PERMAFROST CONDITION AT TSMC HOWSE DEPOSIT

SCHEFFERVILLE, QUEBEC

Report No. L-15-1802
October 22th, 2015

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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

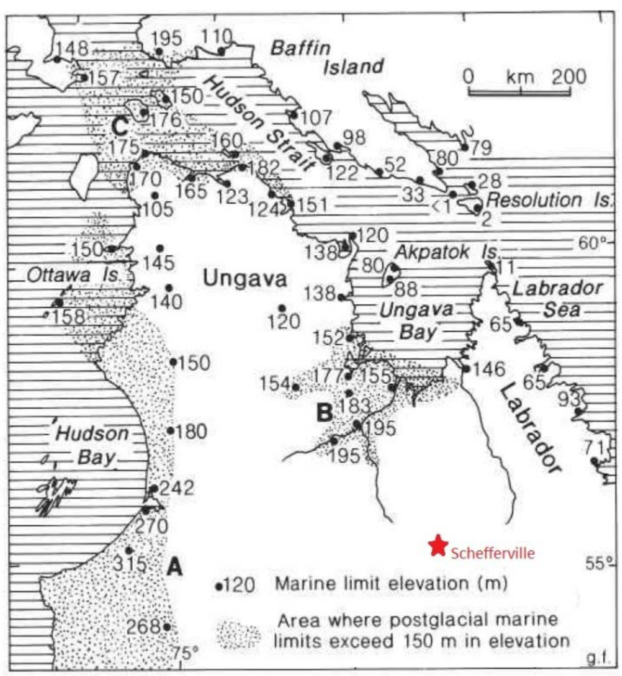

Figure 1-2: Postglacial Marine Limits in Northern Quebec, Relative to Schefferville (Adapted from Gray et al., 1993).

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.

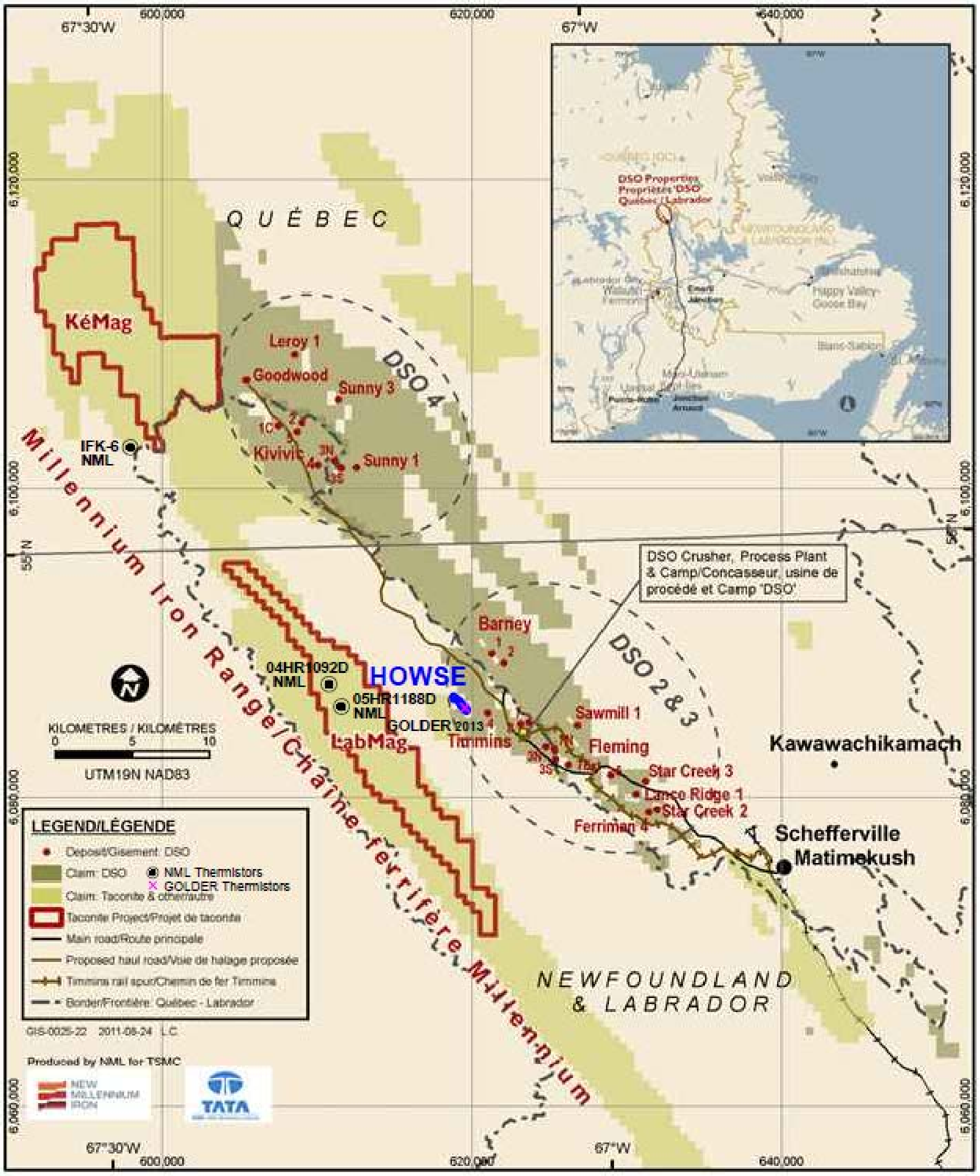

Figure 2-1: Location Plan for Howse Ore Body and DSO Iron ore Pits

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.

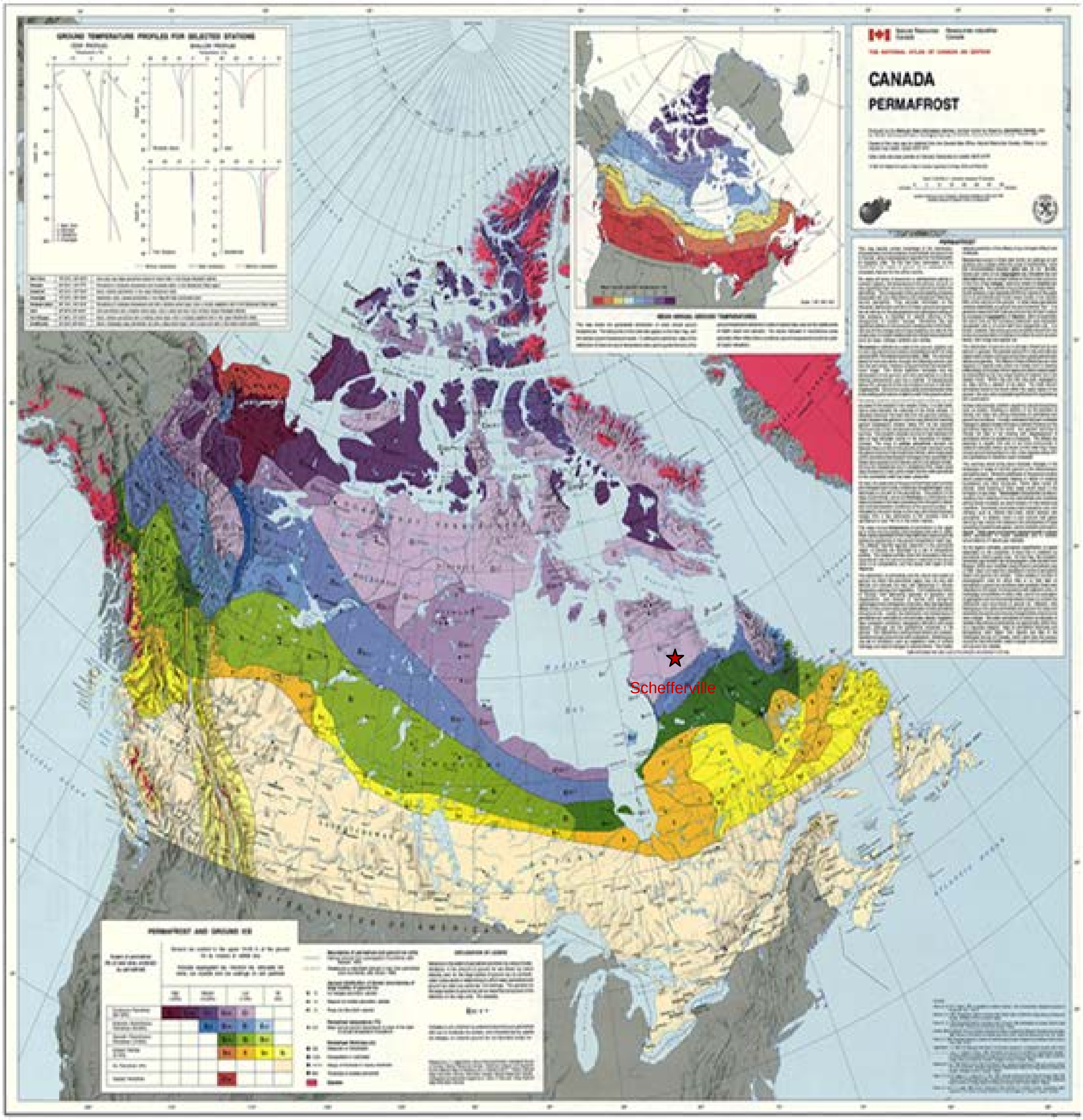

Figure 3-2 : Permafrost Distribution in Canada (Natural Resources Canada)

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).

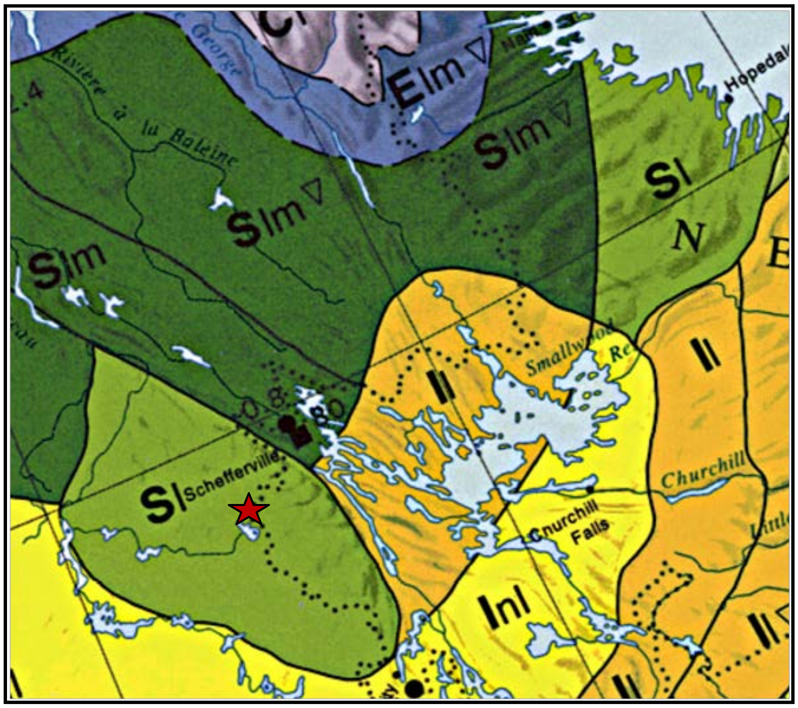

Figure 3-3: Schefferville on Canada Permafrost Map

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.

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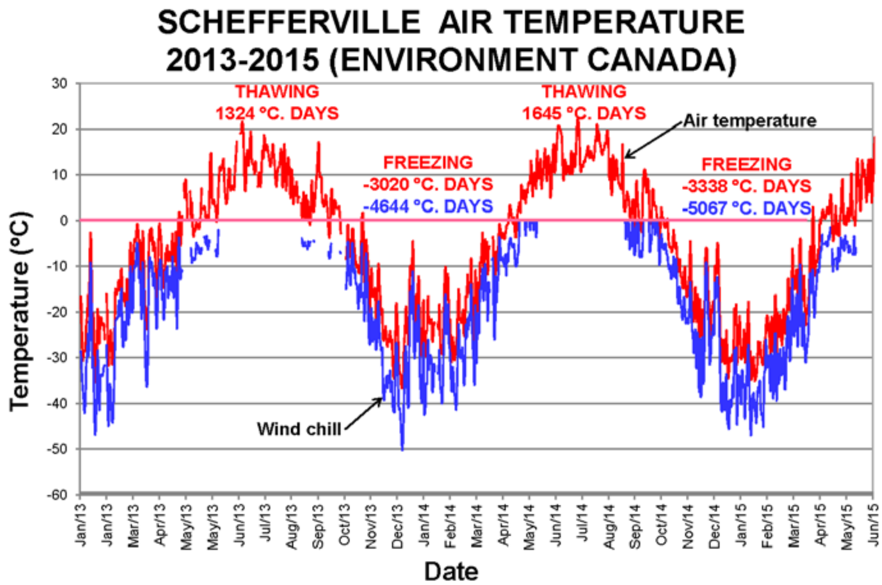
Figure 4-2: Photos of Recent Thawing of Frozen Ground – Active Layer or Permafrost Degradation

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.



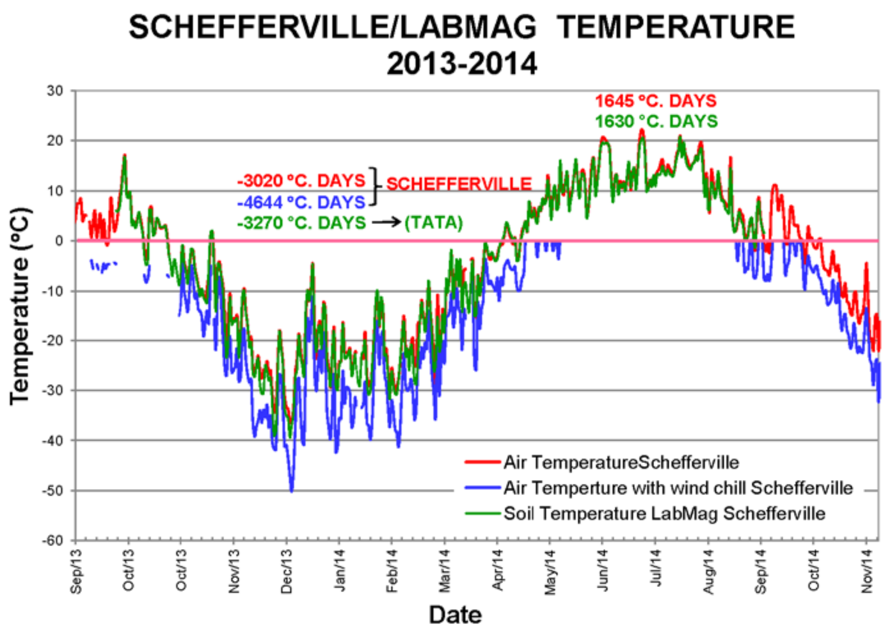
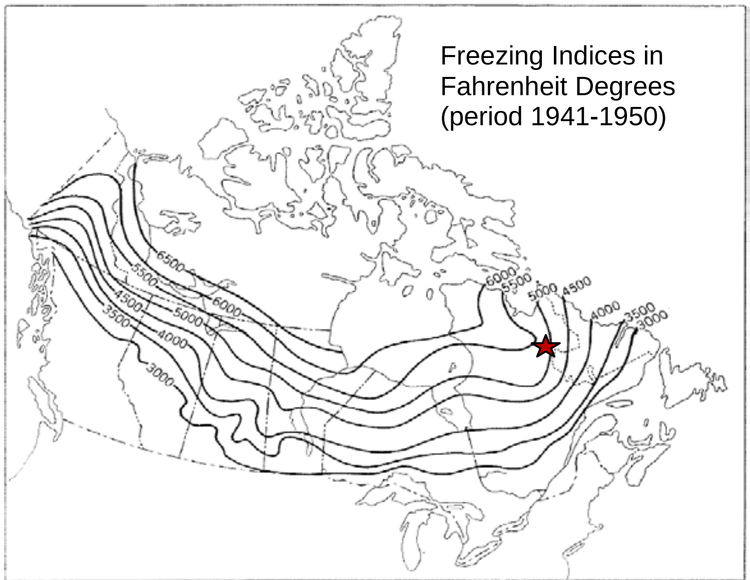


Figure 4-4: Typical Temperature Variations used to Calculate Thawing and Freezing Indices as Well as the Index Considering Wind Chill

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).



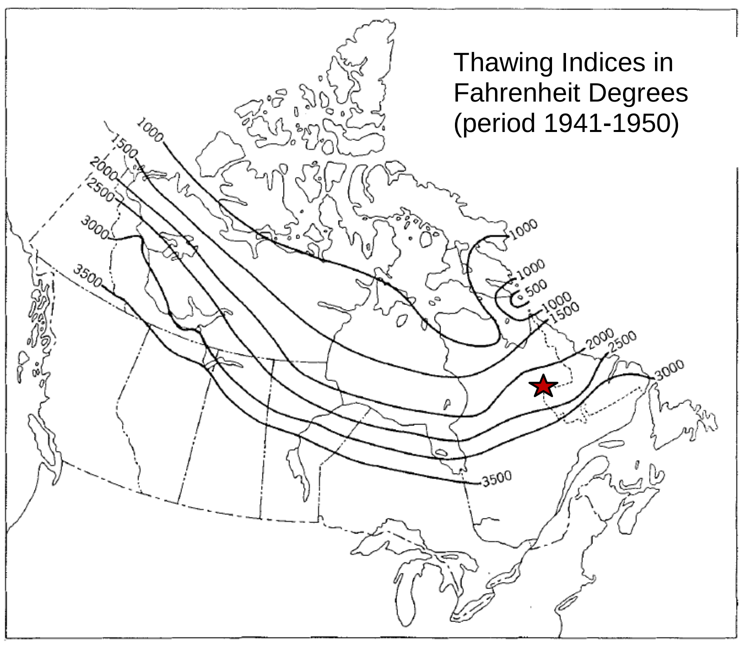


Figure 4-5: Freezing and Thawing Indices in Fahrenheit Degrees between 1941 and 1950 (after Brown, 1960)

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	

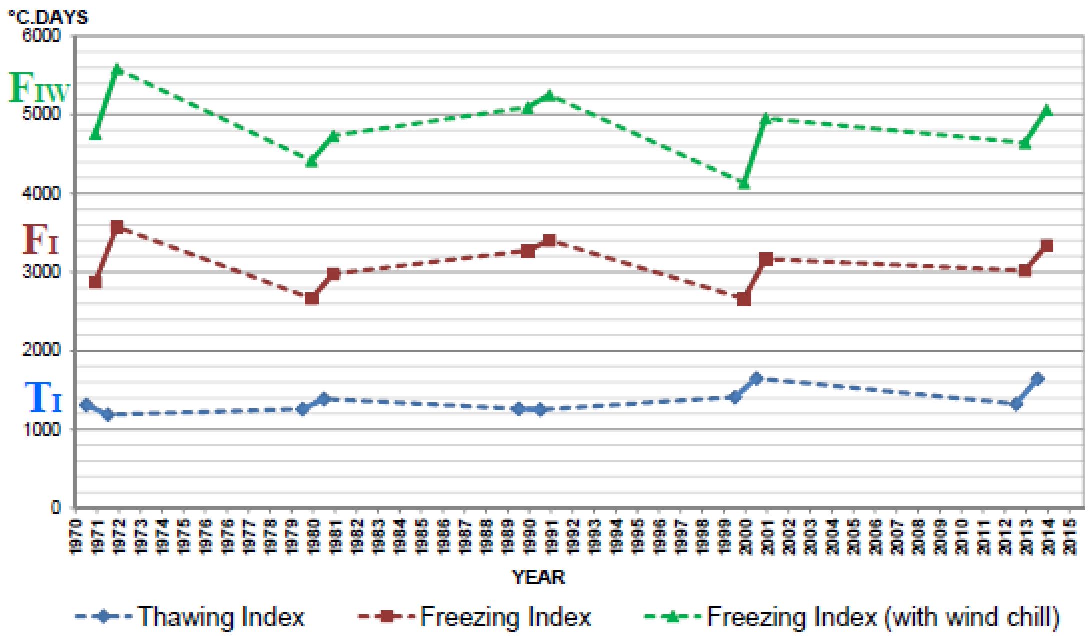


Figure 4-6: Freezing and Thawing Indices – Schefferville Iron Ore Range

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.

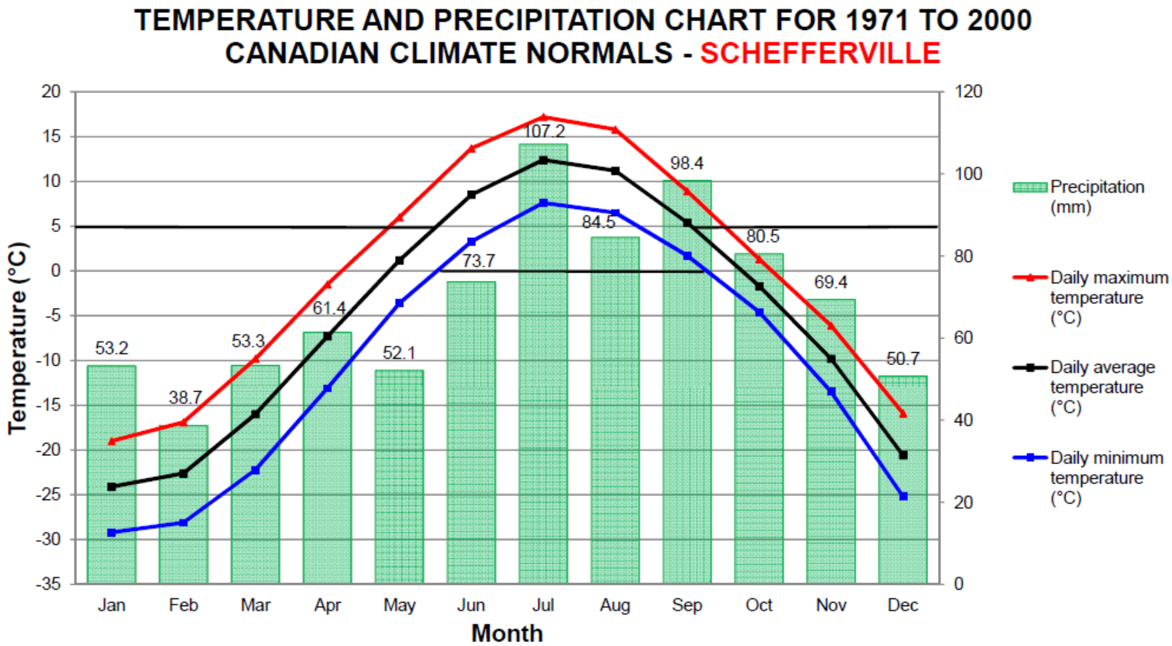


Figure 4-7: Temperatures and Precipitation for Climate Normals in Canada from 1971 to 2000

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.

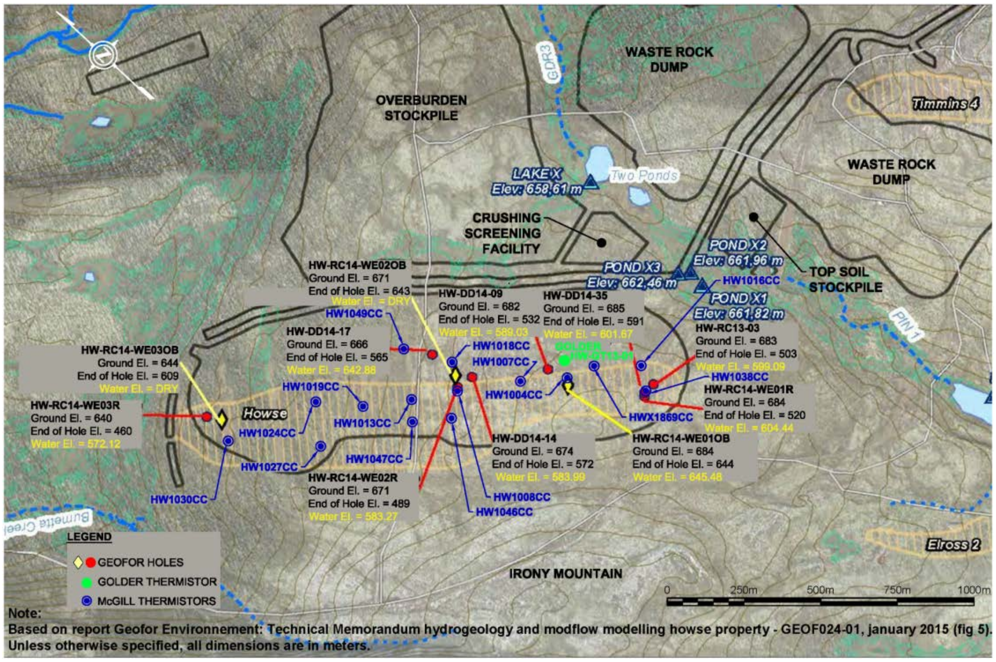


Figure 6-1: Location of McGill Thermistor Installations (Blue Dots) in the Howse area (1980-1981)

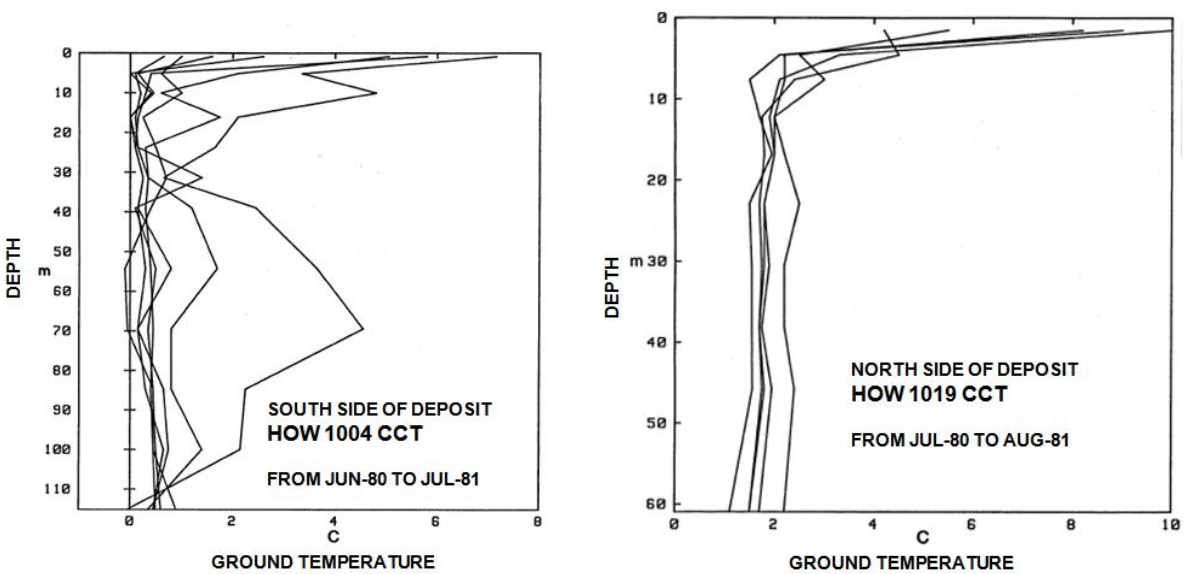


Figure 6-2: Typical McGill Ground Temperature Curves (Granberg) – 1980-1981 - Howse Ore Body at El. 660 m and 670 m

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).

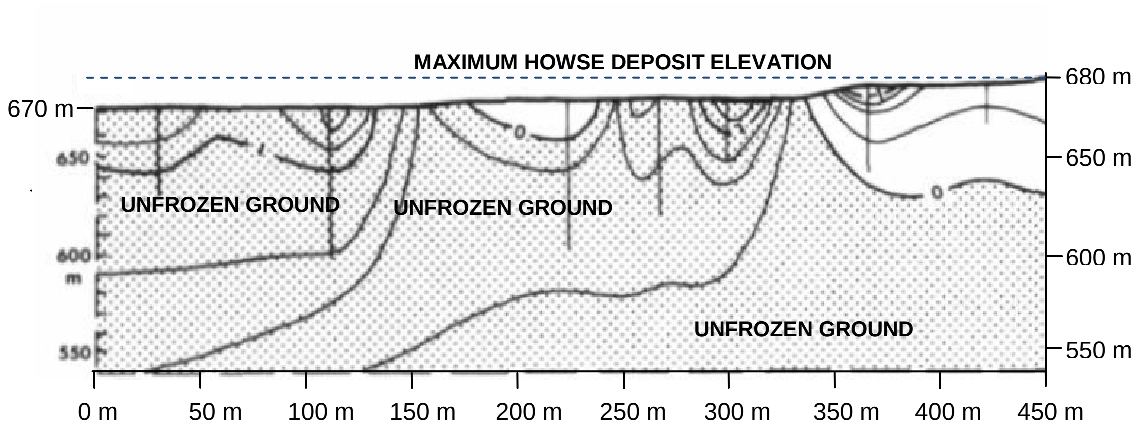


Figure 6-3: Cross Section at Timmins 4 Showing Ground Temperatures (Nicholson 1979). Howse Deposit Elevation Projected on this Cross Section

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.

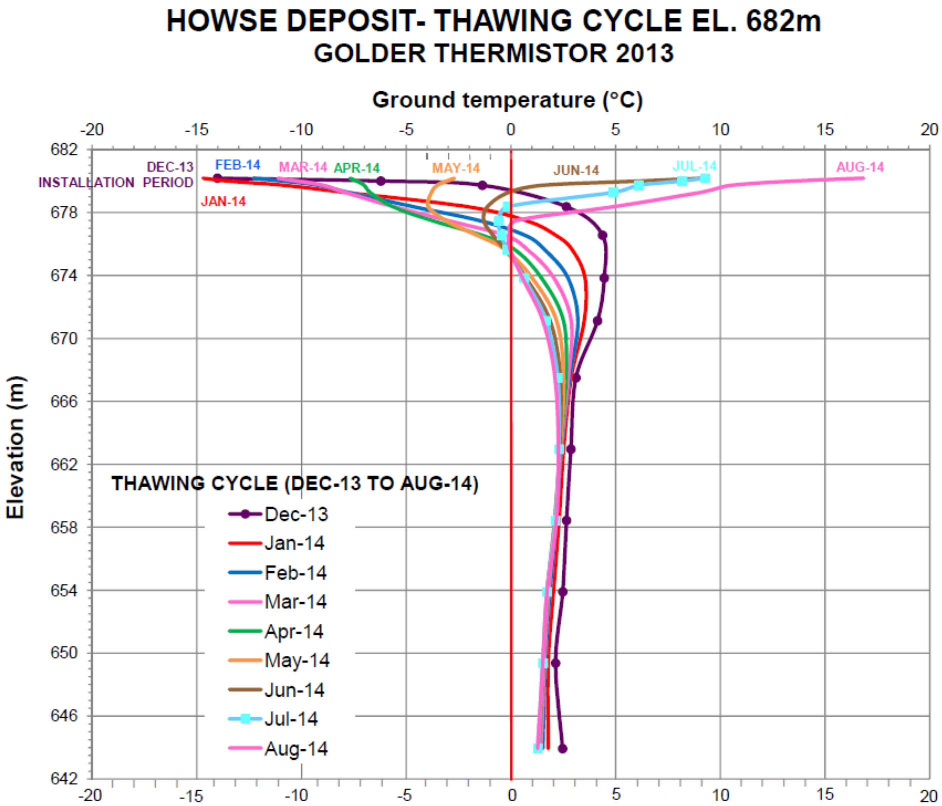


Figure 6-4: Thawing Cycle Dec. 2013 - August 2014

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.

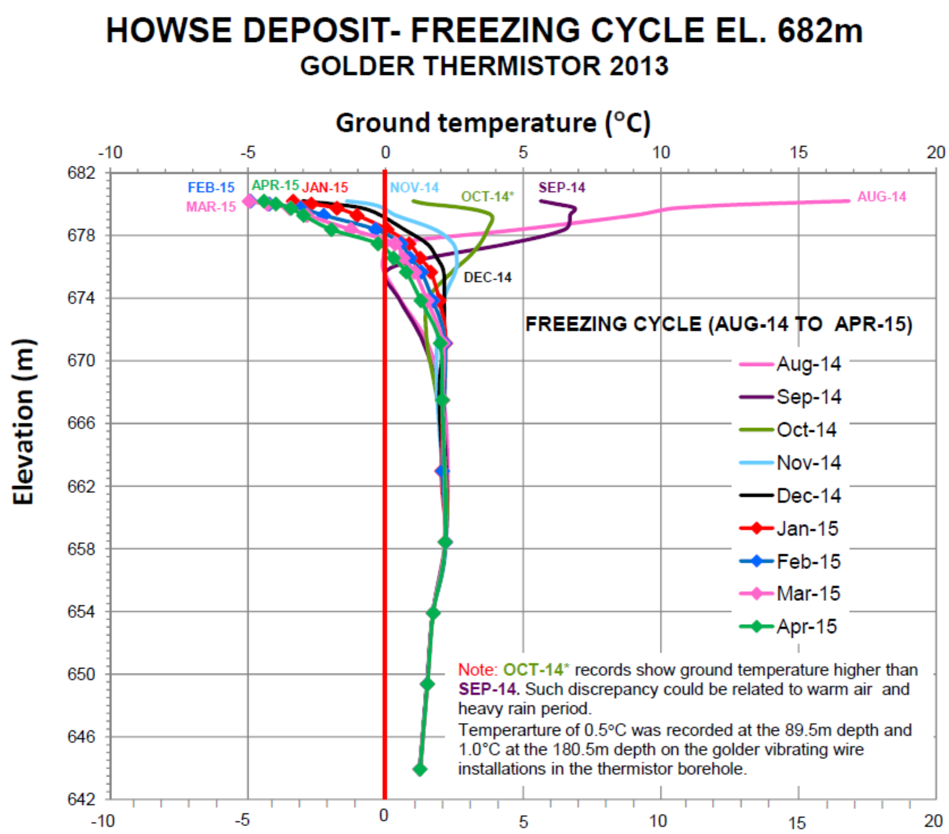


Figure 6-5: Hose Deposit Freezing Cycle - August 2014 to February 2015

The freezing temperature graph shows surface temperatures cooling rapidly from +17°C on August 2014 to about -5°C by February-March 2015. Below the frost cover, the ground temperatures are at about 2.5°C down to the 24 m depth then fall to about +1°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°C, but increased to +2.5°C at the 34-m depth and then cooled to about +1°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°C at the water table interface and 1°C at the 180 m depth. Based on these results, it is concluded that ground temperature probably decreases slowly from 1°C at 40 m to probably 0.5°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°C in September at the 7 m depth, rising to +2.5°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).

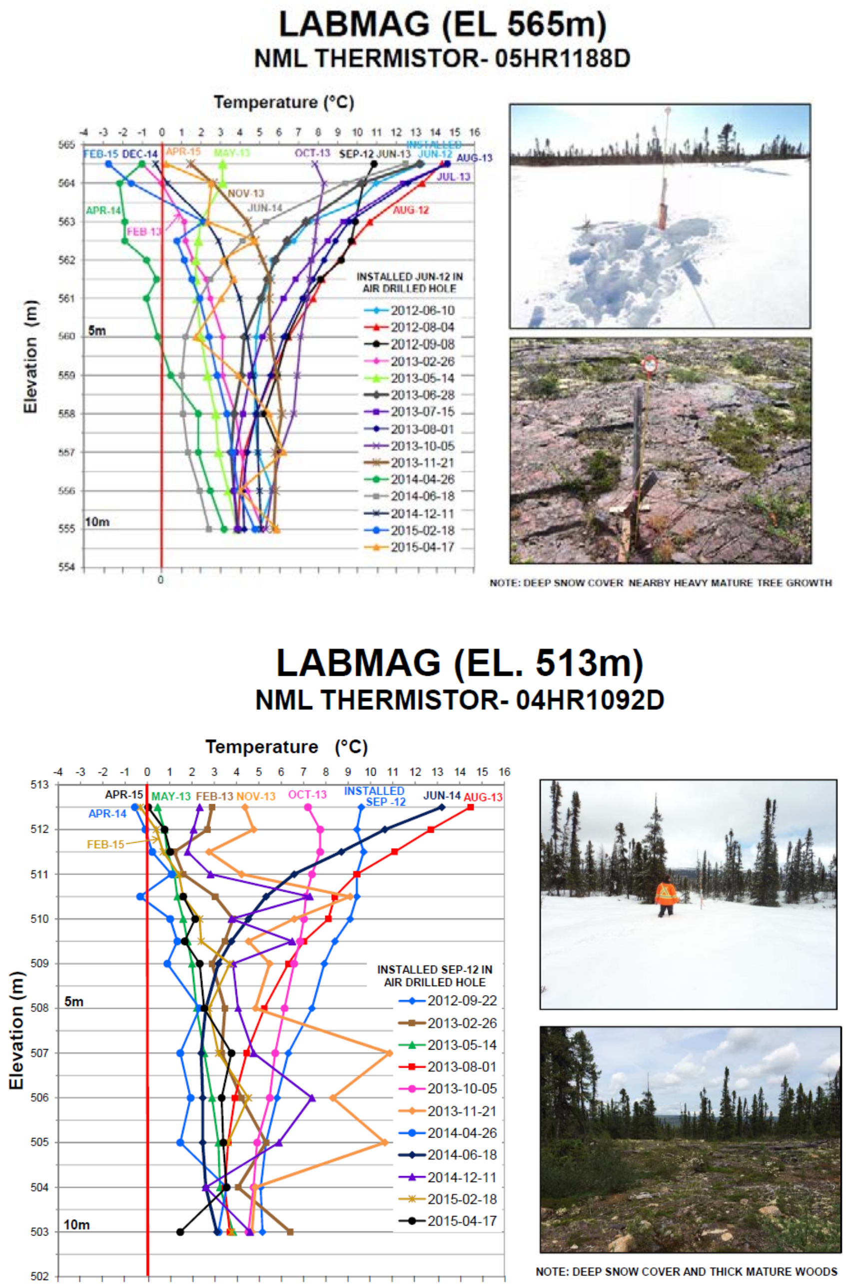


Figure 6-6: LabMag Thermistors Installed at Lower Elevations and in Wooded Areas with Deep Snow Cover

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).

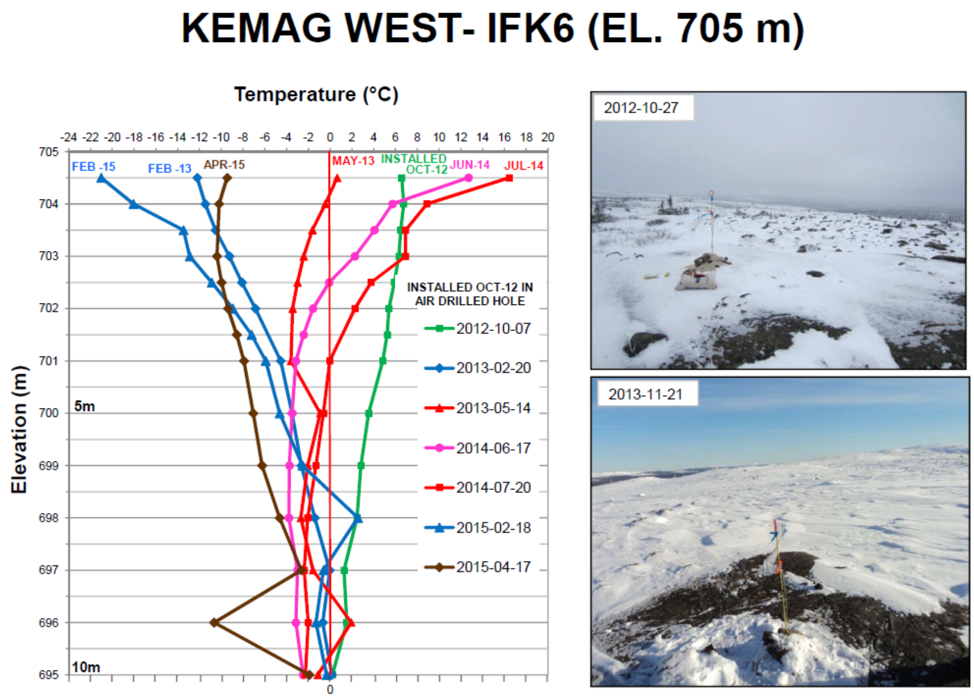


Figure 6-7: Exposed Bedrock and Thin Snow Cover at KeMag

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.

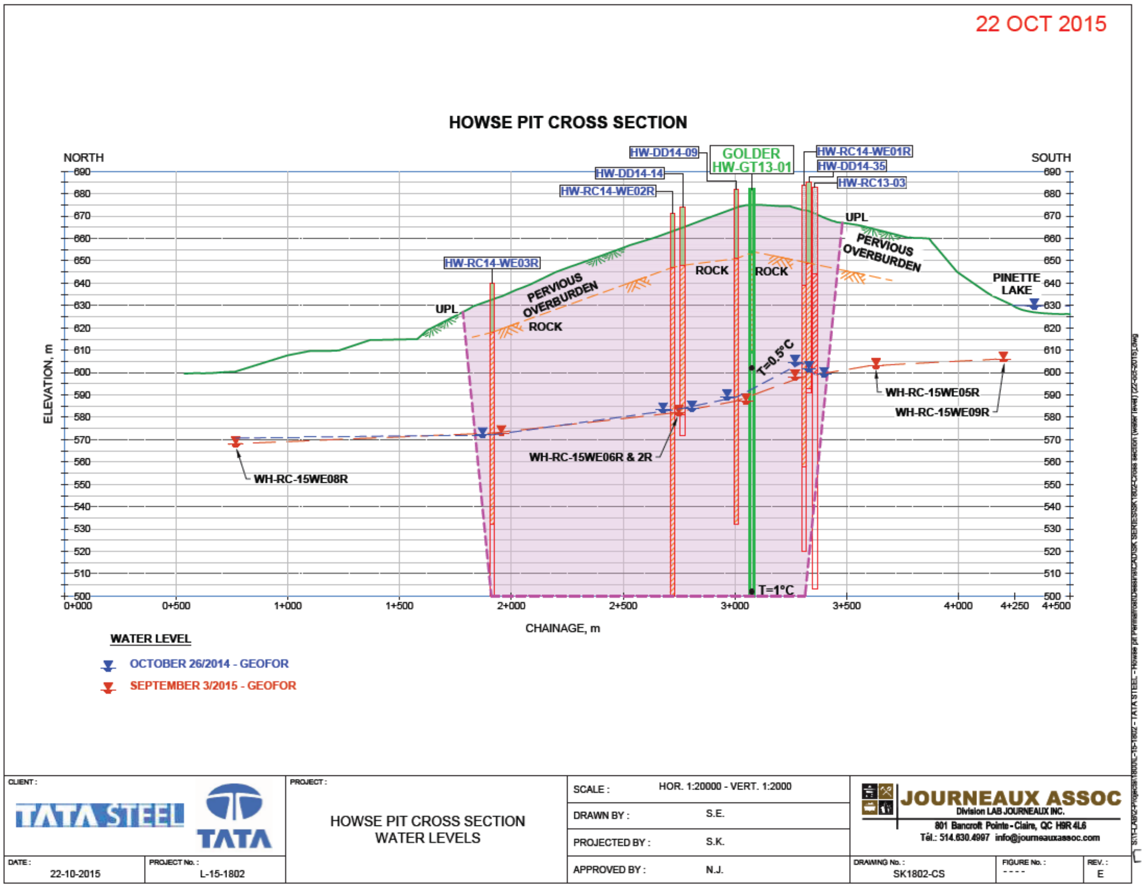


Figure 7-1: Longitudinal cross section along Howse Deposit with measured water levels

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

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- 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
- New Millennium Iron for recent temperature data in the area

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Nicholson, F.H., 1979. Permafrost spatial and temporal variations near Schefferville, Nouveau-Québec. Géographie physique et Quaternaire 33 (3-4), p. 265-277.

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TATA STEEL MINERALS CANADA LIMITED (TSMC)

Permafrost Condition at TSMC
Howse Deposit
Schefferville, Quebec

"CONFIDENTIAL"

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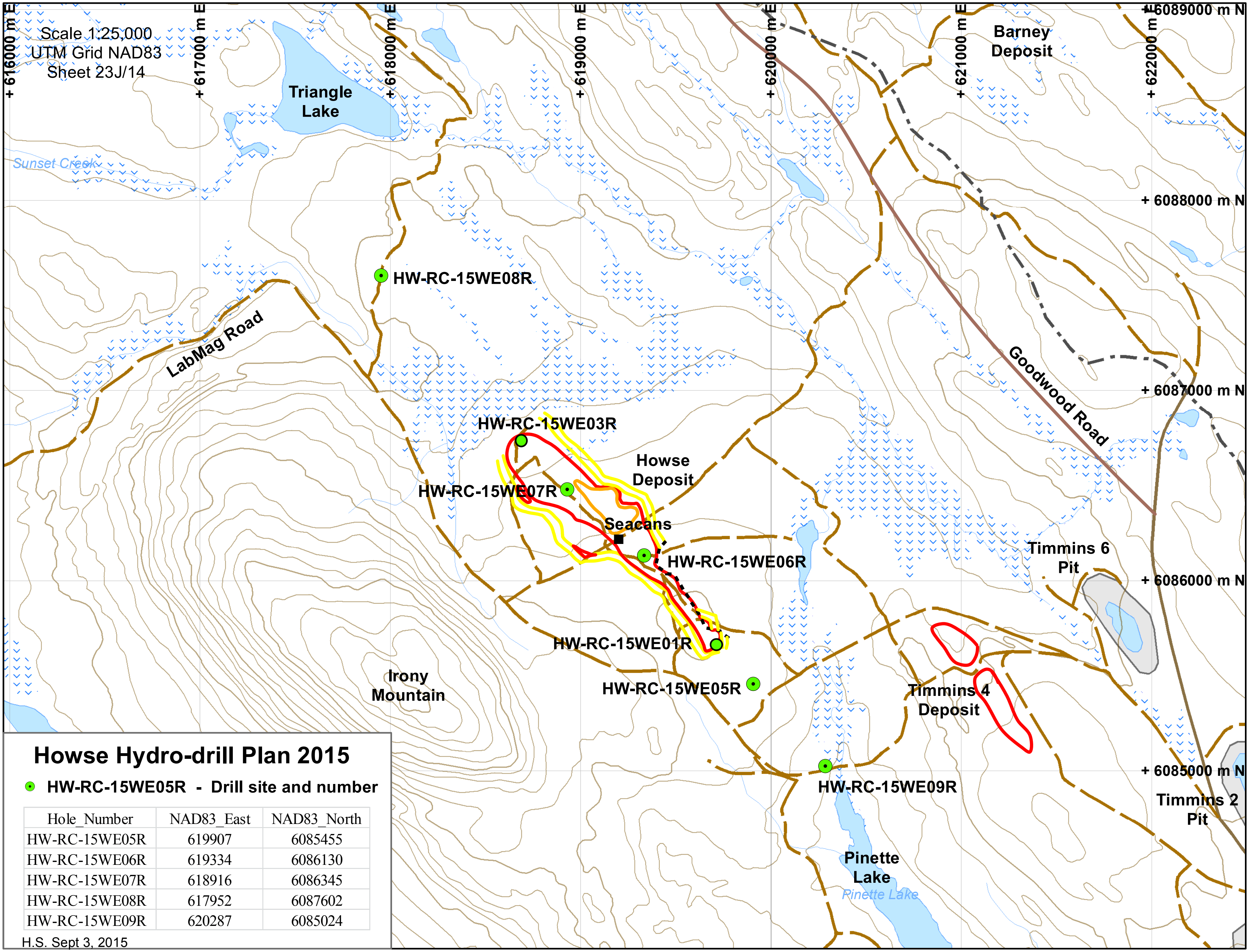
APPENDIX A

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