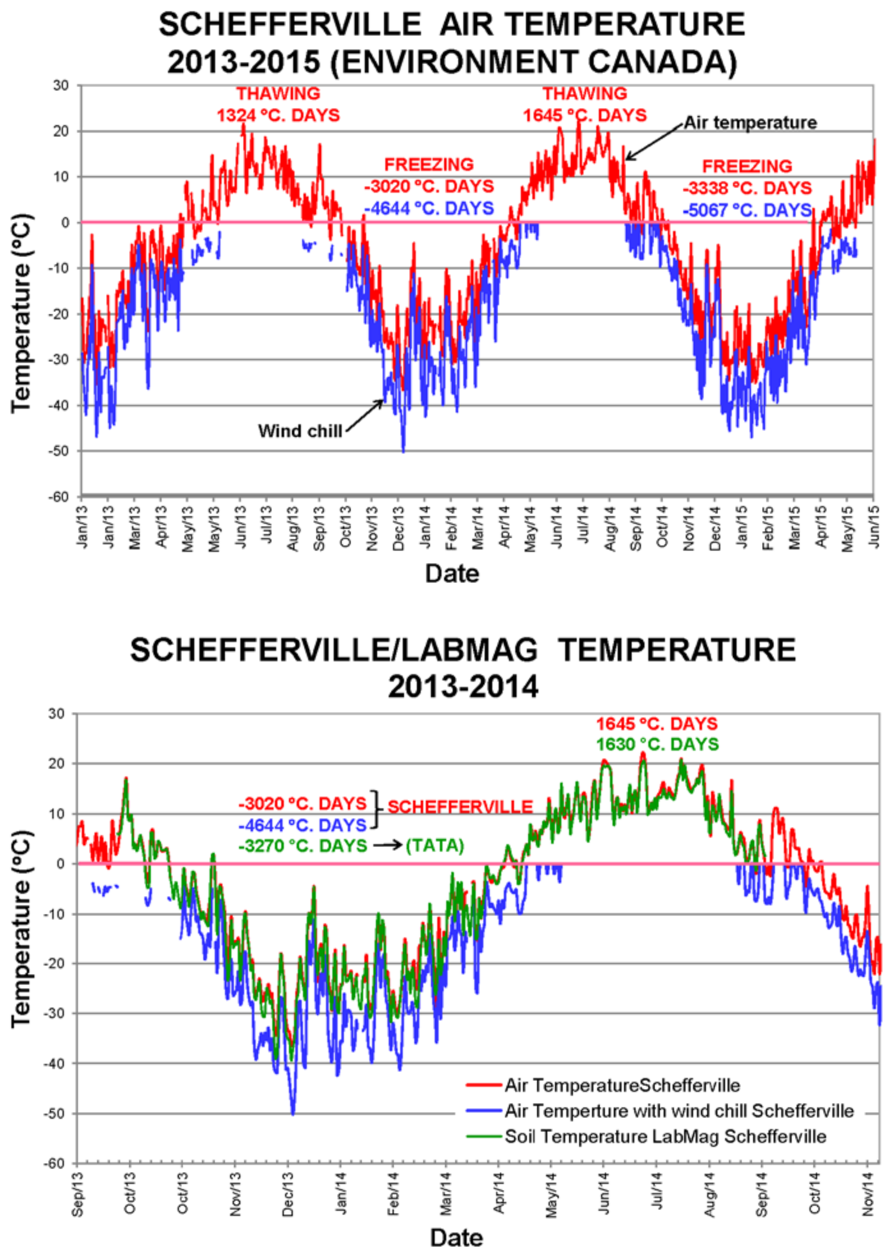
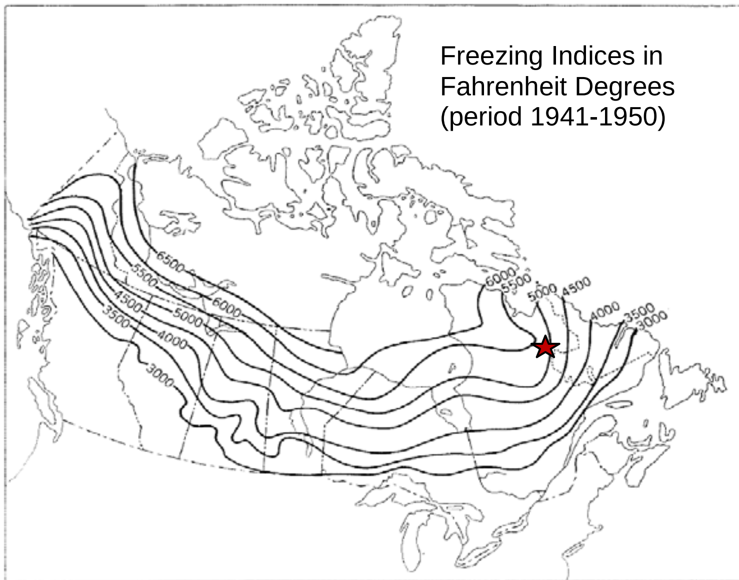


Figure 4-4: Typical Temperature Variations used to Calculate Thawing and Freezing Indices as Well as the Index Considering Wind Chill

Brown (1960) reports a freezing index of 5000 °F-days (2760 °C-days) and thawing index is 2250 °F-days (1230°C-days) between 1941 and 1950 in the Schefferville region (see Figure 4-5).



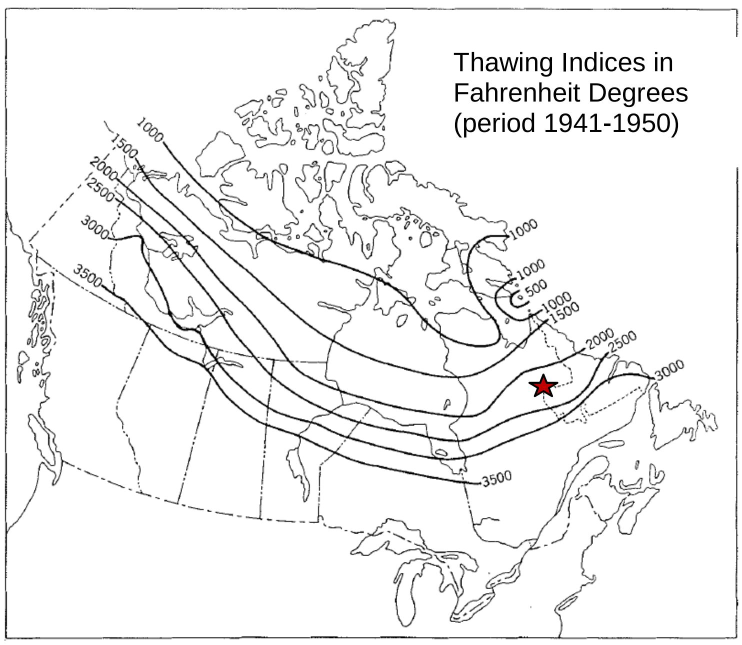


Figure 4-5: Freezing and Thawing Indices in Fahrenheit Degrees between 1941 and 1950 (after Brown, 1960)

Figure 4-6 below provides in a tabular form the general indices from 1970 to 2014 and a graph to show the slight variations over this period.

	THAWING INDEX	FREEZING INDEX	
DATE	T_I (°C.DAYS)	F_I (°C.DAYS)	F_{IW} (°C.DAYS) (with wind chill)
1940-1950	1232	2760	
1970-1971	1314	2875	4763
1971-1972	1188	3576	5583
1980-1981	1259	2665	4416
1981-1982	1387	2979	4734
1990-1991	1264	3274	5095
1991-1992	1253	3404	5250
2000-2001	1409	2661	4135
2001-2002	1650	3165	4955
2013-2014	1324	3020	4644
2014-2015	1645	3338	5067
LabMag 2013-2014	1630	3270	

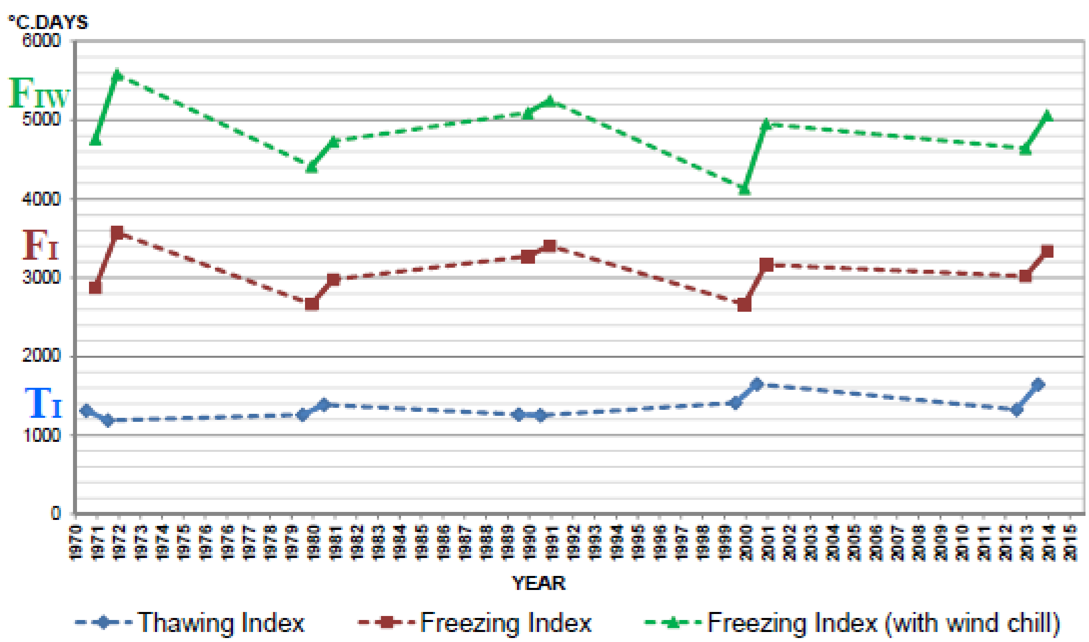


Figure 4-6: Freezing and Thawing Indices – Schefferville Iron Ore Range

Figure 4-6 clearly demonstrates the significance of exposed areas to the presence of permafrost. Of particular interest in this table is the freezing index under wind conditions which is 3 times greater than the thawing index (cumulative number of days above 0°C).

At lower elevations, tree and brush growth is more extensive and deep snows can accumulate and blanket the ground, insulating it from the severe winter freezing temperatures. It is considered that, under such conditions, the insulated terrain could be exposed to as little as 50% of the normal freezing index and the frost penetration is reduced or eliminated if the snow cover is greater than 1 metre. Under these conditions, with the thawing index approaching the freezing index, complete degradation of frozen non-saline ground can occur.

From bottom of the Figure 4-6, it can be seen that the thawing indices have been increasing slightly over time about 1,200 to 1,300°C days since 1940s to present day 1,650°C days. Over the same period the Freezing index has been increased from 2760°C days to 3300°C days. From these values, it is clear that air temperatures experienced slight warmer trend with time. This was compensated with air temperatures that are much colder and longer.

4.2 Precipitation in the Schefferville Area

Figure 4-7 below shows typical precipitation values for summer (June-September) months, which averages about 365 mm; the period when the warm summer rainwater can percolate through the pervious overburden to the deep water table, particularly in the unique outwash gravel in the Howse area.

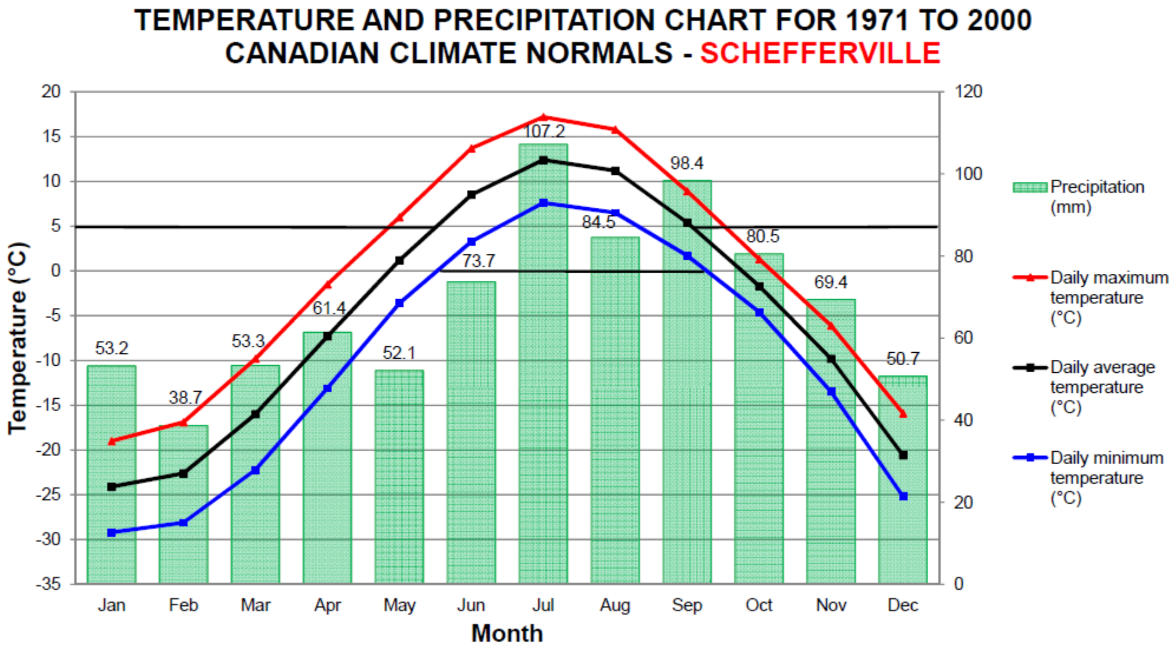


Figure 4-7: Temperatures and Precipitation for Climate Normals in Canada from 1971 to 2000

This phenomenon is particularly relevant at the Howse pit because it is unique in that all of the boreholes (e.g. HW-GT13-01) in the area reported approximately 30 m of course, clean, granular, sandy, gravelly glacial outwash deposits. These conditions have not been reported in the other pits in the area. As such, any summer waters that will percolate into the water table will, over time, thaw any frozen ground within the granular overburden or bedrock.

Finally it follows that, if any permanently frozen ground exists in the low terrain of the Howse area (maximum El. 680 m asl), it would be expected to be present only in widely spaced, small, isolated lenses or pockets of ice-rich materials. If such occurrences exist, they would represent remnants from the degrading original permafrost 20,000 years ago; typical of a stagnating, sporadic permafrost regime.

5 RELATIONSHIP BETWEEN PERMAFROST AND SUBSTRATE

In general, coarse granular soils are more permeable compared to fine grained soils such as silts and clays. Coarse granular soils are characterized by their wide pores allowing warm water to move freely in voids formed between cobles and to percolate deeply into the deposit. In fine grained soils, pores are small and water movement is quite difficult. For this reason, fine grained soils are more susceptible to permafrost where the water retained in their small pores freezes in cold weather and requires much more energy to thaw.

The 30 m thick granular glacial outwash makes Howse Deposit special from the other pits in the area. When warm summer precipitation percolates into the permeable granular deposit, this will naturally have a considerable warming effect on pervious overburden or bedrock, and promote in-situ permafrost melting.

In addition, the downward percolation process was confirmed in an event which occurred in June 2015. The water level in two observation wells at a depth of 80 m in the Howse area rose because of the warm June rain and surface run-off 70 mm after a 2 or 3 days of heavy rain. This is a clear indication that the surface waters flow freely through the pervious, granular, glacial outwash materials and the porous iron formation down to the water table. This suggests that, over several centuries, the soil and groundwater temperatures rose and degraded any isolated permafrost pockets in the overburden and bedrock.

6 GROUND TEMPERATURE RECORDS

Information on ground temperature was available from:

a) 1979 McGill temperature graphs from thermistors installed in the Howse area;

b) Golder ground temperature records beginning in December 2013 in a borehole drilled on the southeastern flank of the Howse deposit;

c) New Millennium temperature records at the LabMag site (El. 513 m asl and 565 m asl) and the high KeMag installation at about El. 705 m asl, both in the Taconite deposits, located on the western limit of the Howse DSO iron ore body;

d) Ground temperatures at Timmins 3 and Timmins 4 by Frank H. Nicholson in 1979.

6.1 Iron ore Company Ground Temperatures 1980-1981 Reported by Dr. Hardy Granberg

Grandberg et al. (1983) reported on a series of ground temperature curves are based on 15 thermistor string installations in 1980-1981, between 60 and 120 m depth in the area of the Howse ore body, as shown on Figure 6-1. Figure 6-2 below show typical curves of results obtained for two thermistors.

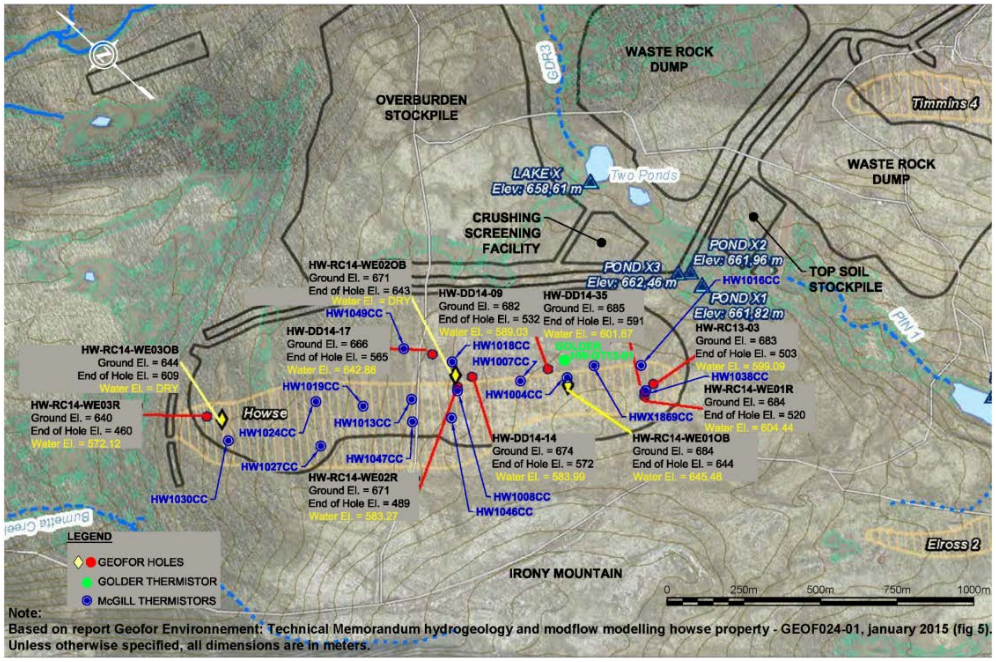


Figure 6-1: Location of McGill Thermistor Installations (Blue Dots) in the Howse area (1980-1981)

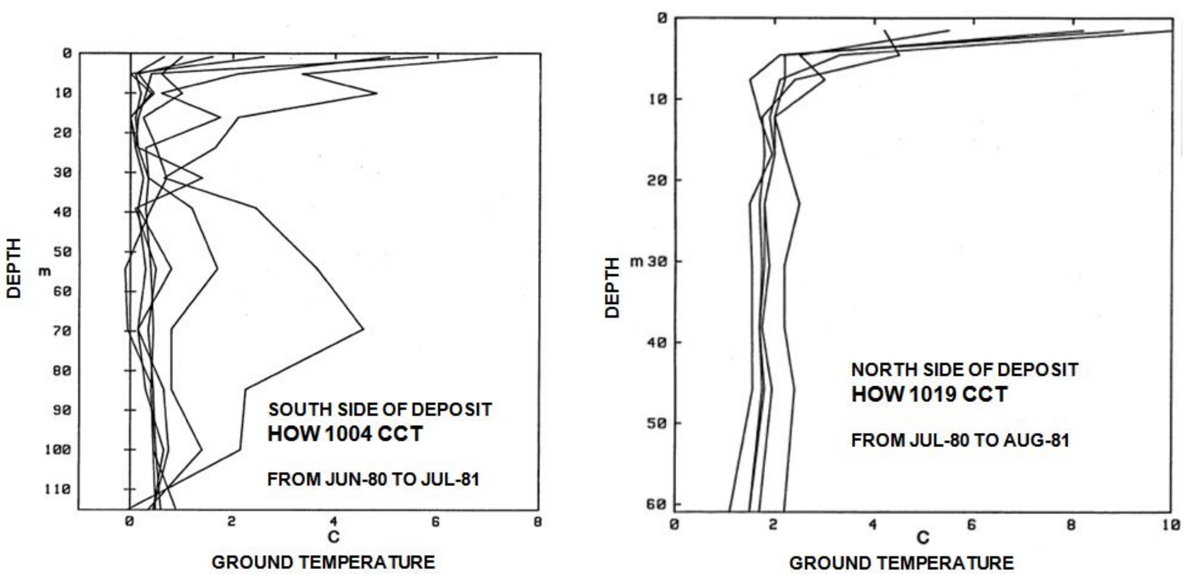


Figure 6-2: Typical McGill Ground Temperature Curves (Granberg) – 1980-1981 - Howse Ore Body at El. 660 m and 670 m

With the exception of the occasional erratic reading, ground temperatures below the winter freeze zone are above zero (+0.5° C to +2° C) and this down to the 60 and 120-metre depths. Since 1983, no other readings were available from McGill.

Nicholson (1979) presented a cross section that showed ground temperatures for an area around the Timmins 4 ore body which illustrates temperatures above 0°C for the terrain below El. 670 m (see Figure 6-3 below).

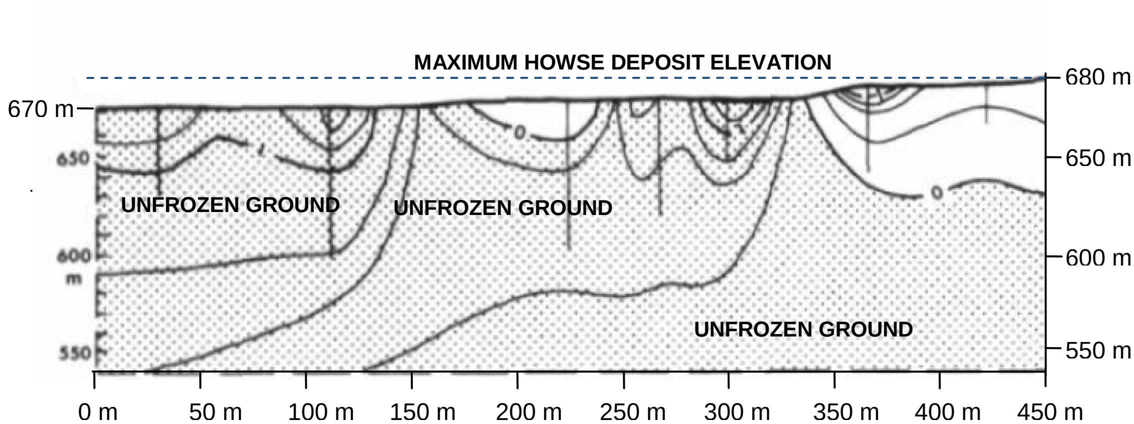


Figure 6-3: Cross Section at Timmins 4 Showing Ground Temperatures (Nicholson 1979). Howse Deposit Elevation Projected on this Cross Section

The Nicholson (1979) findings therefore support the Grandberg (1983) finding by extrapolation; these conditions also exist at the Howse mining area. It is therefore not surprising to see that Granberg (1983) obtained unfrozen ground up to 120- metres in depth.

However, recently it was possible to take resistance measurements on thermistor strings in five (5) boreholes. After receiving the conversion factor from McGill University, the results showed wide variation and they are not considered reliable.

6.2 Golder Ground Temperatures (2013)

Golder Associates installed a thermistor string in December 2013 at 40 m depth on the southeast end of the Howse ore body as shown on Figure 2-1. Figure 6-4 shows that the surface ground temperatures thawed during the first 8 months after installation in December 2013.

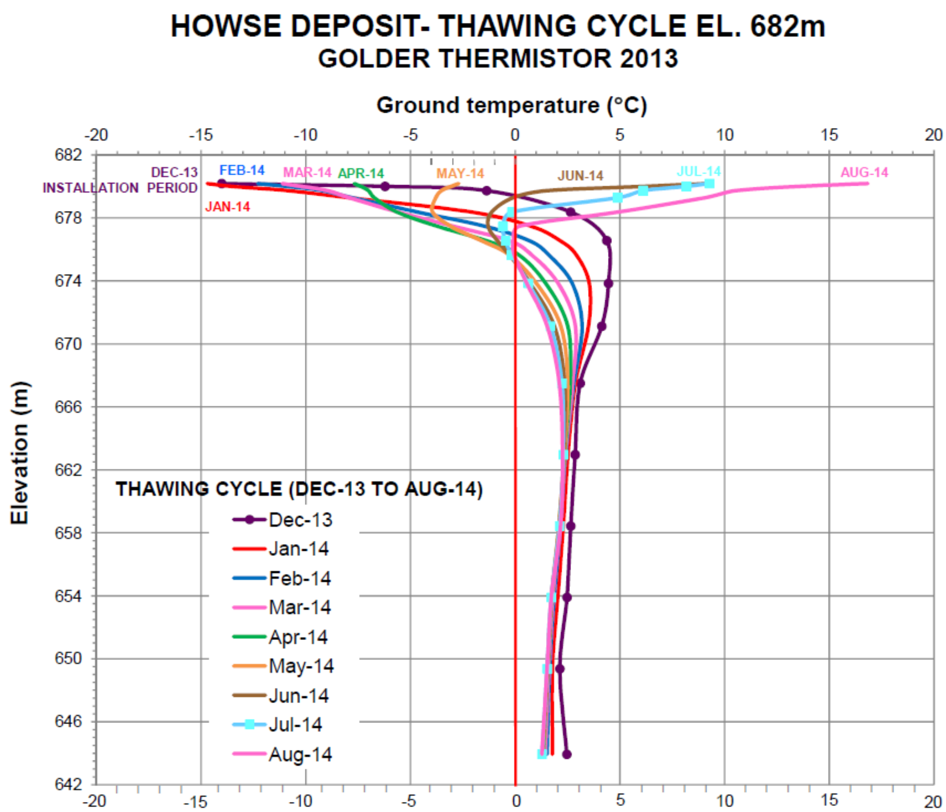


Figure 6-4: Thawing Cycle Dec. 2013 - August 2014

This plot shows the normal surface ground temperature warming from -15°C in December 2013 to +15°C by August 2014. This plot also shows the temperatures below El. 670 m decreasing with depth from +3°C at about El. 666 m or 14 metres below ground surface to about +1.5°C at El. 644 m or 38 m below ground surface. At about the 5-metre depth in seasonal frost penetration zone, the ground temperatures have been warmed to +4°C by the drilling fluid used to drill the holes.

After installation of the thermistor string, all ground temperatures cooled progressively, as expected, to reach the 0°C line by August 2014 at El. 676 m. It is at this point that the warming effects of the drilling fluid have ceased as the subsequent warming cycle begins.

Figure 6-5 below shows the freezing cycle during the following year, from August 2014 to February 2015.

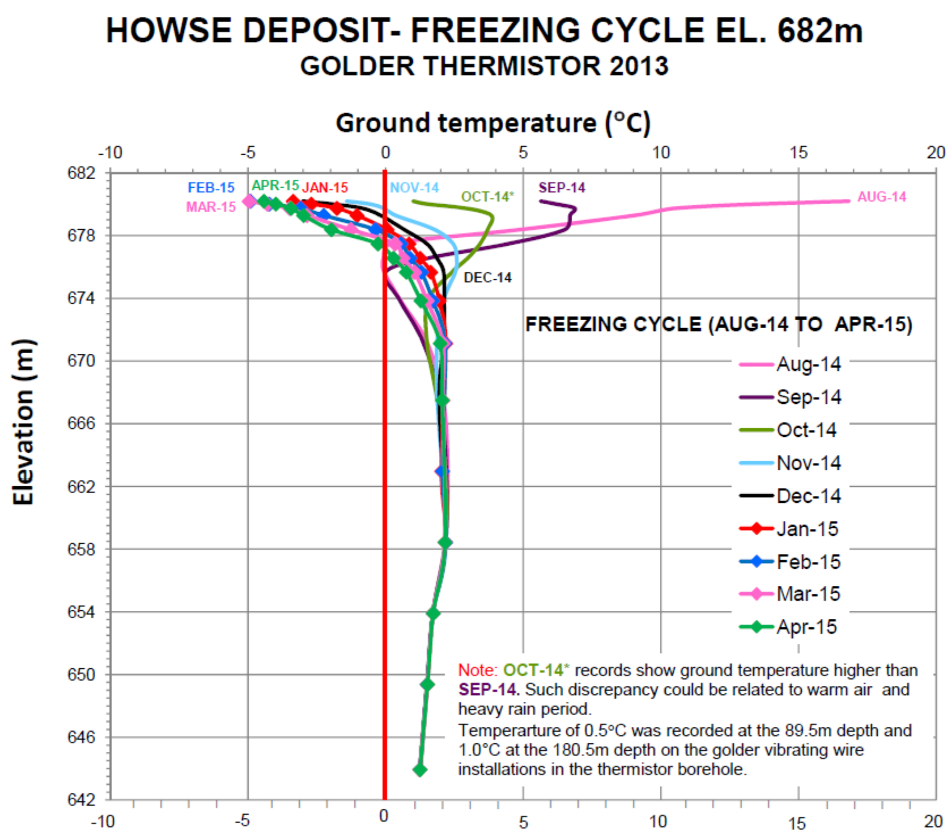


Figure 6-5: Hose Deposit Freezing Cycle - August 2014 to February 2015

The freezing temperature graph shows surface temperatures cooling rapidly from +17^{o}C on August 2014 to about -5^{o}C by February-March 2015. Below the frost cover, the ground temperatures are at about 2.5^{o}C down to the 24 m depth then fall to about +1^{o}C at 38 m depth, or at El. 644 m. At this time, the annual freezing of the surface layer has reached a depth of about 5 m in April. From this information, this is a clear indication that the ground at this location in the Howse ore body is not frozen.

During the following freezing cycle (October 2014 to March 2015), all temperatures in the 4 to 6 metre thick seasonal freezing zone decreased to 0^{o}C, but increased to +2.5^{o}C at the 34-m depth and then cooled to about +1^{o}C at the 40-metre depth.

In conjunction with the thermistor installation, Golder installed two (2) water temperature measuring devices; one at 89.5 m and a second at 180m depth at the same location. These installations recorded a temperature of 0.5^{o}C at the water table interface and 1^{o}C at the 180 m depth. Based on these results, it is concluded that ground temperature probably decreases slowly from 1^{o}C at 40 m to probably 0.5^{o}C at the interface with the water table (80m below ground surface). From this information, it is concluded that there is no permafrost in the terrain below El. 660 m in the Howse area.

Of particular interest on the Golder freezing cycle plot are curves at the 4 to 6 m depth for the months of September and October 2014. These plots show ground temperatures of 0^{o}C in September at the 7 m depth, rising to +2.5^{o}C in October and then cooling again in November. A check of the air temperatures existing at that time shows a distinct hot weather period in October 2014. As such, the warming ground temperatures are likely related to the warm autumn precipitation waters seeping through the pervious sand and gravel overburden to the 7-metre depth, causing the ground temperatures to rise during October. This, in our opinion, is the only explanation for the sharp and unusual rise in ground temperatures this late in the year when air temperatures are usually below freezing. Naturally, if similar events occurred over a period of centuries, serious degrading or elimination on any warm temperature permafrost existing in the overburden would result.

6.3 New Millennium Ground Temperatures

In 2012, New Millennium installed two 10 m deep thermistors in the LabMag Taconite ore bodies located west of the Howse DSO mining area, in wooded areas with relatively deep snow cover in winter (see Figure 6-6 below). These were installed in the southern part of the ore body; one at El. 565 m and a second much further north at a lower elevation of 513 m in the LabMag Taconite formation.

Another 10-metre long thermistor was installed in the southern end of the KeMag deposit located 50 km further north and on much higher ground (El. 705 m) and where bedrock outcrops everywhere (see Figure 6-7 below).

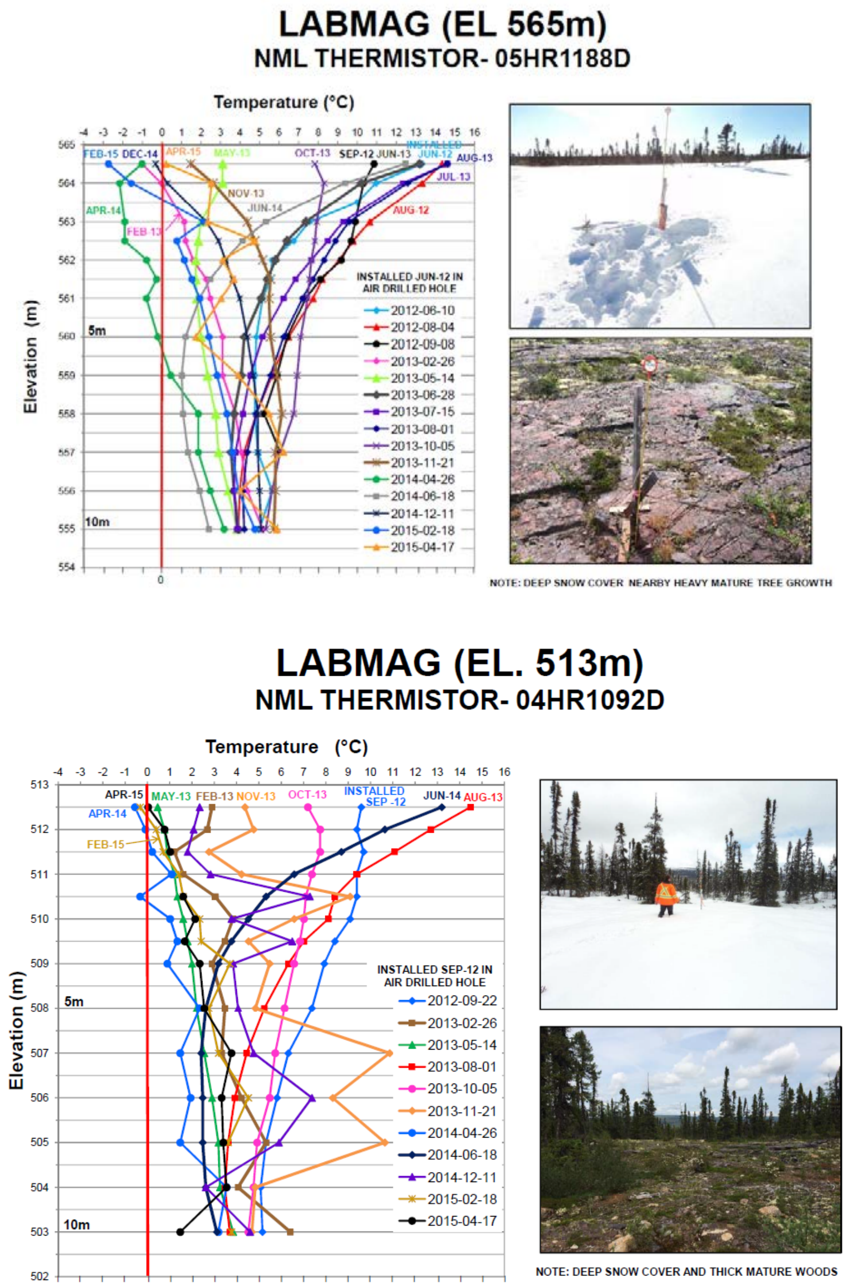


Figure 6-6: LabMag Thermistors Installed at Lower Elevations and in Wooded Areas with Deep Snow Cover

Temperatures over a 2-year period in the two (2) LabMag thermistors west of the Howse property show similar results as the Golder thermistors. Apart from the 3-5m thick annual freezing of the surface layer, all ground temperatures decreased to the bottom of the thermistor strings to a low of about +3°C from a high of about +5°C usually at the 10-metre level.

It is only at the much further north and higher KeMag Taconite site at El. 705 m, west of the height-of-land between the deposit and the lower Caniapiscau watershed, that temperatures suggest permafrost starting at below the 8 to 10-metre depth with temperatures varying between 0° C and -2°C (see Figure 6-7 below).

KEMAG WEST- IFK6 (EL. 705 m)

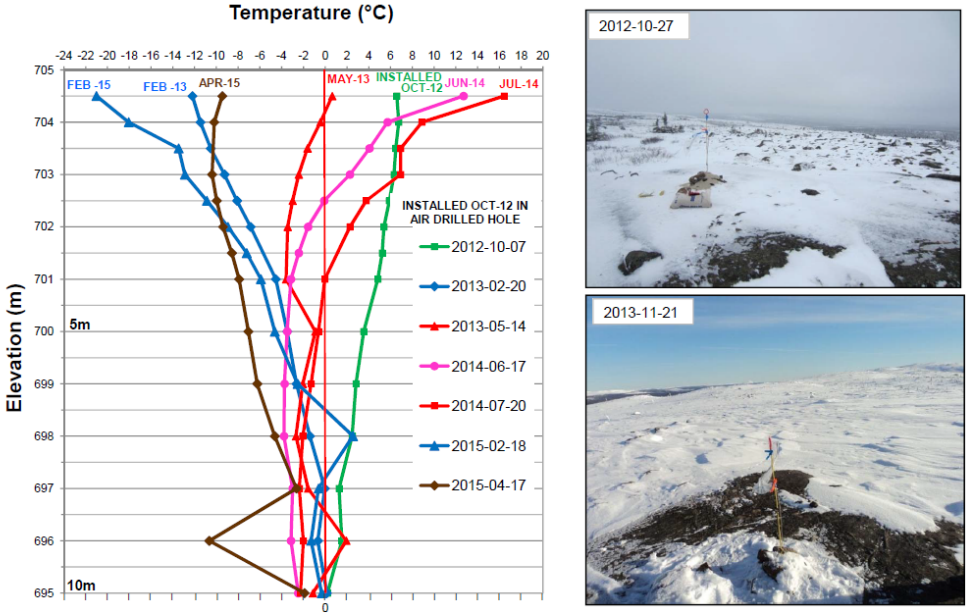


Figure 6-7: Exposed Bedrock and Thin Snow Cover at KeMag

From photographs presented in Figure 6-7 above, one can see that the site is located on the top of a high, bald hill without any tree cover and only a thin snow cover.

Together with the higher ground elevation, this would explain the significant differences between the KeMag and the LabMag ground temperatures, particularly at the 4-metre depth.

7 GROUNDWATER CONDITIONS

Geofor Environment did an extensive evaluation of groundwater conditions in the region and has begun a hydrogeological drilling program over the Howse deposit in 2014. Pumping tests were carried out combined with observation holes to determine drawdown conditions of the iron formations. Table 7-1 shows the depth of groundwater measured for some wells. The locations of these wells with respect to Howse deposit can be seen in Figure 6-1.

Table 7-1. Well Main Specifications (After Geofor)

Hole Identification	Northing (mN) zone 19	Easting (mE) zone 19	Diameter mm	Final Depth (m)	Elevation (TOC)* (masl)** August 28, 2015	water Depth (TOC)* (m) August 28, 2015	water elevation (masl)**	Drill Date (end)
HW-RC14-WE01R	6085660	619715	152.4	164.00	684.173	88.34	595.83	9-13-14
HW-RC14-WE03R	6086703	618737	152.4	180.00	640.145	69.67	570,47	10-19-14
HW-DD14-09	6085950	619571	122.6	150.00	681.599	94.71	586,89	8-20-14
HW-RC13-03	6085655	619755	122.6	180.00	683.449	86.78	596,67	12-07-13
	*TOC = Top Of Casing			**masl = meter above sea level				

A complementary study started in August 2015 was ongoing after submitting the draft for review of this report. Figure 7-1 below presents the longitudinal cross section showing the water levels initially measured in October 2014. Since the completion of 2015 drilling program, the water levels measured in seven additional boreholes have been added to the original graph. The location of these holes as provided by Geofor is presented in Appendix A.

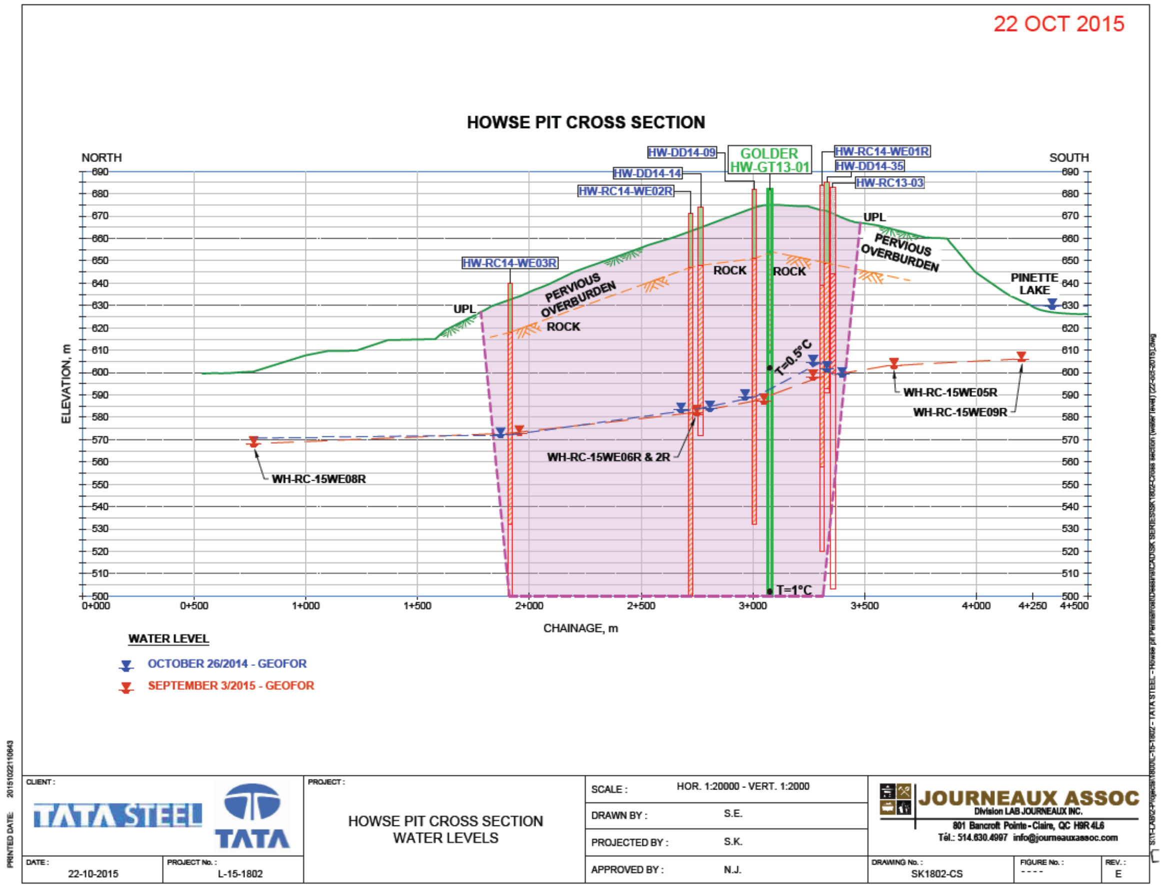


Figure 7-1: Longitudinal cross section along Howse Deposit with measured water levels

It can be seen that the water levels are deep below ground surface in the Howse area, varying usually between 70 and 90 mbgs. In addition, the water table slopes from the southeast end of the deposit towards its northwest with a gradient of about 2 %. The groundwater flow is mainly controlled by the bedding planes and fractures, which trend parallel to major direction of deposit i.e. NW-SE.

7.1 Artesian Groundwater Conditions

Artesian groundwater is groundwater under positive pressure. Such phenomenon is encountered when groundwater exists at different elevations and confined between a layer of impermeable rock or clay.

At several standpipe installations at high elevations, artesian groundwater conditions, confined by the overlying permafrost layer, were identified by the drilling down to free water at considerable depths. These artesian pressures caused water levels to rise to a shallow depth in the observation tubes. Once stable, the water froze in the pipes and ice prevented the measuring devices to go any deeper. Table 7-2 summarises frozen water conditions encountered.

Table 7-2 : Artesian Conditions and Freezing Water in Standpipes

PIT NAME	GROUND ELEVATION (m)	NOTES	APPROXIMATE WATER ELEVATION (m)
Fleming 7N	740	Water encountered at 124 m Water froze at 55 m	685
Timmins 3N	710	Water encountered at 60 m Water froze at 17 m	683
Kivivic 2	775	Water encountered at 26 m Water froze at 20 m	755
Kivivic 1C	740	Water encountered at 44 m Water froze at 42 m	698

It is interesting to note that similar deep water levels (15 to 20 metres) were reported in the Joyce Lake ore body, some 30 km east of Schefferville, in an area at about El. 500 to 540 m where several hundred boreholes were drilled without recovering any frozen ground.

8 DISCUSSION AND CONCLUSIONS

The overwhelming number of thermistor readings reported by McGill 1980-1981 (Howse), Golder (Howse) and NML (LabMag), the deep water levels in pervious granular outwash deposits and the absence of any indication of permafrost below El. 660 m, indicate temperatures all above 0^{o} C and no permanently frozen ground at low elevations in the Howse mining area. This is also confirmed by extrapolating the Nicholson (1979) cross section for the Timmins 4 area for ground above freezing below El. 680 m.

If permafrost exists despite no observation during drilling, it occurs in erratic and isolated small lenses or pockets but not in any extensive identifiable layers.

Further, any remnant frozen ground in the area has insignificant effects as far as the mining operations are concerned, as it will progressively degrade over the 10-year life of the mine as it continues to be exposed to the high calorific warm summer rains as they seep down through the 30-metre deep porous and highly permeable glacial outwash materials to the deep water table. It is this process, occurring below El. 660 m that has completely degraded any localised permafrost pockets or lenses in the overburden and bedrock above the deep water table.

This report concludes that all available records published in McGill reports show that ground temperatures are above 0^{o} C in the low elevations in the Howse region and suggest that massive permanently frozen cold permafrost does not exist. This conclusion is based on the premise that the combined unique geologic circumstances (30-metre deep porous granular deposit and deep water table) have all contributed, over the centuries, to the degradation, if not the elimination, of any remnant of permafrost that could have lingered in the Howse ore body.

It is noted that temperatures measurements of 0^{o} C to $+4^{o}$ C in the Howse area do not support Nicholson's general comment (1979) that temperatures before 1980 were between -2^{o} C and 0^{o} C when Granberg of McGill 1980-1981 thermistors all show temperatures above 0^{o} C.

For all these reasons it is concluded that modeling of such an isolated and erratic frozen ground condition, of unknown thickness and overall lateral limits, would be very difficult if not impossible. It would give only unreliable if not unrealistic results of little value.

References and Acknowledgments

Brown, R.J.E., 1960. The distribution of permafrost and its relation to air temperature in Canada and the U.S.S.R. Journal of the Arctic Institute of North America, 13 (3), pp. 163-177.

- Natural Resources Canada
- Tata Steel Minerals Canada from its various drilling and geotechnical reports (Golder, Geofor and others)
- Rabi Monhanty, TSMC Team Leader
- McGill Sub-arctic Research Station's historic ground subsurface temperature date
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TATA STEEL MINERALS CANADA LIMITED (TSMC)

Permafrost Condition at TSMC
Howse Deposit
Schefferville, Quebec

"CONFIDENTIAL"

Prepared by:

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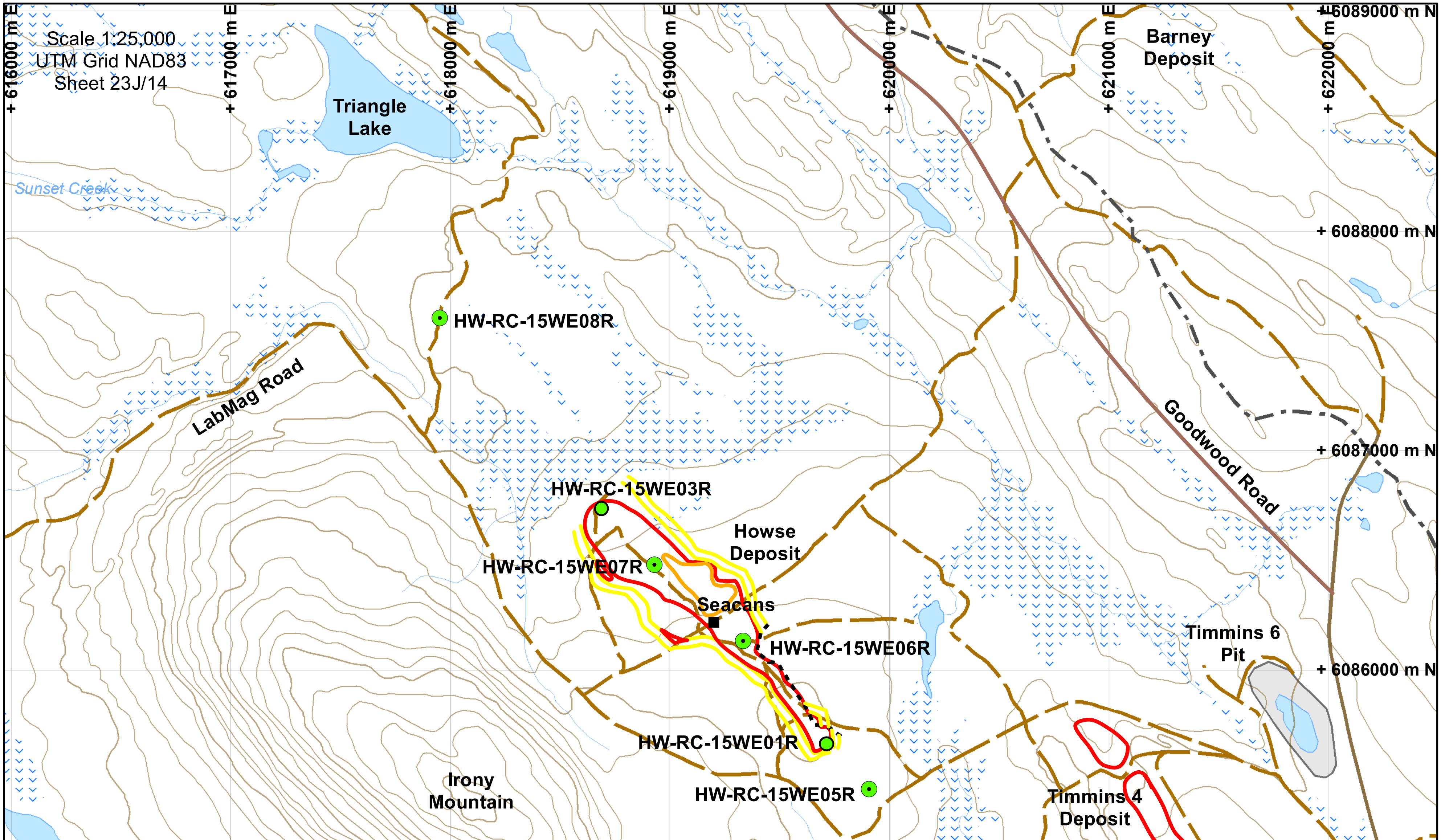
APPENDIX A

LOCATION PLAN OF BOREHOLES DRILLED IN 2015



Howse Hydro-drill Plan 2015

HW-RC-15WE05R - Drill site and number

Hole_Number	NAD83_East	NAD83_North
HW-RC-15WE05R	619907	6085455
HW-RC-15WE06R	619334	6086130
HW-RC-15WE07R	618916	6086345
HW-RC-15WE08R	617952	6087602
HW-RC-15WE09R	620287	6085024

H.S. Sept 3, 2015

ANSWERS FOR QUESTIONS ASKED BY NATURAL RESOURCES CANADA

FOLLOWING THE REVIEW OF JOURNEAUX ASSOC PERMAFROST REPORT FOR HOWSE DEPOSIT

NRCan Request: Please confirm that the borehole HW-GT13-01 equipped with a thermistor cable as reported by Golder Associates (Volume 2, Appendix A) is the same cable mentioned in the Report No. L-15-1802. If yes, please confirm the location of the borehole according to the "potential permafrost map" (Figures 6.19 and 6.20, Volume 1, Main Document).

Answer:

The thermistor cable HW-GT13-01 mentioned in the Journeaux Assoc report L-15-1802 is the thermistor cable installed by Golder Associates in borehole HW-GT13-01 drilled in December 2013.

The borehole HW-GT13-01 is located at the south east limit of Howse deposit as shown below in Figure 1. As shown, HW-GT13-01 is between 50 m and 100 m outside the potential permafrost boundary limit shown on the plan prepared by IOC in the 1980s.

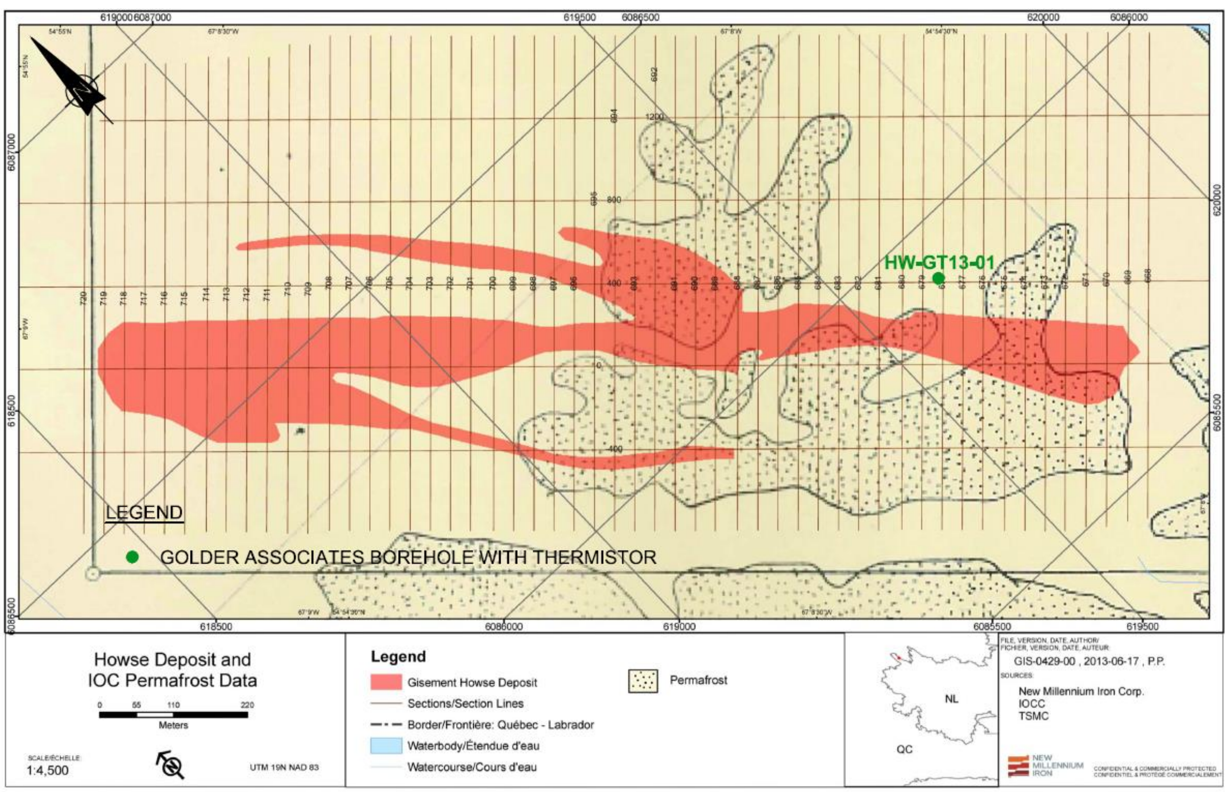


Figure 1: Location plan showing Golder Associates borehole HW-GT13-01 equipped with thermistor

The permafrost boundary limit shown on the plan is a virtual line which does not exist in the field. When the drillers located the borehole on site, they intended to drill an inclined hole to intersect the east pit wall.

It should also be clarified that the original program of Golder Associates was to drill four holes at the two pit wall limits; but due to adverse winter conditions the program was abandoned. The main objective of these thermistors along the pit walls was to investigate if permafrost was to be encountered during the mining operations. For this reason, the thermistor HW-GT13-01 was oriented towards the north east into the pit wall instead to the permafrost area shown on the plan.

- **In the absence of the information requested (Granberg, 1983; IOCC 1974)**

Answer:

The Granberg article is available for consultation only at the McGill library in Montreal, Québec. The article is also available through the GEOSCAN search results at http://geoscan.nrcan.gc.ca/, but is currently un-digitized. TSMC has made a request to be alerted when the digitized request becomes available, and will communicate it to NRCAN when available.

The IOCC (1974) document is appended to this document.

- **NRCAN request: Please provide clarification as to how this "potential permafrost map" has been produced.**

Answer:

The predictive 'permafrost potential mapping' was completed prior to more current, field-based data becoming available from a combination of (i) recent, project-specific measurements of ground temperature data (e.g., from thermistors installed by Golder Associates in the Howse Deposit); (ii) a study completed by Journeaux Assoc (2015) that reveals the important local relationship between elevation and permafrost occurrence, based on both historic and current data; and (iii) additional field observations made by Journeaux Assoc (2015) and Gilles Fortin (pers. comm., 2015). While the general spatial trends predicted in the original mapping are still valid - that is, permafrost is most widespread on windswept hill crests - the new information indicates that ground temperatures in the woodlands in the area are insufficient to maintain permafrost. Accordingly, permafrost (if present) is likely restricted to windswept highs above about 660 m elevation.

The ground temperature of the thermistor HW 1008 CC published by Granberg (1983) is presented in Figure 3. As it can be noticed the ground temperatures available from this thermistor are not very reliable due to the limited data collected. Thermistor HW 1008CC data shows in general no frozen ground with all temperatures above or around zero except in 18/8/81 a year later the surface ground temperature is still positive but much lower. This data shown in Figure 3 confirms that there is no frozen ground at the middle of the permafrost map therefore this map is in error. Therefore the potential permafrost map presented or questioned by the NRCan does not reflect the present observations and data collected on site.

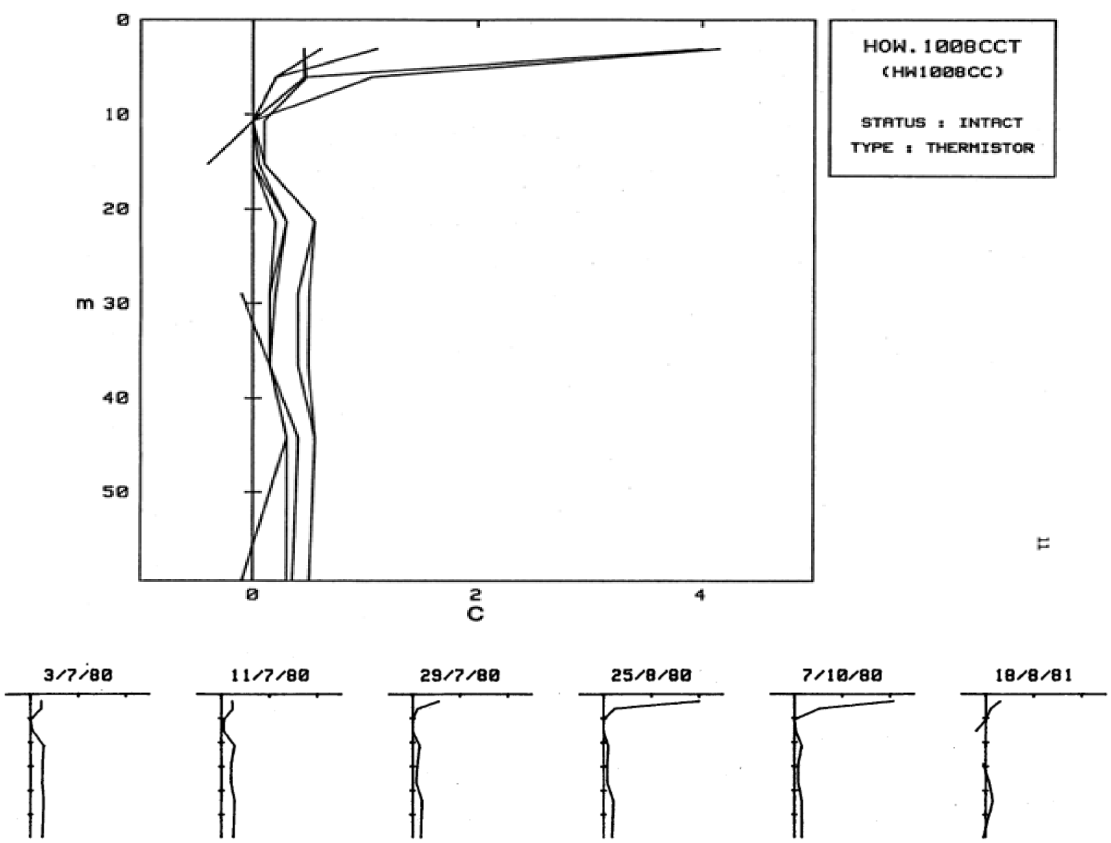


Figure 2: Ground temperature of McGill thermistor HW 1008 CC as reported by Granberg (1983)

- **NRCAN request: Based on the above clarification, NRCan proposes that the proponent install thermistor cable(s) at location(s) within the "potential permafrost map" area to assess the presence/absence of permafrost. NRCan suggests that this (the addition of thermistor cable(s) in permafrost areas) only be considered once an assessment of the literature, that has been used to produce the "potential permafrost map", is completed.**

Answer:

HML will install 2 additional thermistors in Spring 2016 to monitor the permafrost area within the Howse deposit. The location of the first hole is suggested to be at the west near the south end of the ore body.

The location of the second hole is suggested to be at the east side of the ore body half way to the pit wall.

There is no recent information showing permafrost areas in the Howse deposit. Therefore, it is concluded that a new permafrost map cannot be made since all available information does not provide data from which a map can be made.

The irregular line on the map is a surface expression of the permafrost area drawn arbitrarily on the plan. The accuracy of the surface plot on paper is not detectable on site, so there is no positive and definite indication nearby Golder borehole was either within the boundary or outside the boundary. However, it is clear that all subsequent drilling done in the area did not identify any frozen ground and we would conclude that the Golder borehole is in fact valid.

If the investigation was carried out by test pitting, the excavations would have been terminated in frozen ground, particularly if they were located in high, open and exposed areas where seasonal frost penetration could be very deep.

In reviewing the IOC test pit description done in the1980 Trenching Field Notes, for work carried on in the Howse deposit we note that the technician referred several times to (permafrost) with water not far below. These notes were prepared from shallow test pits and this would suggest that it was only frozen ground that the technician was observing. There is no way that the technician could confirm with the equipment he had to confirm that it was permanent frozen ground in the middle of the thawing season which can extend to October as it can be seen on the surface ground temperature of October 7 1980 in borehole HW 1008 CC.

It is considered that confusion was created by using very loosely the term permafrost. From observations at shallow depth in the test pit which in many locations encountered free water below the frozen ground. In this situation, the technician was only observing remnants of the frozen ground developed over the previous winter.

It is therefore it is not surprising that McGill Borehole HW1008 CC drilled in the middle of the potential permafrost map and the temperature readings over a period of 3 months do not show any permafrost mostly all above zero, with the exception of one reading taken nearly a year later which is incomplete and probably not reliable.

From all this information, it is clear that the map of potential permafrost area could only be accurate if one assumes that the frozen ground layer observed in test pits at extensive depth.

The McGill Borehole HW1000CC in the middle of the permafrost map did not confirm such a condition.

- **NRCan Request: Please clarify why permafrost is considered in the hydrogeological model if the conclusion of the Report No. L-15-1802 stated that there is no permafrost at the Howse deposit.**

Answer:

The new hydrological report has been amended to reflect the new permafrost status of the Howse Project.

XX-03-0031

IRON ORE COMPANY OF CANADA

GEOTECHNICAL ENGINEERING

PERMAFROST STUDIES

A REPORT ON

"SUMMARY OF THE PERMAFROST STUDIES

IN THE SCHEFFERVILLE AREA"

MAY 1, 1974

PREPARED AS AN INPUT TOWARDS

CHAPTER 11 ON RESOURCE DEVELOPMENT

(PART II - MINING) AND

CHAPTER 5 ON SITE INVESTIGATIONS

(GEOPHYSICAL SURVEYS)

OF THE PERMAFROST ENGINEERING MANUAL

BEING COMPILED BY THE NATIONAL RESEARCH

COUNCIL OF CANADA, OTTAWA

10

ACKNOWLEDGEMENT

This is a Geotechnical Engineering Report.

PROJECT NAME: Permafrost Studies

REPORT NAME: Summary of the Permafrost Studies in the Schefferville Area.

REPORT DATE: April, 1974

SUBMITTED TO: J. Devon, Supervisor
Geotechnical Engineering

SUBMITTED BY: O. Garg, Engineer
Geotechnical Engineering

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

1.1 General

Mining exploration and production activities in the permafrost regions of Canada have increased rapidly over the last twenty years. A brief history of these mining developments in the Canadian Arctic and Sub-Arctic regions has recently been compiled by Brown (5) and Dubnie (7). From both these publications it becomes clear that a major contribution to studies in the discontinuous permafrost zone has resulted from the observations in the Central Labrador - Ungava Peninsula region. These studies have been undertaken in connection with the open pit iron ore mining operations of the Iron Ore Company of Canada (I.O.C.C.). The mining operations in the Labrador Trough are centered around the town of Schefferville (54°49'N, 66°50'W) in Northern Quebec and lie within the discontinuous zone of permafrost (16) (see Figure 1). The general topography of the area is one of parallel ridges and valleys. Permafrost occurs at higher elevations.

1.2 History of Permafrost Investigations

Permafrost studies in the Schefferville area began in 1955 with a joint I.O.C.C. and National Research Council program in the Ferriman Mine area. This was the first mine where extensive permafrost was encountered in development trenches and continued to a depth of approximately 250 feet. Studies in the Ferriman area continued until the mid 1960's, largely in the form of a joint I.O.C.C.- McGill University project with technical advice from the Division of Building Research of the National Research Council. The details and the results obtained from these studies have been reported by Bonnlander and Major-Marothy (3), Ives (14) and Annersten (1).

In 1967, the focus of interest was transferred to the Timmins area, located approximately 13 miles west-northwest of Schefferville, when the decision was made to open the Timmins 1 mine. The realization that of a total of some 40 deposits, approximately half are expected to be wholly or partially affected by permafrost, led to the establishment of an experimental site on the Timmins 4 deposit. The purpose of this site was to study the factors affecting permafrost and to develop techniques for delineation of permafrost (18,22,23). In addition to continuing these studies, the Geotechnical Engineering section has developed, between 1970-73, a program of routine permafrost delineation for the operating pits as well as determination of the physical properties of frozen rocks (10).

CHAPTER 5 SITE INVESTIGATIONS

2.0 GEOPHYSICAL SURVEYS

2.1 Distribution of Permafrost

In order to evaluate the various deposits from an economic aspect, and schedule the introduction of new deposits into the operation, delineation of permafrost on a regional and deposit scale is essential. Furthermore, if the operating and handling costs are to be kept to a minimum, the distribution of permafrost within a 38 foot mining lift must also be known. It is with these objectives that the Geotechnical Engineering Section of the Iron Ore Company of Canada has developed a three phase program of permafrost delineation and determination of the properties of frozen rocks. The three phases are:

1) Regional Exploration Phase
2) Deposit Development Phase
3) Mining Phase

Each stage produces a prediction aimed at a specific phase of decision making. A summary of the prediction program appears in Figure 6.

2.1.1 Techniques Used in Delineation of Permafrost

The two geophysical techniques used most commonly in the delineation of permafrost in the Schefferville area are:-

1) Seismic Surveys
2) Resistivity Surveys

In addition, borehole logging techniques have been used on a limited basis in the delineation program.

2.1.1.1 Seismic Surveys

Seismic refraction surveys with an S.I.E. RS-4 multichannel seismograph are carried out to delineate overburden depths and the permafrost table. In order to avoid dip effects, the geophone arrays are oriented parallel to the strike. A typical plot depicting the relationship between the first arrival time of the signal, and the shot-detector (geophone) distance is shown in Figure 4. The depths to the various layers are calculated by using the standard relationships between the velocities and the critical distances (6). These surveys are undertaken preferably in August and September when most of the groundfrost is no longer present.

Interpretation of the data is based on these following broad groups of velocities:

1) $<$ 3,500 ft/sec for unfrozen overburden

2) 3,500 to 6,000 ft/sec for frozen overburden and leached unfrozen rock.

3) $>$6,000 ft/sec for bedrock, with velocities in frozen bedrock being up to 3 times those for the same material in an unfrozen state.

Based on the above interpretation procedure the depths to the permafrost table at the locations of the survey are obtained (9).

Seismic surveys are being used on a routine basis in the Schefferville area for determining the top of permafrost and for obtaining the physico-mechanical properties of the material (11).

2.1.1.2 Resistivity Surveys

Resistivity surveys using a Soiltest R-60 dc system are performed in order to delineate the base of the permafrost. The survey lines are oriented parallel to the strike of the geological formations. Although both Wenner (horizontal profiling and vertical sounding) and Schlumberger configurations were tested and found to be satisfactory, the latter was preferred because of its lower sensitivity to lateral inhomogeneities. Since the aim of the resistivity surveys is to obtain the depth to the base of permafrost, an expanding electrode configuration is used.

An example of the plot of calculated apparent resistivity values versus the electrode spacing used in the survey on log-log paper is shown in Figure 5. These plots are interpreted using Orellana and Mooney two and three layer Master Curves. The maximum depth of penetration obtained in permafrost is in the order of 150 feet using the above instrumentation. However, greater depths of penetration in the order of 250 feet have been achieved in the permafrost areas of Schefferville using a high power ac transmitter (20).

It should be mentioned that the depths to the base of permafrost obtained from the resistivity surveys in areas of known geology correlate within 15 percent with depths obtained from temperature measurements.

2.1.1.3 Borehole Logging

The initial attempt to evaluate the use of borehole logging techniques in the delineation of permafrost was made in 1971 (24). The logging was done with equipment built to NIM specifications by Gearhart-Owen Industries Inc. It was concluded that the dry-hole resistivity and natural gamma logging tools offered the best potential for the delineation of permafrost and the stratigraphic correlation respectively.

Based on a subsequent study it was concluded that higher electrical resistivity and negative self potential values obtained from logging could successfully delineate permafrost at depth (20).

Finally, the results from a recent study suggest that uphole wave-front (seismic) shooting techniques also have potential for determining the bottom of permafrost in the Schefferville area (13).

2.122 Results from Permafrost Prediction Program

Permafrost investigations for a particular deposit such as Fleming 3 constitute the second of the three phased delineation program (8).

During this stage the aim is to delineate permafrost in three dimensions using geophysical methods and ground temperature measurements from thermocable installations.

Seismic surveys provide the depths to the permafrost table and resistivity surveys are used for determining the base of the permafrost. An example of the results obtained from resistivity surveys for Fleming 3 is shown in Figure 8. The map is subdivided into four zones (9). These are:-

i) unfrozen

ii) unfrozen to 70'feet talik but possible permafrost below 70 feet.

iii) Permafrost with a base between 100 and 150 feet.

iv) Permafrost with a base greater than 150 feet.

The delineation of permafrost in a deposit at this stage has the following practical applications in the development and production of an ore body. These, in order of time are:-

i) Delineation of areas where development trenching is feasible.

ii) Expected ground conditions during development drilling.

iii) Economic planning of mining operations, particularly with respect to production drilling and blasting costs.

iv) Delineation of areas of the pit wall which will be affected by permafrost. This is required for the design of pit slope angles.

v) Operational planning of areas where free digging is possible during dirt stripping.

vi) Delineation of areas of potential water problems during operations.

vii) Broad delineation of the blasting patterns and charges to be used.

For some of these applications only the depth of the permafrost table is required, whereas for others only the depth to the base of permafrost is required. Keeping these separate purposes in mind, two different plans can be drawn. Figure 7 is a contoured plan of the depth to the permafrost table. This also delineates areas of frozen overburden which generally require drilling and blasting. Figure 8 shows the estimated base of the permafrost, as interpreted from the resistivity survey.

2.2 Ice Occurrence and Distribution

An understanding of the nature of permafrost and its relationship to the material affected by it is required for a possible solution to any of the problems caused by permafrost. Therefore, observations regarding the type and distribution of ice have been made on a regular basis in the operating pits such as Timmins 1 and Fleming 3. These observations indicate a definite relationship between the lithology and moisture content of the rocks and the nature of permafrost. The highly leached porous ores generally contain less than 5 percent moisture (by weight) and ice is rarely visible, even with a hand lens. The material is well bonded by minute crystals of ice present in pore spaces. In such cases the presence of permafrost must generally be confirmed by temperature measurements.

In the lower grade ore material and waste wall rocks which are more massive and have a distinct fracture pattern, ice is generally present as sheets and lenses (1/2" or more in thickness) parallel to the bedding and joints (Figure 2). The moisture content shows variations with rock type, with average values being in the 10-15 percent range (by weight) and local maxima as high as 30 percent (by weight) in slates. Ground temperatures in permafrost vary between 25° and 32° F. Although no definite measurements have been taken, it seems likely that a portion of pore water in most of the rock types must remain unfrozen at the range of temperatures encountered in the Schefferville area.

It should be emphasized that at any given depth there is very little temperature difference between rock types. A strong correlation exists between the moisture (ice) content, and the form of ice for a particular rock type. The mining problems caused by the presence and distribution of permafrost are discussed in Chapter 11.

CHAPTER 11 RESOURCE DEVELOPMENT

3.0 OPEN PIT MINING IN PERMAFROST

3.1 Exploration (Techniques for Delineation)

As outlined in Figure 6 the distribution of permafrost at the exploration stage of the open pit mining is required for:

a) Preliminary deposit scheduling

b) Long range planning of mining access facilities and

c) Selection of areas where future detailed permafrost studies are required.

In order to achieve the above objectives a study of the topography, vegetation, snow cover and the surficial features indicative of permafrost is undertaken in the area.

3.1.1 Vegetation and Snow Cover

It is fairly well established that topography, vegetation, snow cover, drainage and mean annual air temperature are the controlling factors in the distribution of permafrost in the discontinuous zone (4). Based on the earliest study undertaken in the Schefferville area, it was concluded that the quickest way to predict the location of permafrost was through the analysis of the topography and vegetation (3). Based on recent studies, the critical snow depth for the maintenance of permafrost in the Schefferville area has been found to be approximately 27 inches (12, 17).

Although snow is the most important parameter in the distribution of permafrost, the widespread application of the concept of critical snow cover is still in the process of refinement. Therefore it is necessary at this time to place great emphasis on temperature measurements at depth.

3.1.2 Temperature Measurements

The initial temperature measurements in the Schefferville area were made using thermocouples as sensors. Thermocables having 12 thermocouples per cable were initially installed in oil-filled holes lined with plastic tubing. The instruments used to measure the temperatures were a Speed-o-max recorder and a Honeywell potentiometer (21). In the next series of installations in 1968, thermocables were enclosed in rubber hose and inserted in drill holes, which were filled with sand. This was done primarily to reduce the risk of loss of oil and inflow of water to the plastic-lined tubes. The Honeywell potentiometer was used in the measurements. The accuracy of the potentiometer was estimated to be 0.2°F to 75 feet with increasing inaccuracy to about 0.6°F at 200 feet

(21, 22). Apart from the need to improve upon the accuracy of the temperature measurements using a potentiometer, its use for extended periods of time during the cold winter months posed practical problems, such as the freezing of the ice bath and the variation of the emf of the standard cell.

Thermistors mounted on multi-conductor cables have been used in all the holes since 1971. Thermistors were preferred over thermocouples for the following reasons:-

1) Higher sensitivity to changes in temperature.
2) Compactness, and simplicity in mechanical design.
3) Availability of an accurate readout system (precision bridge) capable of providing satisfactory temperature measurements for extended periods of time in cold winter months.

The accuracy of the temperature measurements using thermistors depends on the accuracy of their calibration. The thermistors used since 1971 are accurate to $\pm$ 0.005°F.

The end product of the regional exploration phase is a 1" = 1000 feet scale permafrost prediction map. The estimated accuracy of the 2-dimensional prediction is in the order of $\pm$ 500 feet or better.

3.2 Production (Problems Associated with the Mining of Frozen Material)

3.2.1 Drilling and Blasting

The heat generated during rotary blast-hole drilling with air circulation in permafrost particularly with high ice contents and temperatures close to 32°F, causes the ice on the sides of the hole to melt. This leads to severe caving. Also, the filling of blast holes with water from the nearby talik zones of limited extent further aggravates the problems of melting and caving, and often several holes have to be drilled before one is suitable for loading.

Ice present in the permanently frozen rocks absorbs a large proportion of the energy generated by the explosives in a blast

Therefore, in order to obtain the required fragmentation, far more explosives are needed to break the frozen material as compared with the unfrozen material. It has been found that the efficiency of a blast is controlled not only by the total ice content but also by the type and distribution of the ice. In practice, a more dense blast hole pattern and a more powerfullexplosive (Metallized Slurry such as Hydromex as opposed to AN-FO) is required (2,15). This results in an increase in the cost of the blasting operation.

Poor fragmentation due to permafrost produces large blocks of material and uneven pit floor topography and results in a reduction of production rates.

3.2.2 <u>Processing (on site) - Crushing</u>

Problems are encountered due to the blasted material refreezing together and causing bridging in the crusher feed hoppers. Based on a study conducted on the crushability index it was concluded that the percentage of the particles larger than 1 1/2 inches at the secondary crusher is at least three times greater in frozen material than in unfrozen ore. This is due to the increased hardness and plasticity of the frozen material. Therefore the cost of crushing the frozen ore on site prior to shipment is increased.

3.2.2.1 Construction of Structures on Site

The presence of permafrost has created problems in the selection of construction sites. The active layer over permafrost provides an unstable base for buildings and railroads.

During the construction of the railroad from Sept-Iles to Schefferville (19), other rail facilities, and the Schefferville townsite,permafrost was encountered. The ice rich material was excavated and the site filled with dry unfrozen rock.

Site investigation of the proposed location of the Timmins Mine service garage proved the existence of extensive zones of ice richhpermafrost with an unstable active layer. Further site investigations, including ground temperature measurements located a permafrost free area. The building was constructed in 1968 and no problems have been encountered with the foundations.

3.2.2.2 Material Handling

In addition to the above mentioned problems, there are handling problems which also contribute to the increased cost of mining the frozen ore in the Schefferville area. These are:-

1) The surface and near surface runoff conditions in the permafrost areas lead to an open pit acting as a sump. The runoff

water flows over the permafrost surface and enters the pit. The presence of water on the pit floor results in thawing of the permafrost and leads to difficult operating conditions.

2) Unfrozen overburden may normally be stripped without blasting, but frozen overburden must be drilled and blasted prior to its removal.

3) The stockpiles in Sept-Iles may freeze if not insulated during the cold winter months. A program has been initiated in Sept-Iles to monitor the temperature changes in the stockpiles:

a) with natural snow cover

b) with an artificial snow cover which has been put in place early in the winter before heavy snow occurs, and before frost has had the opportunity of penetrating very far.

These problems can only be controlled by careful planning and closely controlled operating procedures. Therefore the delineation of permafrost on a regional and deposit scale as well as on a 38 foot mining lift is essential.

3.2.3 *Transportation*

Two problems that are usually encountered during the transportation of frozen ore from the producing mines in Schefferville to Sept-Iles, Quebec, 360 miles away are:

1) Thawing of ore en route to Sept-Iles results in wet 'sticky' ore which is difficult to remove from the rail car.

2) During the beginning and the end of ore season when the air temperatures are still below 32°F, the ore freezes to the sides and the bottom of cars. This necessitates breaking the bond between the ore and

the car by heating with propane heaters before the ore can be dumped.

3.3 Techniques Used in the Delineation of Permafrost at the Mining Phase

In addition to carrying out the geophysical surveys for each 38 foot lift prior to mining, temperature measurements are made both in the pit walls and floors and in blast holes during the mining phase (see Figure 6) of the permafrost program. These temperature measurements involve the use of portable thermistor probes specially developed for this purpose (Figure 3).

In the pit floor, holes are drilled to between 2 and 5 feet using either a steel rod or a Cobra drill. Temperature stability is generally reached within 20 minutes, although in cases of exceptional ground disturbance this can be extended to 2 hours.

In the 9 7/8 inch blast holes the thermistor probe is mounted on copper wire in a bell shaped insulator. This insulates the probe from the air temperature in the drill hole. The major problem experienced in temperature measurements involve ensuring that the results are not affected by outside influences such as air temperature, surface water and heat generated during drilling.

The results of this third and the final stage of investigation for the permafrost delineation are:-

1) a plan showing the distribution of permafrost which outline the areas of potential problems in drilling and blasting.

2) the distribution of permafrost on a 1 in=40 ft scale geological cross section which contains the designed pit limits. Examples of these are shown in Figure 9 and 10 respectively.

In addition to temperature measurements in the pit face, pit floor and blast holes, observations on the type, quantity and distribution of ice in the various rocks are also made on a lift by lift basis during the excavations in the pit. This allows evaluation of the accuracy of the permafrost delineation and makes available supplementary information required for a complete understanding of the behaviour of frozen material for future mining operations in permafrost.

As a part of the overall program of predicting the behaviour of frozen material during the mining operations on a 88 foot lift, the following physical and mechanical properties of frozen rocks have also been measured in the laboratory:-

1) Thermal conductivity.

2) Sonic velocity.

3) Electrical resistivity.

4) Compressive and shear strengths.

It is hoped that these studies will help in the optimization of the mining operations.

4.0 SUMMARY AND CONCLUSIONS

To date the main efforts in the Iron Ore Company of Canada's permafrost program have been aimed at the three dimensional delineation of permafrost in the Schefferville area. Permafrost predictions on three different scales are required for three distinct phases of the open pit mining operations i.e. exploration, development and mining. However limited efforts have also been made towards:

1) the determination of physical and mechanical properties and the behaviour of frozen material and

2) the monitoring of blasts in permafrost.

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FIGURE 2

OCCURRENCE OF ICE ALONG THE BEDDING
AND JOINTS

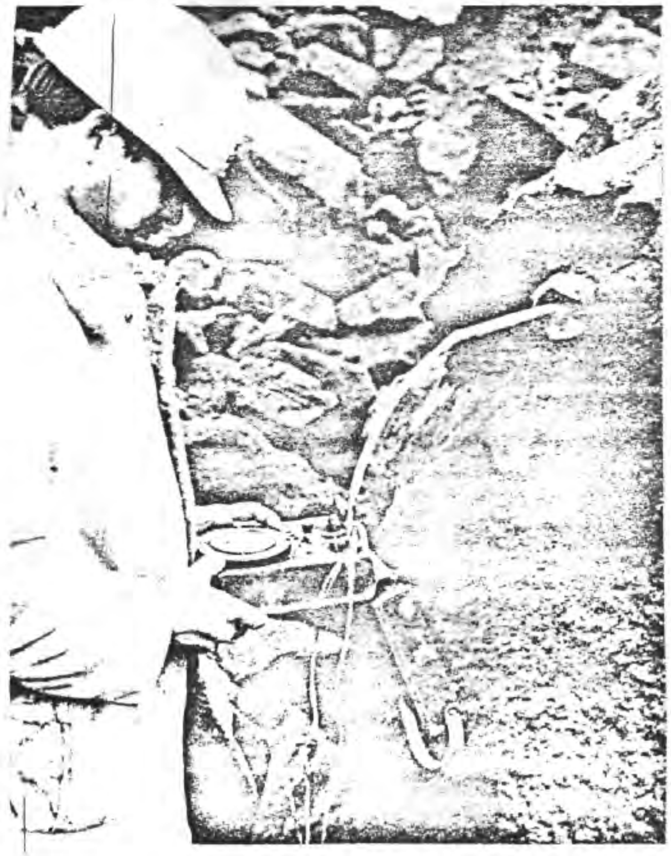


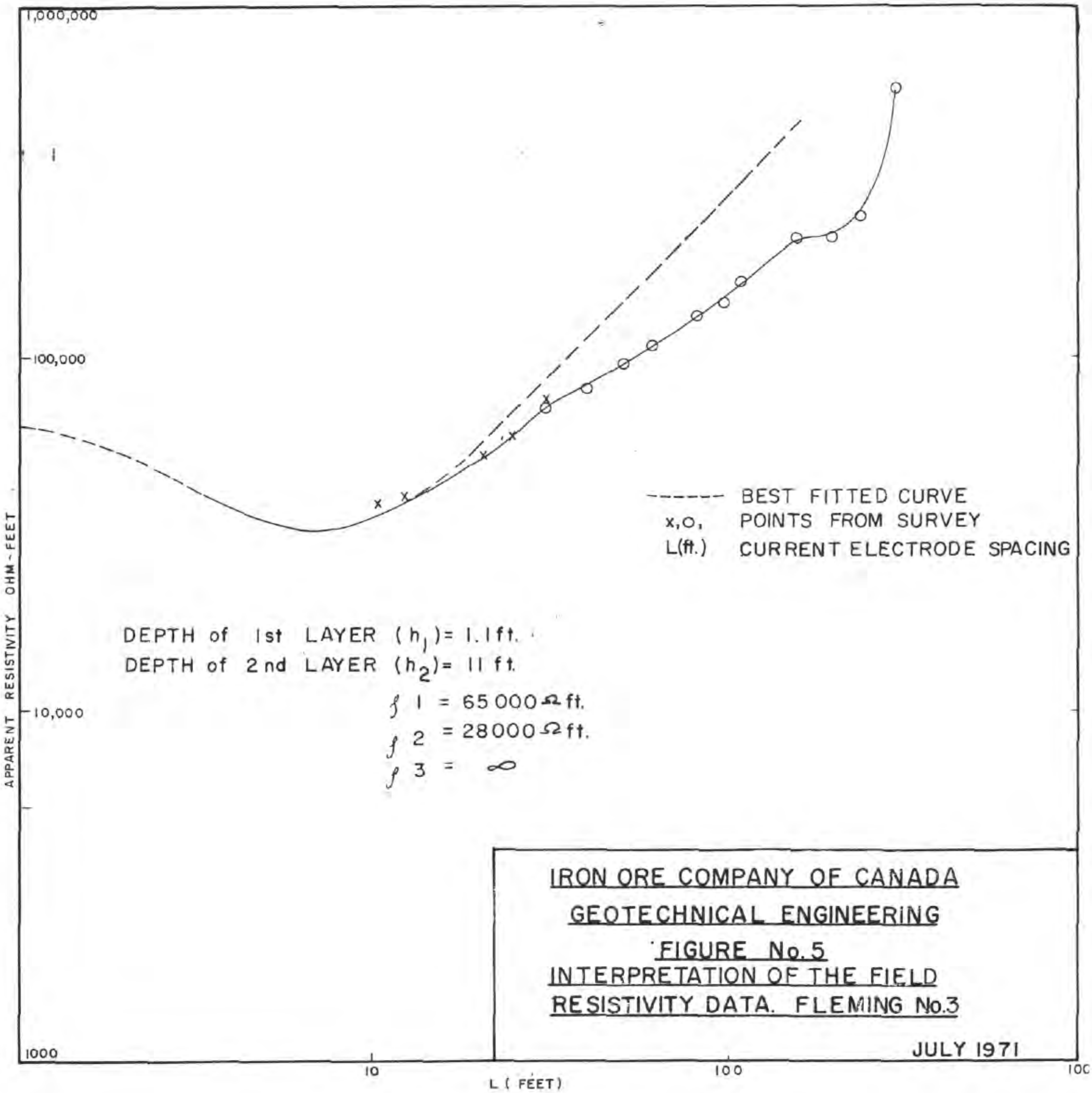
FIGURE 3

MEASURING THE TEMPERATURE IN A PIT FACE USING A THERMISTOR PROBE DEVELOPED BY THE GEOTECHNICAL ENGINEERING SECTION, IRON ORE COMPANY OF CANADA.

FIGURE No. 6

SUMMARY OF PERMAFROST PREDICTION PROGRAM

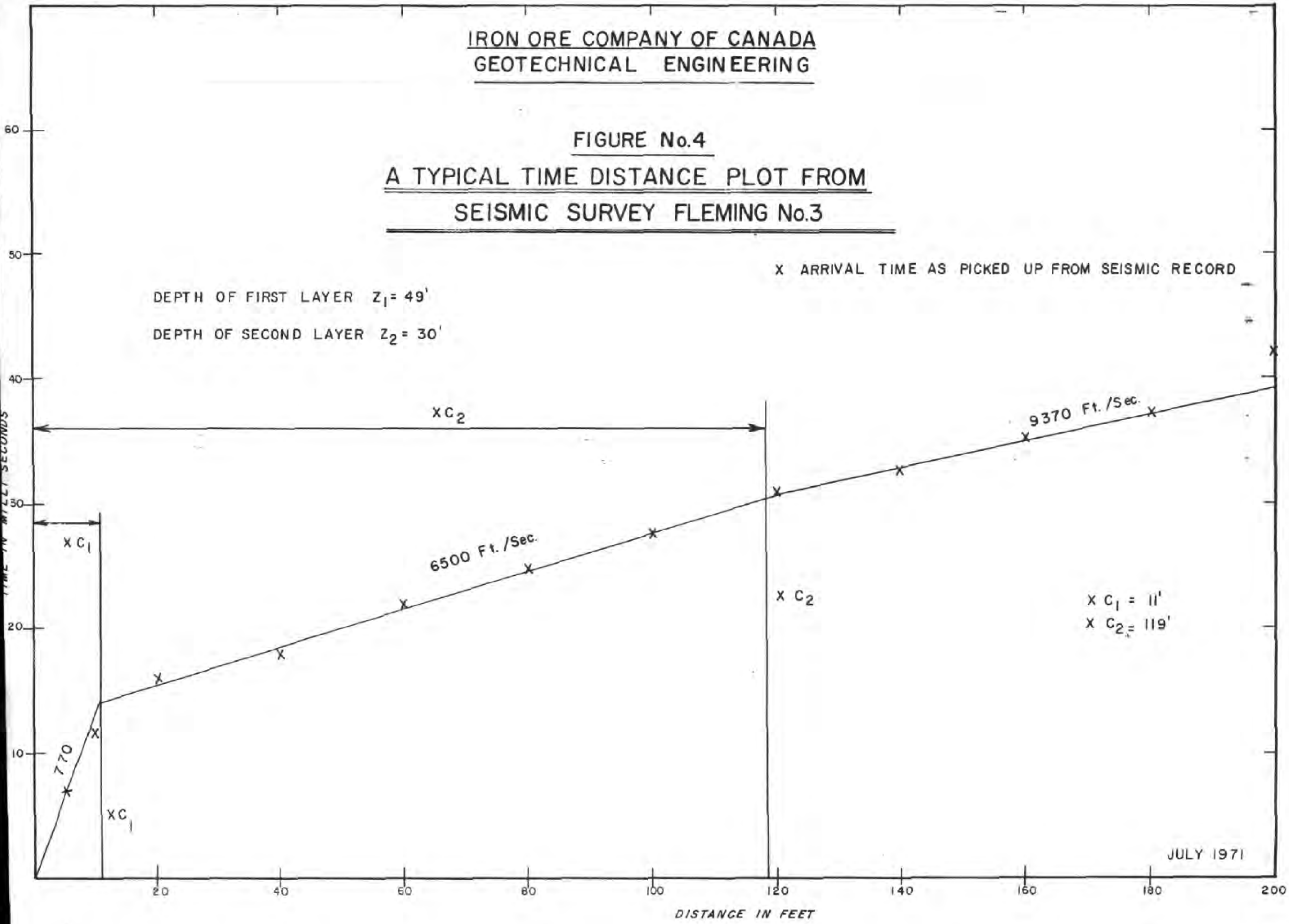
PHASE	SCALE	TECHNIQUES USED	PURPOSE
Regional exploration	1" = 1000'	Aerial photos, use of geomorphological features	① Preliminary deposit scheduling. ② Long range planning of mining access facilities ③ Future permafrost studies
Deposit development	1" = 100' 1" = 200'	① Ground temperature measurements ② Seismic surveys ③ Resistivity surveys	① For an economic evaluation of a deposit ② Facilitates mine planning (Design of slopes and hydrological problems)
Mining (lift by lift)	1" = 40'	① Seismic surveys ② Resistivity surveys	① Outline areas for difficult drilling ② Prediction of response to blasting


1,000,000
100,000
10,000
1000
APPARENT RESISTIVITY OHM - FEET
10
100
L (FEET)
------ BEST FITTED CURVE
x,o, POINTS FROM SURVEY
L(ft.) CURRENT ELECTRODE SPACING
DEPTH of 1st LAYER (h_1)= 1.1ft.
DEPTH of 2nd LAYER (h_2)= 11 ft.
ρ 1 = 65 000 Ω ft.
ρ 2 = 28000 Ω ft.
ρ 3 = ∞
IRON ORE COMPANY OF CANADA
GEOTECHNICAL ENGINEERING
FIGURE No. 5
INTERPRETATION OF THE FIELD
RESISTIVITY DATA. FLEMING No.3
JULY 1971

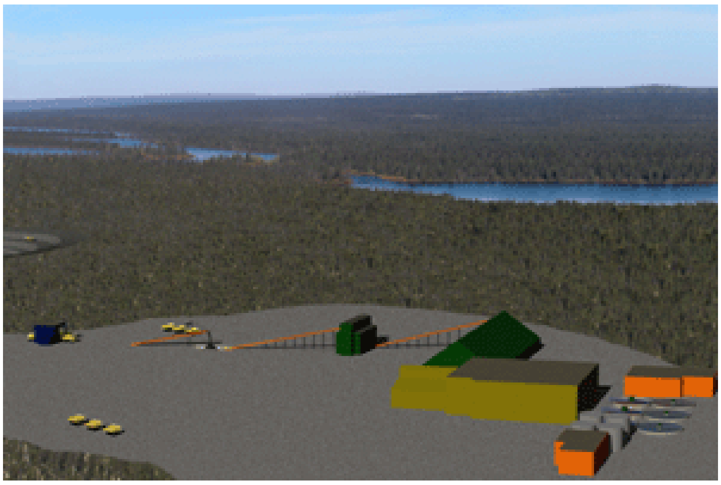
IRON ORE COMPANY OF CANADA
GEOTECHNICAL ENGINEERING

FIGURE No.4

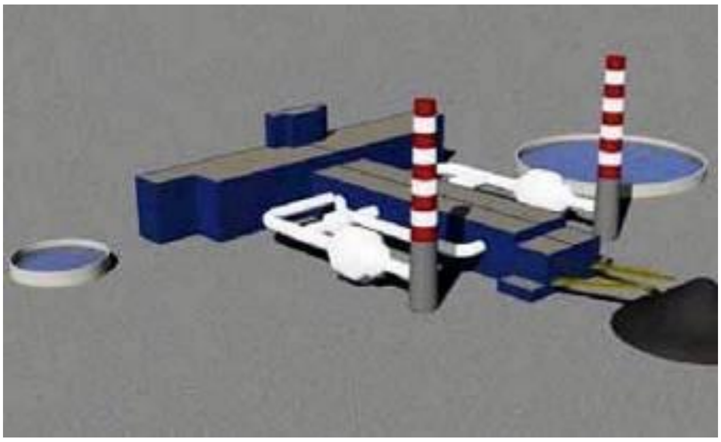
A TYPICAL TIME DISTANCE PLOT FROM SEISMIC SURVEY FLEMING No.3



LabMag GP Inc.

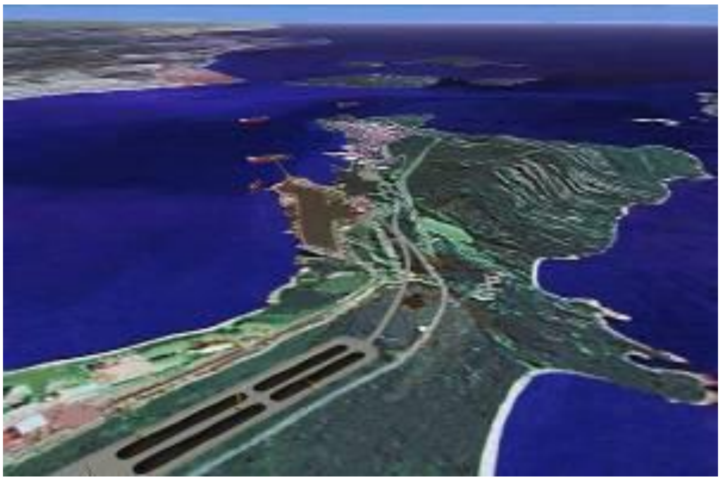


LabMag IRON ORE PROJECT



The Elross Lake Automatic Weather Station

BY: Wayne Pollard



2005

The Elross Lake Automatic Weather Station

Introduction

This report summarizes 11 months of data (September 2003 to August 2004) from an automatic meteorological station installed in the Elross Lake area as part of an environmental analysis for mineral exploration activities. This report includes technical data about the sensors installed and details about the location and setting of the meteorological station.

Background

Schefferville lies in a part of the Canadian Shield known as the Labrador Trough. The physiography is dominated by a northwest-southeast trending ridge and valley topography created by 2 large synclines; one with its long axis lying along the Howell's River Valley and the other along Lake Petitskipau. The climate of central Ungava has been classified as humid microthermal under the Koppen-Gieger system (Petersen 1969) but is more widely described as a continental subarctic boreal forest climate. Long-term records indicate a mean annual air temperature of -4.9°C (for the town site at 520 m asl) but tundra ridge areas have been documented to have mean annual air temperatures as low as - 7°C. The seasonal pattern in air temperature is typically continental and is characterized by dramatic extremes with extreme minimums as low as -50°C and extreme maximums above 30°C. The annual precipitation is roughly 732 mm and is roughly skewed with a peak in late summer. Despite the low annual air temperatures permafrost in central Ungava is discontinuous and in the Schefferville area is restricted to upland tundra areas and some lowland organic soils where patched of permafrost form palsas. The discontinuous nature of the permafrost is largely due to the relatively deep snow cover that insulates the ground from the cold winter air temperatures.

Schefferville lies in the transition zone from lichen woodlands of southern Ungava and the true tundra of northern Ungava. The significant relief of the Schefferville area (200-300m) has produces a wide range of vegetation communities. Open lichen spruce woodland and Spruce feather moss communities dominate the forested lowlands while poorly drained areas are typically covered by wetlands. Upland surfaces typically display alpine tundra and alpine heath communities.

Meteorological Station

A standard Campbell Scientific automatic meteorological station was installed adjacent to Elross Lake to provide background environmental data in support of resource exploration activities in the area. The Campbell system installed is designed for use in harsh arctic environments (tested to -55°C) and includes an anchored tripod base equipped with: (1) a Kipp & Zonen SP Lite Pyranometer to measure incoming solar radiation, (2) a HMP45CF T&RH sensor with a radiation shield to measure air temperature and relative humidity, (3) a RM Young wind monitor to measure wind speed and direction, (4) two 107B soil thermistors installed at depths of 5 and 30 cm to measure the ground temperature regime, and (5) a CS105 atmospheric pressure sensor to monitor barometric pressure. A 12-volt gel cell recharged by a 5-watt solar panel powers the system. The heart of the system is a Campbell CR10X data logger which monitors sensor outputs every 60 seconds and records data as hourly averages (base value of the station is ~ $15,000). Air temperatures are collected at a height of 2.0 m above the ground surface and wind and radiation data are collected 3.0 m above the ground.

The station was set up and started by Dale Andersen (Ph.D. student with W. Pollard) on September 21, 2003 and the first download was on August 26, 2004 by Pollard. The McGill Subarctic Research Station (MSARS) maintains a network of 4 other stations in the Schefferville region as part of a CFI funded climate change project called ECONET designed to determine regional variations in microclimate (comparisons between forest, burn, tundra and community locations), to assess the representativeness of airport data and to provide detailed baseline data from which future climate changes can be analyzed.

Setting

The Elross Lake automatic meteorological station is located at 54º 56.1086'N; 67º06.4847'W (UTM 6-21-210E, 60-89-212N zone 19U) roughly 3 km east of Irony Mountain at an elevation of approximately 619 m asl. The met station is situated on the west side of Elross Lake on a small peninsula (Figures 1 & 2) in an area of open spruce woodland (Figure 3). The forest canopy is predominantly White and Black spruce (*Picea glauca and P. mariana*) with scattered Larch (*Larix laricina*), the largest trees are 20-30m high but are ~ 30 m from the station. Smaller spruce (1-2 m high) and shrub vegetation (<1m) surround station. The shrub under story is mainly Labrador Tea (*Ledum sp*), Birch (*Betula glandulosa*) and Willow (*Salix sp*). The ground cover consists of small shrubs (several species of *Vaccinium*) various lichens and mosses (*Cladian stellaris, Cladina rangifera, Hylocomnium splendens, Ptilium sp, Pleurozium sp*).

Elross Lake is one of a string of lakes linked by the Howell's River. These lakes are typically long, narrow, relatively shallow and rimmed with shaley gravel and bouldery beach materials of glacial-fluvial origin. However, much of backshore area on the west side of the lake consists of wetlands and flooded boulder surfaces. The Howell's River Valley occupies a large syncline that formed in the Churchill Province of the Canadian Shield where it meets the Superior Province. The ridge and valley topography of the Labrador Trough reflects Archean tectonic activity and exerts a strong control on drainage patterns in this part of the Churchill Province. The Superior Province lies only 5-6 km west of the Howell's River and is characterised by more typical shield topography. The landscape around Schefferville displays widespread evidence of erosion by glacial meltwater, there are numerous subglacial metlwater channels perched and nested high on the upland surfaces (e.g. Houston Mountain) and there are vast areas of boulder filled channels that are more characteristic of proglacial meltwater. The Howell's River Valley is much wider than the modern river system with a wide flood plain and several terraces indicative of much higher water levels. Boulder streams and surfaces are common in these areas and occur along the west side of Elross Lake.

Soils at the site are poorly developed consisting of an organic layer 5-10 cm thick overlying weakly eluviated reddish silty-sand. The soil is well drained and despite the widespread occurrence of wetlands there is no evidence of gleying. The peninsula upon which the station is located appears to be a small delta deposited by one of the several streams that drains the extensive wet lands west of Elross lake.

Meteorological data

Table 1 and Figures 4, 5 and 6 present the temperature and wind data for the 11 month period from Sept 21, 2003 -August 26, 2004 for the Elross Lake met. station. Over this period the mean air temperature was – 5.4°C, the mean annual temperature is probably only slightly warmer (~ -5.1°C). Over the same period the mean temperature for the town of Schefferville was –3.5°C and –4.8°C for the tundra site on Ferriman Ridge, so clearly the Elross Lake area is considerably cooler than the town site. A minimum of –47.45°C was recorded at the Elross site in mid January while the town and Ferriman Ridge recorded minimums of -39.9°C and –43.1°C, respectively. The difference probably reflects cold air drainage from the surrounding upland surfaces. The maximum temperature of 27.07°C is warmer than the town site and Ferriman ridge which saw a maximum temperatures of 25.7°C and 23.4°C, respectively. The plot of temperature data (Figure 4) displays considerable variability with several warm periods during the winter and even positive temperatures in mid March. A comparison between the temperature and humidity data suggests that the warm periods during the winter correspond to snowfall events. Despite the apparently high maximum, the summer temperatures were consistently cool hovered around 10°C and with several frost events in June and July. Table 1 presents a statistical summary of the air temperature data.

Table 1: Temperature Data for Elross Lake	
Minimum	-47.450001
Maximum	+27.07
Sum	-43684.05
Mean	-5.3864427
Median	-3.5555
RMS	15.342373
Std Deviation	14.366631
Variance	206.40009
Std Error	0.15953079
Skewness	-0.41803562
Kurtosis	-0.4429504

At first glance the soil temperatures appear problematic in that they remain relatively warm during the coldest winter months when they reached only –2.1°C. Shallow frost occurs from mid December until early June (Figure 5); the flat nature of the soil temperatures indicates a thick continuous snow cover. In a previous study Nicholson (1978) found that 80-cm of snow was sufficient to inhibit deep frost penetration. Summer temperatures are very warm reaching 15°C and consistently around 10°C, even at depths of 30 cm. These warm temperatures reflect direct heating by solar radiation and relatively dry soil with little evaporation. These soils are much warmer than the tundra soils of Ferriman Ridge where temperatures rarely rise above 5°C, and permafrost is reached at depths of 120-130 cm. The steep rise in soil temperature around June 7 probably corresponds with the completion of snowmelt. Even though the mean annual air temperature is cold enough to generate permafrost the warm nature of the soil temperature suggests that permafrost is probably not present at this site. However deeper temperature sensors would be needed to confirm this hypothesis. Permafrost up to 100 m deep has been recorded at various mine sites during the main period of ore extraction. Permafrost overlain by an active layer 2.4 m thick was documented near the Timmins Mine site (south east of Elross Lake) by Wright (1981) and palsas (permafrost cored peat mounds) were documented at Goodream Lake 3-4 kilometres east of Elross Lake (Cummings and Pollard 1988).

The site is not very windy despite its close proximity to Elross Lake; normally a large open area (long fetch) like Elross Lake is much windier than woodland locations. There is a fairly constant wind of 3-5 kph. Roughly 5-6 major wind events were recorded with sustained velocities >25 kph. A sustained maximum wind velocity of 36 kph was experienced, in mid January. By comparison the met station on Ferriman ridge recorded an average wind velocity of 23 kph for the same period (this includes periods when the wind sensor was immobilized by rime ice). The maximum sustained wind velocity recorded on Ferriman Ridge was 65 kph (same January storm), but the most notable pattern was the sustained nature of the winds (these ridges would be good locations for wind farms. The strongest winds were from the north and north north-east at Elross Lake. Ferriman winds also had high winds from the north and north-northeast but also displayed significant wind events coming from the south and east. Winds patterns in the Schefferville region reflect the funnelling effect of the ridge and valley topography, the high winds on the ridge reflect compressive airflow. At Elross Lake the fall and winter are the windiest periods while the late winter, spring and summer were fairly calm, by comparison, Ferriman Ridge displayed high winds year round.

Summary

In general the Elross Lake site is slightly cooler than the town of Schefferville, however it appears to have its own microclimate that is characterized by very cold winter temperatures. Summer temperatures are comparable to Scheffervilles but the sheltered nature of the study site results in slightly warmer maximum temperatures. The local microclimate might be controlled by topographic inversions in temperature. Normally windy regions like Schefferville experience considerable mixing and temperature inversions are scarce, but the calm nature of the Elross Lake site and the high local relief would be conducive to local cold air drainage. This might explain why the extreme minimum (-47.5°C) is so much colder than for Schefferville (-39.9°C). Extreme minimum temperatures for other ECONET sites include -41°C for both the woodland site (east of Irony Mountain) and a burns site (south of the Howell's River bridge just off the Mennihek Road), and -43.1°C for Ferriman Ridge. Cold air drainage might also explain the several summer frost events.

Ground freezing and permafrost in the Schefferville region are strongly influenced by snow distribution. At Elross Lake snow insulates the ground against the extreme cold winter air temperatures. Widespread wetlands also inhibit ground freezing. It is therefore unlikely that permafrost is present in this part of the Howell's River Valley, highland areas to the east probably have patchy permafrost particularly Irony Mountain. The topography rises toward the west where areas of open vegetation and well drained surfaces could be subject to permafrost. If permafrost is a potential issue it would be useful to install a series of deeper (20+ m) ground temperature cables.

Figure 1: Oblique air photos showing the location of the automatic weather station location on the west side Elross Lake at 54º 56.1086N; 67º06.4847W.

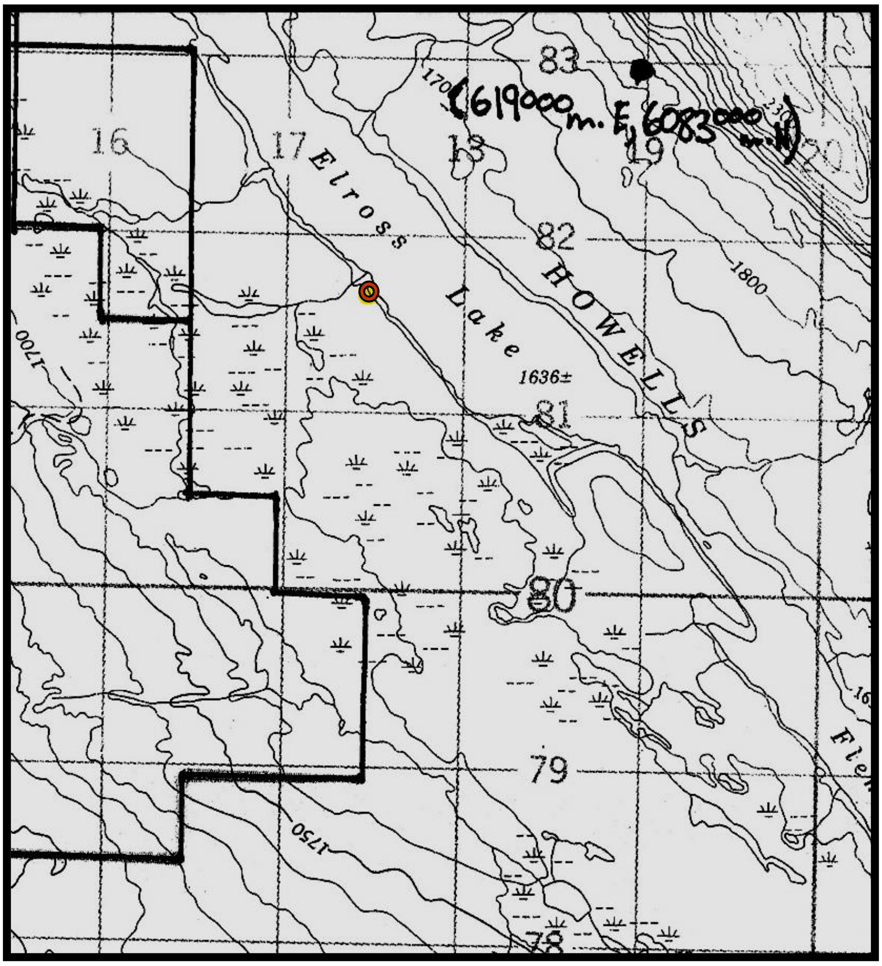


Figure 2. Location of the automatic weather station on the west side of Elross Lake (from 1:50,000 NTS topographic map).

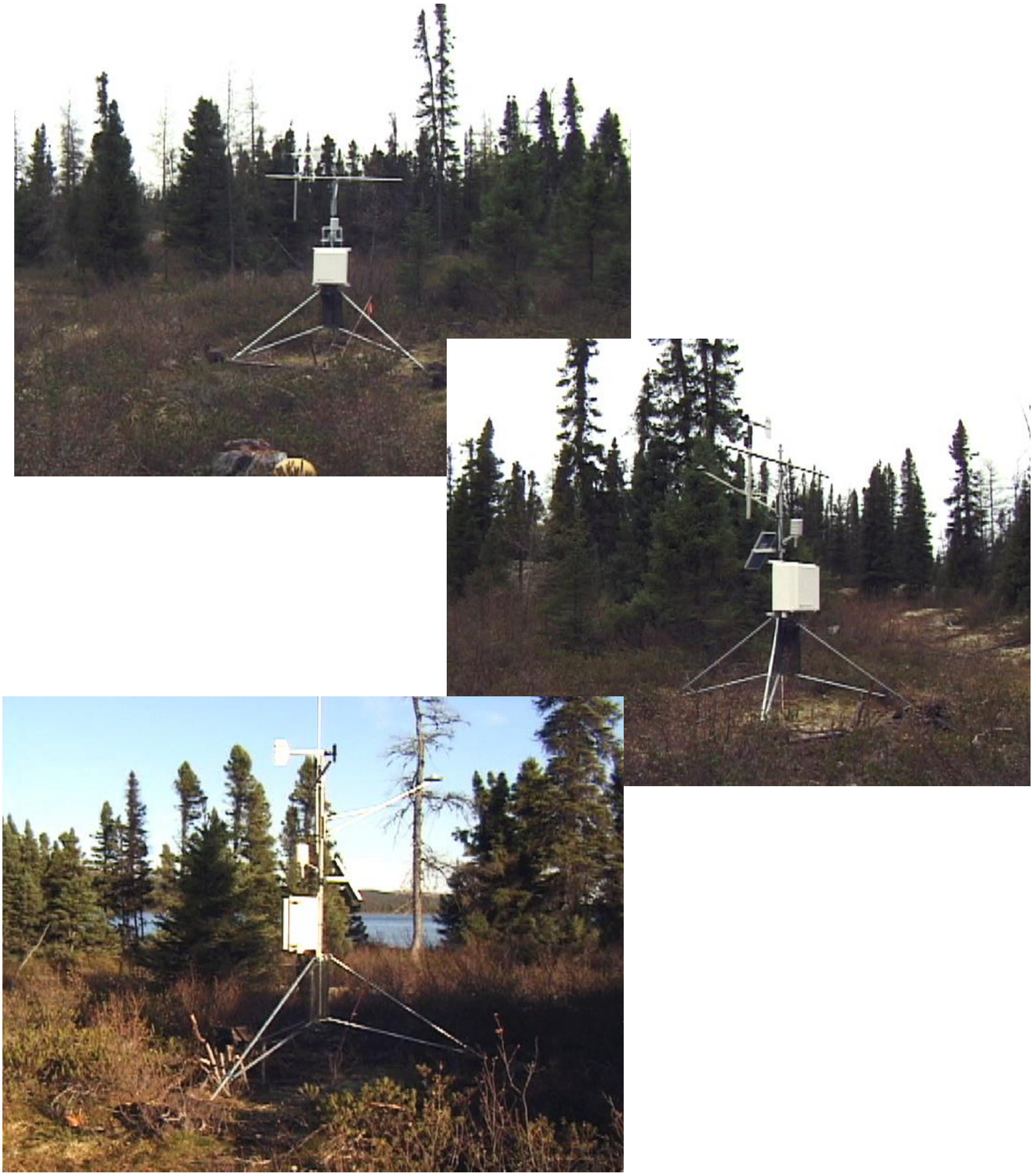


Figure 3: Campbell automatic meteorological station installed in September 2003. Sensors include air temperature, soil temperatures at 5 and 25 cm, wind velocity and direction, relative humidity, solar radiation and barometric pressure. The station is situated in a clearing adjacent to a collapsed cabin approximately 30m from Elross lake. The local vegetation is open spruce forest (*Picea mariana* and *Picea glauca* with lichen C*ladina rangifera* and *Cladina stellaris* ground cover.

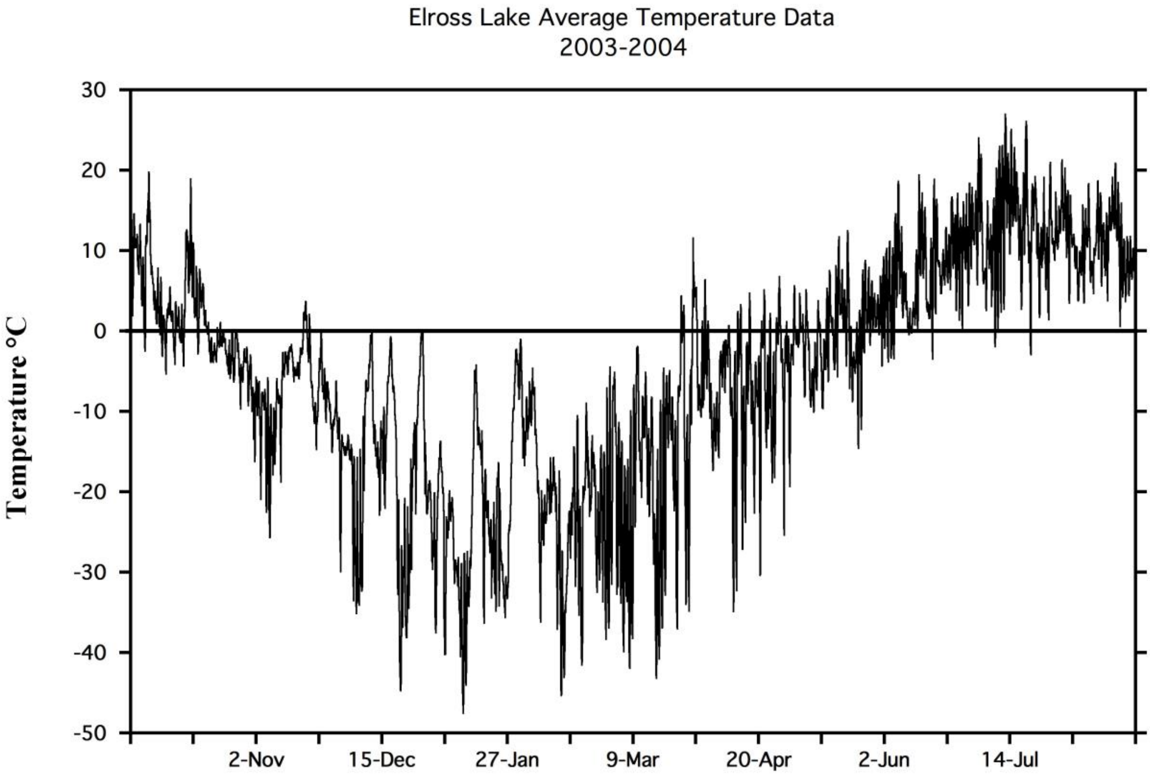


Figure 4. Elross Lake air temperature summary (based on plot of hourly air temperatures)

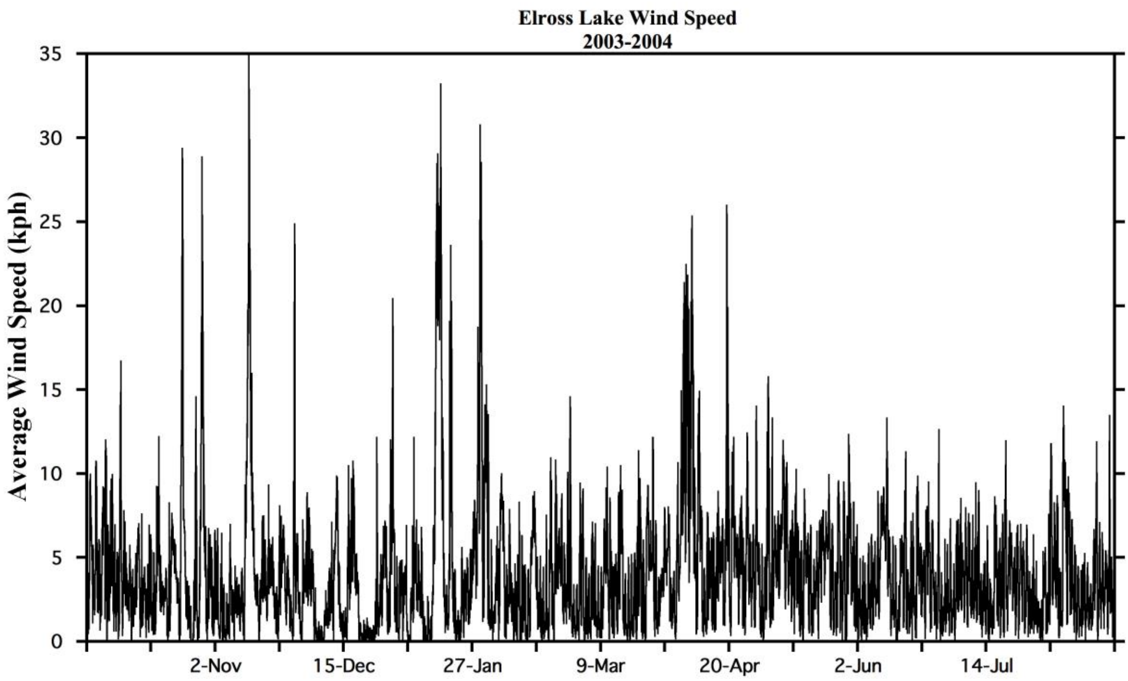


Figure 5: Elross Lake wind velocity summary

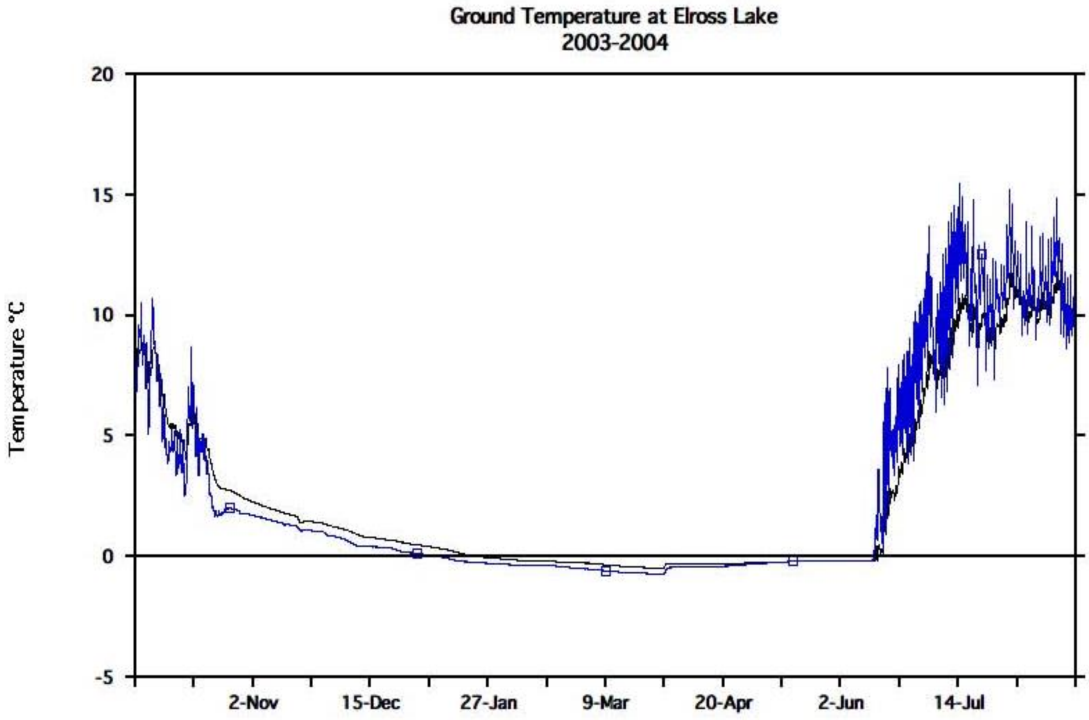


Figure 6: Elross lake soil temperature data at depths of 5 (blue) and 25 (black) cm.