Water Management Plan - Howse

CONCEPTUAL ENGINEERING FOR HOWSE WATER MANAGEMENT PLAN

GLOBAL MINING & METALLURGY – SUSTAINABLE MINE DEVELOPMENT

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1.0 INTRODUCTION

1.1 Context

Howse Minerals Canada Ltd (HML) plans to mine iron ore within the Howse deposit (Direct-Shipping Ore Howse Property Project) located near the border between the provinces of Quebec and Newfoundland and Labrador, approximately 25 km north of the community of Schefferville, Quebec. One open pit is planned and the anticipated mining period is from 2016 to 2024. Two waste dumps, one overburden stockpile and one topsoil stockpile are also planned for the site (see Map 1 in Appendix B). No tailings will be generated in this area since the majority of the ore will only be crushed and screened on-site, with the ore then being directly shipped for secondary processing.

The Howse property sits on three different watersheds leading to Pinette Lake, Burnetta Creek and Goodream Creek (see Map 2 in Appendix B). The water management strategy aims to manage surface run-off water and pit dewatering water with less impact possible on these three watersheds. In order to maintain a good water quality around Howse property, run-off water on site and dewatering water from the pit will all be managed through several Sedimentation ponds before being released to the environment. In order to address local stakeholders concerns, no water will be discharged into Pinette Lake, even after sedimentation through a pond. The infrastructures planned for water management are the following:

- Run-off from surrounding area on the south-west side of the site will be collected by a ditch leading to Sedimentation pond no. H1 and then diverted to Burnetta Creek;
- Run-off on the east part of the Waste Rock Dump 1, on Waste Rock Dump 2, on the overburden stockpile and on the crushing and screening plant area will be collected by ditches leading to Sedimentation pond no. H2 and then diverted to Goodream Creek;
- Run-off on the west part of Waste Rock Dump 1 and on the topsoil stockpile will be collected by ditches leading to Transfer pond no. 1. The water in the transfer pond will then be pumped to existing Timmins 4 Sedimentation pond 3 and then diverted to Goodream Creek;
- Water from pit dewatering will be diverted to a ditch on the south-west side of the overburden stockpile leading to Sedimentation pond H2 and then diverted to Goodream Creek. The portion of the ditch receiving the dewatering water along the pit will be waterproofed to avoid infiltration of water directly back into the pit;
- Surface runoff in the Howse pit will be diverted to Sedimentation pond H3 and then diverted to Burnetta Creek.

1.2 Content

This technical note summarizes the conceptual design of the Howse project water management infrastructures. First, hydrological base data will be presented. Comments on water quality and information on hydrogeology will then be discussed. The Water Management Plan concept will be presented and options studied before the selection of the preferred option will be discussed. Design of ditches, ponds and water balances will be presented. Potential impacts on natural watersheds will be presented. Finally, the data that need to be collected before the next phase of engineering will be discussed.

Intensity-Duration-Frequency data are presented in Appendix A, maps and drawings are presented in Appendix B and Design criteria are presented in Appendix C. Water quality results from Timmins 4 project are presented in Appendix D.

2.0 HYDROLOGICAL DATA

2.1 Hydrological Data

2.1.1 Meteorological Data Sources

Data recorded at Environment Canada meteorological stations, located close to the Howse mine site, was used to develop a data set representative for the Howse mine site. Data from the following stations was used:

Table 2-1: Environment Canada Meteorological Stations

Station		Latitude North	Longitude West	Elevation [m]	Available Data
Number	Name				
7117825	Schefferville A	54°48'00"	66°49'00"	521.8	1948-2010
7117823	Schefferville A	54°48'19"	66°48'19"	520.9	2012-present
7117827	Schefferville	54°48'00"	66°48'00"	517.2	2005-present
704BC70	Fermont	52°48'00"	66°05'00"	594.4	1976-2004

The Schefferville stations, called Schefferville hereafter, are located approximately 24 km South-East from Howse. Fermont is located approximately 240 km South from Howse. Data from this station was used during the period between October 1993 and December 1995, to fill in some missing data from Schefferville.

2.1.2 Temperature

Average monthly temperature data was computed based on daily data from the Schefferville station for the period of 1949 to 2013 (65 years) and is presented in Table 2-2. During the period between October 1993 and December 1995, no temperature data is available for Schefferville. To fill this gap, data from Fermont was used, with an adjustment of -1.6 C corresponding to the average temperature difference between both stations during their period of concomitant data (July 1976 to September 1993).

Schefferville monthly temperature is above freezing during the months of May to September. July is the warmest month with an average temperature of 12.7 C and the coldest month is January with an average temperature of -23.3 C.

Table 2-2: Schefferville Monthly Average Temperature (1949-2013)

Month	Average Temperature [°C]
Jan	-23.3
Feb	-21.7
Mar	-15.3
Apr	-6.9
May	1.5
Jun	8.8
Jul	12.7
Aug	11.3
Sep	5.9
Oct	-0.9
Nov	-9.0
Dec	-18.5
Year	**-4.6**

An average temperature colder by a degree or two is expected for the Howse mine site as it is located at an elevation approximately 140 m higher than Schefferville.

2.1.3 Precipitation

A daily total precipitation data series, including rainfall and snowfall, was obtained for the period of 1949 to 2013 (65 years). During the period between October 1993 and December 1995, no precipitation data is available for Schefferville. To fill this gap, data from Fermont was used. First cumulated precipitation data from both stations, during their period of concomitant data (July 1976 to September 1993, and January 1996 to December 2013), was compared on a double mass curve. As both stations recorded similar amounts of precipitation, without any jump in the double mass curve, data from Schefferville was filled with data from Fermont, corrected by a factor of 0.96, the ratio of cumulated precipitations between both stations over their concomitant period. Due to the proximity between Howse and Schefferville, the obtained precipitation series is assumed representative for the Howse mine site.

As shown in Table 2-3, the average annual precipitation during the period of 1949-2013 is 782 mm. July is the wettest month averaging 101 mm of precipitation, and February is the driest month with 37 mm of precipitation.

Table 2-3: Monthly Total Precipitation (1949-2013)

Month	Total Precipitation [mm]
Jan	45
Feb	37
Mar	45
Apr	50
May	52
Jun	73
Jul	101
Aug	96
Sep	91
Oct	75
Nov	68
Dec	49
Year	**782**

Annual precipitation varied between 523 mm in 1953 and 1038 mm in 1983. However, over the 65 years period (1949-2013) of available precipitation data, annual precipitation remained relatively stable (Figure 2-1).

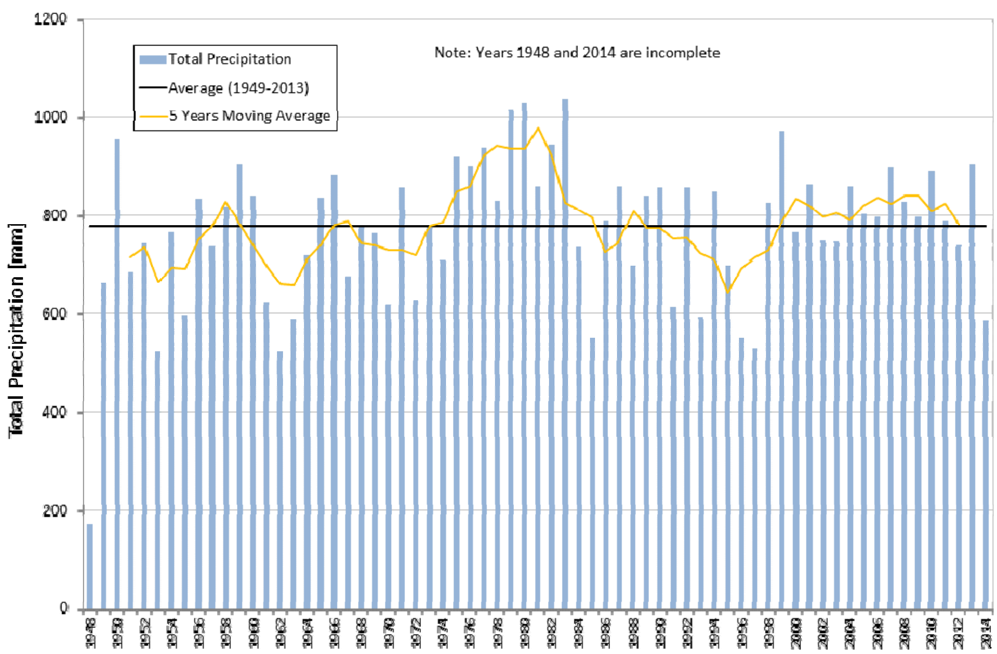

Figure 2-1: Total Precipitation (1948-2014)

A frequency analyses was performed, using the Pearson type 3 probability distribution with the method of moments, to determine annual precipitation for different return periods presented in Table 2-4:

Table 2-4: Annual Precipitation for Different Return Periods

Return Period [year]	Total Precipitation [mm]
1000	1130
100	1050
50	1030
25	994
10	942
5	891
2	787

2.1.4 Rain

Daily rainfall data is available for the period of 1948-1993 from the Schefferville station. To extend the data set to 65 full years (1949-2013), rainfall was derived from total precipitation. Comparing the average annual recorded rainfall with the average annual derived rainfall, during the period 1949-1992, it was determined that precipitation falling during days with an average temperature higher than 1.2 °C would fall in the form of rain. Average monthly rainfall values are presented in the following table:

Table 2-5: Average Monthly Rainfall (1949-2013)

Month	Rainfall [mm]
Jan	0
Feb	0
Mar	0
Apr	5
May	28
Jun	69
Jul	101
Aug	96
Sep	81
Oct	28
Nov	3
Dec	0
Year	**411**

Rainfall hyetographs can be derived from intensity-duration-frequency (IDF) curves. Environment Canada developed an IDF curve for Schefferville based on annual rainfall data for the period 1965-1992. It is assumed that the shape of this curve is representative of rainfall in the Schefferville and Howse area.

To transform the annual IDF curve into spring and summer-fall IDF curves, the following steps were followed. First, the spring season was assumed to happen between May 15th, the approximate date when the average air temperature is over 2 °C, and June 10th, the approximate date when the snow cover is completely melted. Then, frequency analyses were performed for daily spring and daily summer-fall rainfalls presented respectively in Table 2-6 and Table 2-7. In both cases, the Pearson type 3 probability distribution with the method of moments was adopted. Then, daily rainfall values were transformed into 24 h rainfall, by applying a correction factor of 1.13 (WMO, 2009). Then, spring and summer-fall IDF curves were obtained by using the shape of the annual IDF curves and the ratio between annual and seasonal 24 h rainfall for each return period considered. Because it was found that annual values for the 24 h rainfall were larger than the computed summer-fall 24 h rainfall, annual values were retained for summer-fall rainfalls. Finally, daily hyetographs were constructed for different return periods between 2 and 100 years. The central part of these hyetographs is presented in Figure 2-2 and Figure 2-3.

Table 2-6: Spring Rainfall Depth for Different Return Periods

Duration	Return Period [year]					
	2 years	5 years	10 years	25 years	50 years	100 years
	Spring Rainfall Depth [mm]					
5 min	1.4	2.6	3.3	4.3	5.0	5.7
10 min	2.0	3.4	4.3	5.5	6.3	7.1
15 min	2.3	3.9	4.9	6.2	7.1	8.0
30 min	2.8	4.7	5.9	7.4	8.5	9.5
1 h	3.8	5.9	7.3	9.0	10.1	11.3
2 h	5.0	7.5	9.0	10.9	12.2	13.4
6 h	8.4	12.3	14.7	17.5	19.5	21.4
12 h	10.9	16.5	20.0	24.3	27.3	30.2
24 h	13.8	21.8	26.9	33.1	37.5	41.8

Table 2-7: Summer-Fall Rainfall Depth for Different Return Periods

Duration	Return Period [year]					
	2 years	5 years	10 years	25 years	50 years	100 years
	Summer-Fall Rainfall Depth [mm]					
5 min	3.7	5.8	7.2	9.0	10.3	11.6
10 min	5.2	7.7	9.4	11.4	13.0	14.5
15 min	6.1	8.8	10.6	12.9	14.6	16.3
30 min	7.5	10.7	12.8	15.5	17.4	19.4
1 h	10.1	13.5	15.8	18.7	20.8	22.9
2 h	13.4	17.1	19.6	22.7	25.0	27.3
6 h	22.3	28.0	31.8	36.5	40.0	43.5
12 h	29.0	37.7	43.4	50.6	56.0	61.4
24 h	36.8	49.7	58.3	69.1	77.1	85.0

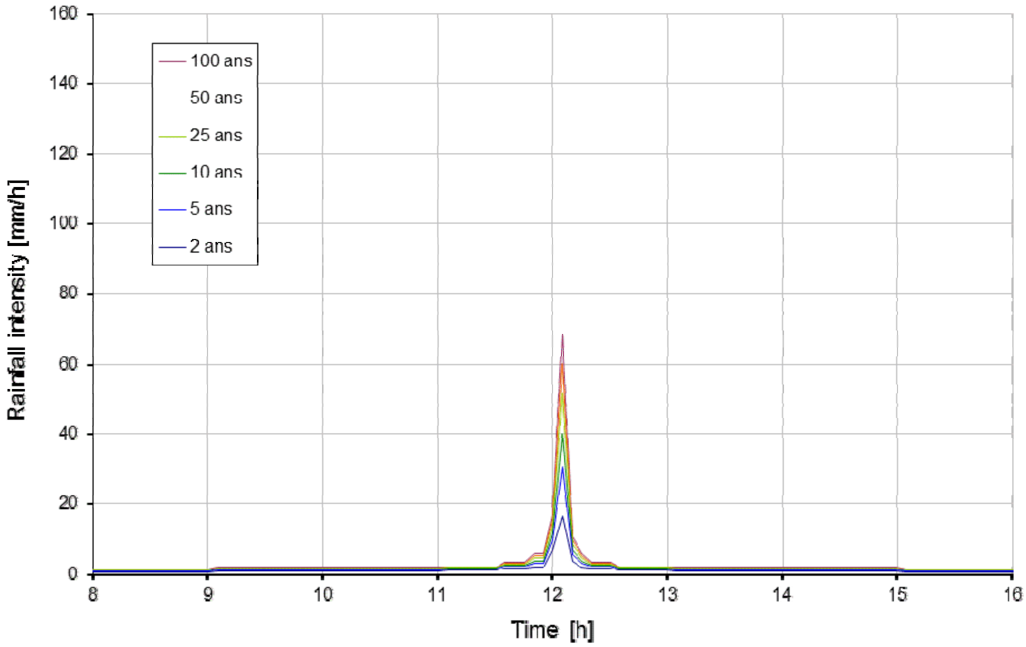

Figure 2-2: Spring Rainfall Hyetographs

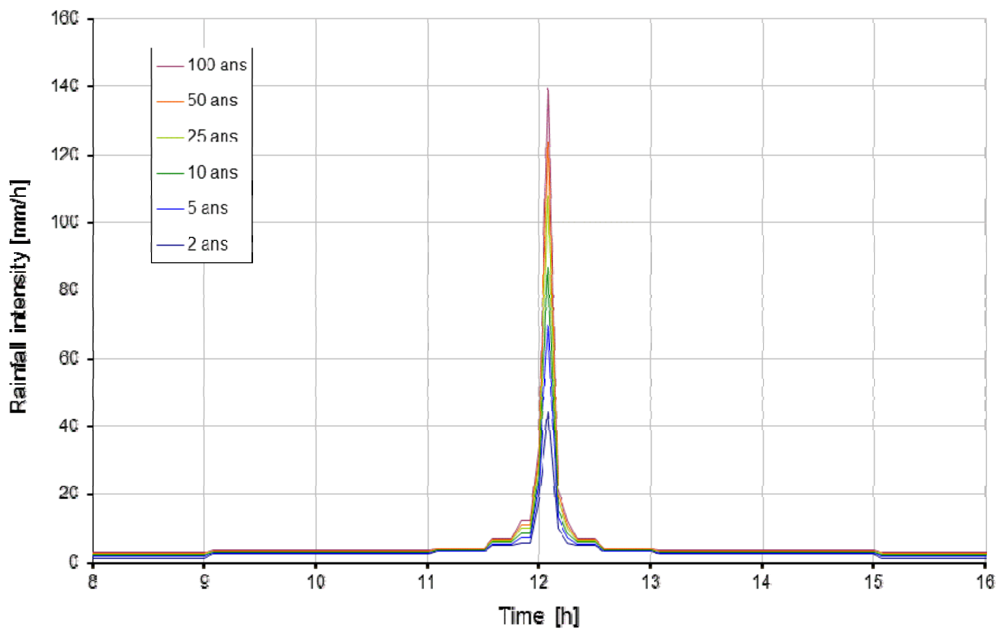

Figure 2-3: Summer-Fall Rainfall Hyetograph

2.1.5 Snow

Daily snowfall data is also available for the period of 1948-1993 from the Schefferville station. To extend the data set to 65 full years (1949-2013), snowfall was derived from total precipitation, by considering only precipitations that happened when the average daily temperature was lower than 1.2 °C. Average monthly snowfall values are presented in the following table:

Table 2-8: Average Monthly Snowfall (1949-2013)

Month	Snowfall [mm]
Jan	45
Feb	37
Mar	44
Apr	45
May	24
Jun	4
Jul	0
Aug	1
Sep	10
Oct	47
Nov	65
Dec	49
Year	**370**

On average, during the period 1949-2013, precipitation in the form of snow represented approximately 47 % of total precipitation.

Snow on the ground data is also available from the Schefferville station for years 1955 to 1993 and 2013 to 2014. Historical annual maximum snow cover depth varied between 43 cm in 1958 and 190 cm in 1977. A frequency analysis, using the Pearson type 3 probability distribution and the method of moments, was performed on snow cover depth to determine the values corresponding to different return periods. To compute the amount of water produced by snowmelt, snow density needs to be assessed. Snow density varies with time and from one year to another. According to Maidment (1993), typical values for settled snow density are 2 to 3 mm of water equivalent/cm of snow. Based on experience with other projects in the same area, a snow cover density of 2.5 mm of water equivalent/cm of snow was estimated for Howse. Those results are shown in Table 2-9.

Table 2-9: Maximum Annual Snow Cover Depth for Different Return Periods

Return Period [year]	Snow Cover [cm]	Snow Cover [mm]
2	100	250
5	128	320
10	144	360
25	163	408
50	175	438
100	187	468

It was determined that snow cover would melt between approximately 20 and 60 days, with an average around 35 days. The average melting time of 35 days was adopted to select a typical snow cover melting sequence, as illustrated for a 25 years return period snow cover on the following figure:

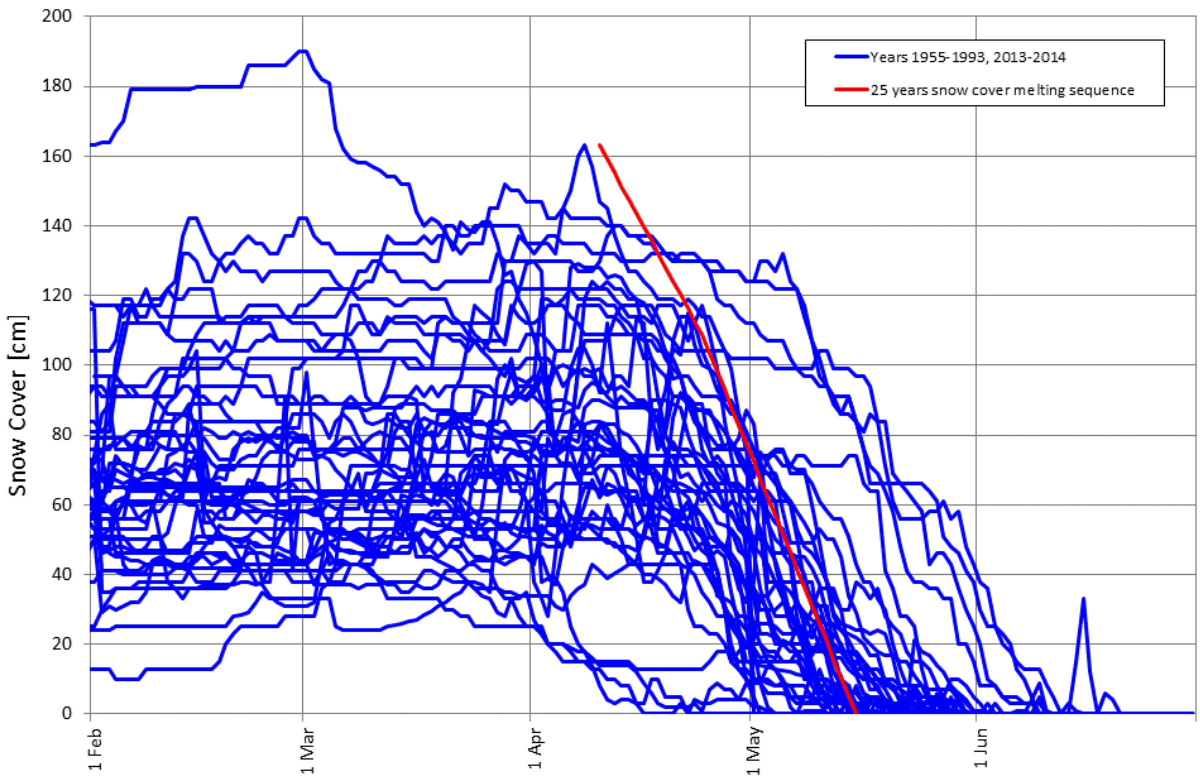

Figure 2-4: Snow Cover Melting Sequence

2.1.6 Lake Evaporation and Evapotranspiration

Some monthly lake evaporation data is available for the Schefferville meteorological station. This data was compiled from measurements made during the period 1951 to 1980 (Rollings, 1997). This data was compared with the Churchill Falls lake evaporation data from HML (2014) and with potential evapotranspiration computed using the Thornthwaite equation (Maidment, 1993).

The yearly lake evaporation from Churchill Falls (288 mm) is approximately 9 % lower than lake evaporation values for Schefferville (318 mm), and Schefferville annual computed potential evapotranspiration (393 mm) is approximately 24 % higher than lake evaporation values for Schefferville (318 mm). Lake evaporation data from Rollings (1997) was selected as the most representative data set for Howse. Monthly Lake Evaporation data from the three collecting points are presented in Table 2-10:

Table 2-10: Monthly Lake Evaporation

Month	Schefferville Rollings (1997) Adopted for Howse [mm]	Schefferville Thornthwaite Equation [mm]	Churchill Falls HML (2014) [mm]
Jan	0.0	0.0	0.0
Feb	0.0	0.0	0.0
Mar	0.0	0.0	0.0
Apr	0.0	0.0	0.0
May	0.0	24.5	0.0
Jun	104.0	96.4	99.0
Jul	98.0	123.3	105.4
Aug	70.0	100.2	83.7
Sep	46.0	48.9	0.0
Oct	0.0	0.0	0.0
Nov	0.0	0.0	0.0
Dec	0.0	0.0	0.0
Year	**318.0**	**393.2**	**288.1**

Evapotranspiration is another component of the hydrological cycle that needs to be estimated, in particular for water balance computations. Based on experience with other similar projects, evapotranspiration is assumed to be equal to 35 % of lake evaporation for the Howse mine site.

2.1.7 Infiltration and Runoff

When water, in the form of rainfall or snowmelt, reaches the ground, part of it might infiltrate the ground, if it is not frozen or already saturated with water, and part of it will be runoff.

To obtain relatively accurate values of infiltration and runoff volumes, hydrological modeling of one or more representative watersheds in the Howse area should be undertaken. However, such modelling requires a large amount of data, typically a minimum of five complete years of stream flow data, to perform a proper model calibration.

Another way to estimate infiltration and runoff is to use a runoff coefficient. This coefficient should be representative of average conditions, when used for water balance computations, or it should be representative of conditions during a particular flood, when used for the design of hydraulic structures like ditches, culverts, and sedimentation basins.

Available data to estimate runoff coefficients for Howse are:

- Hydrometric data recorded on small creeks on the Howse mine site (GH, 2011, GH 2014a);
- Values estimated for larger watersheds (Rollings, 1997);
- Typical values sited in the literature (MTQ, 2006).

The hydrometric data collected during one summer campaigns is representative of the conditions during this particular summer. However, they don't permit statistical analyses and the derivation of values for different return periods because the duration of the campaigns was too short. For this reason, this data was not considered in the present study.

Based on regional analyses, runoff and precipitation maps are available for Labrador (Rollings, 1997). According to these maps, for the Howse area, the mean annual total precipitation is in the order of 800 mm, a number similar to the 782 mm obtained in section 2.1.3, and the mean annual runoff is in the order of 650 mm. The ratio of these numbers leads to an annual runoff coefficient of approximately 0.8.

Typical runoff coefficient values cited in the literature are given for peak flow function of soil type, watershed slope and land use. For example, gravel roads and roadsides, or a cultivated soil with a medium porosity, and a watershed slope between 3 and 8 % would have a peak flow runoff coefficient between 0.4 and 0.6.

For Howse, the following assumptions were made:

- A runoff coefficient of 1.0 is assumed for water balance computations for the winter months, between October and April, due to frozen ground, and for the month of May, when most of the snowmelt occurs and the ground is saturated with water;
- A runoff coefficient of 0.4 is used for water balance computations during the summer months between June and September;
- A runoff coefficient of 1.0 is assumed during spring floods combining snow melt and spring rainfall, and for 100 year return period floods;
- A runoff coefficient of 0.5 is assumed for the 25 year return period summer-fall flood.

3.0 EFFLUENT QUALITY, TYPE AND TREATMENT STRATEGY

3.1 Effluent Quality

Water quality analytical results sampled at the current mining operation Timmins 4 were used to evaluate the expected water quality that could be observed on the Howse property since they are located close to each other. The water quality results from Sedimentation ponds B and C (sampling COA-SW11 and COA-SW12) were reviewed since they are the most representative of the effluent that is expected on the Howse property. The water quality results taken from Sedimentation ponds B and C are presented in Appendix D (HML, 2014c).

The water is of good quality and generally meets the requirements of the Certificate of Approval (CofA) (GNL, 2012) for all parameters except for suspended solids, where the concentration in the water tested is slightly above 30 mg/L. The Certificate of Approval is based on the Metal Mining Effluent Regulations (MMER) 2002 (Government of Canada, 2002). The concentration of total iron, which is not currently regulated by the MMER, was tested once and the result was high. This parameter should be closely monitored in the future, but it is assumed that iron is present as a suspended solid form and should settle out in the Sedimentation pond, thus possibly lowering the concentration to an acceptable limit. It is important to note that the MMER is currently under review and iron could be included in its next edition.

Consequently, for the purpose of this study, and assuming that any effluent collected on the Howse DSO property will have a similar water quality as observed on the Timmins 4 site, the main parameters of concern is assumed to be limited to suspended solids.

3.2 Type of Effluent

There are three types of effluent that will need to be managed on the Howse DSO property:

1) **Natural site runoff:** The main parameter of concern with the natural site runoff will be suspended matter, specifically during heavy rainfall event and snowmelt event. It is assumed that suspended solids will mainly consist of silt, sand and grit.

2) **Runoff from Overburden and Waste Rock dump:** The overburden at the Howse DSO property is expected to be mainly composed of silt, sand and gravel. The waste rock is expected to be composed of fine rock particles. The waste rock is also expected to be non-acid generative. The main parameter of concern is assumed to be with fine suspended matter.

3) **Pit Dewatering:** The pit dewatering water will consist mainly of groundwater that infiltrate into the pit, as well as surface runoff that flows into the pit:

   a. **Groundwater:** The groundwater is expected to be of similar quality to the natural site runoff. The groundwater pumped from the wells around the pit is expected to have very little suspended solids.

   b. **Sump Water:** The main parameter of concern in the sump water from the pit is assumed to be limited to only fine suspended matters. Total suspended solids of the sump water are expected to be high due to the mining activity in the pit.

   The sump water could also be contaminated with ammonia, nitrate, and diesel coming from un-exploded explosive residues, and oil and hydrocarbon spills from the machinery. In order to minimize the load of ammonia and nitrate that could migrate into the sump water, proper explosive management should be implemented. The objective of the explosive management will be the leaching of ammonia and nitrate from the explosive into the water column. The explosive management could include the following:

I. Proper selection of a water resistant based emulsion explosive.

II. Monitoring blasting performance based on explosive quantities, blast design and surface water quality.

III. Proper explosive handling in combination with proper spillage control in order to promptly remove explosive spills around the blastholes.

IV. Proper blast design to minimize incomplete detonation of explosive.

To manage any oil and hydrocarbon spills from the machinery, once a spill is detected, it will be promptly contained and removed through the use of absorbing pads. Furthermore, to manage any diesel that could be present in the sump water, an oil/water separator system could be used to remove the diesel before the surface runoff is transferred to the sedimentation pond

3.3 Treatment Strategy

Sedimentation ponds are proposed on the Howse DSO property to manage and remove the suspended solids before the water is returned to the natural receiving streams. All the Sedimentation ponds are sized to provide the required settling area to allow for the smallest design particle size to settle out in the pond.

The Sedimentation ponds will not be lined with any impervious material to prevent or reduce water infiltration into the ground. Ammonia and nitrate residues are expected in effluent water, but at such a low concentration that it should not require any specific treatment. Effluent monitoring will be conducted on a regular basis and specific treatment will be considered if ammonia and nitrate blasting residues concentration are above the criteria. The only parameter of concern is suspended matters. Consequently, if some of the runoff water does infiltrate into the ground, it will not have a negative impact on the water quality of the underlying groundwater.

An allowance of 0.5 m is provided at the bottom of the Sedimentation pond for sediment storage. The frequency at which the sediments will need to be removed from the pond and properly managed following all applicable regulations during the life of the mine will be evaluated in the next phase of the project.

If runoff water from the overburden, waste rock dumps, or the pit exhibit water quality issues other than suspended solids, such as color issues due to the presence of colloidal particles, it will be possible to add the necessary equipment to dose treatment chemicals, such as a coagulant, upstream of the corresponding sedimentation ponds. The treatment chemicals will help destabilize the colloidal particles and help it co-precipitate out with the resulting floc formed by the addition of a coagulant.

Please refer to sections 6 and 7 for more details on the design of the Sedimentation ponds planned for the Howse DSO project.

4.0 HYDROGEOLOGY

For this conceptual water management plan, the dewatering rate of the Howse pit was first estimated based on dewatering historical data of other similar mines in the area and using few conservative assumptions.

An overview of the historical mine dewatering at Knob Lake during previous mining operations is given in Stubbins & Munro (1965). The studied mines included Wishart, Gagnon, French and Ruth mines, where the dewatering was very much depth correlated and increased with the mine pit floor depth. The Table 4-1 summarizes these results. The range of the dewatering rates varied from 16,874 to 86,547 m^3/d for those old mines. Obviously, this wide range of dewatering rates is due to several factors for which data are unavailable, such as pit dimensions, hydraulic conductivities of the geological units, fault zones, proximity to the water bodies, permafrost presence, and mining and dewatering operations.

Other new dewatering simulations were conducted for two new future mines, Timmins 3 and LabMag, located about 5 km to the northeast and south of the Howse deposit respectively. The results are summarized in the Table 4-1. The dewatering simulation results for these two closer mines are in the same order of magnitude to the ones recorded for Wishart and Gagnon mines (dewatering rate between 13,000 and 23,000 m^3/d).

The hydraulic conductivities of the iron ore units at the Howse deposit estimated from pumping tests by Geofor 2014 were very close to the ones determined for Timmins 3 and LabMag deposits. This similarity suggests that the dewatering rate of the Howse pit would be in the same order of magnitude of the dewatering rates of those two closer mines.

Based on these observations, a flow rate of 23,000 m^3/d with a safety factor of 50%, representing a total dewatering rate of about 34,500 m^3/d was considered a conservative value for the Howse deposit, and therefore it was used for a preliminary design criteria.

Recent results of the groundwater flow modeling for the Howse deposit (SNC-Lavalin, January 2015) showed in fact that the dewatering rate range obtained was very close to the one for Timmins 3 and LabMag sites. The dewatering rates were estimated to be 13,950 m^3/d for a base case dewatering scenario considering a safety factor of 1.5. This flow rate may reach higher values, ranging from 17,740 to 31,035 m^3/d, with slightly higher hydraulic conductivities of geological units surrounding the pit and of the recharge rate.

Consequently, the dewatering rate for the design criteria was maintained at 34,500 m^3/d.

Considering that the water table at the Howse deposit was generally between 64 and 90 m in depth (Geofor, 2015 and Golder, 2014), it will be expected during the first years of mining operations that the dewatering rate will be lower than the rate estimated for the final pit. During this period, dewatering will be limited to water accumulated in the pit basically from direct precipitations and infiltration through the unsaturated geological units until the pit floor reaches the water table. After, dewatering rate will increase gradually with pit floor depth and reach its maximum rate at its final depth.

Table 4-1: Summary of Hydrogeological Data

Type of Data	Mine Site	Floor Depth (m)	Dewatering (m^3/d)	Data References
Historical data of DSO mines	Wishart	69	16,874	Stubbins, J. B. and P. Munro. 1965. Historical information on mine dewatering of DSO (Knob Lake). The Canadian Institute of Mining and Metallurgy Bulletin, 58:814-822.
	Gagnon	83	20,412	
	French	116	84,370	
	Ruth	144	86,547	
Simulation results on new mines	Timmins 3	80	12,960	Groupe Hémisphères, march 2010. Hydrological and hydrogeological study: survey season 2009, DSOP. Final technical report.
	LabMag	150	22,262	SNC-Lavalin, in preparation. Hydrogeology and mine pit dewatering modeling - LabMag site. New Millenium Iron – TATA Steel
Assumption	Howse	160	34,500(*)	--
(*) Including a safety factor of 50%				

The water management infrastructures have been designed based on the conservative dewatering flow assumption presented in this section.

5.0 DESIGN CRITERIA FOR WATER MANAGEMENT INFRASTRUCTURES

A summary of the design criteria is presented in the following table. The complete Design Criteria document is in Appendix C.

Table 5-1: Design Criteria of the Planned Water Management Infrastructures

Type of criteria	Criteria	Value	Comments
Location criteria	Buffer zone between infrastructures and Irony Mountain	500 m	--
	Buffer Strip between infrastructures and water course and wetlands	Minimum of 15 m	--
Environmental Criteria	Alteration of Pinette Lake	No alteration of Pinette Lake water quality is accepted	No surface water from Howse mine site can be discharged to Pinette Lake, even after treatment through a Sedimentation pond.
	General location of infrastructures	Avoid building infrastructures on wetlands whenever possible.	--
	Quality of run-off water and dewatering water	The only issue is assumed to be total suspended solids	See section 3 for discussion on this issue.
	Pond and ditches waterproofing	No waterproofing	See section 3 for discussion on this issue.
Hydrological criteria	Source of meteorological Data	Schefferville A meteorological station	Intensity-Duration-Frequency data used for Infrastructure design is presented in Appendix A
Ditches design criteria	Ditch longitudinal slopes	Minimum 0,5%	--
	Ditch transversal slopes	2H:1V	--
	Ditch excavation	Minimize volume of excavation	--
	Return period of design flow	100 years	--
Ponds design criteria	Infiltrations	No infiltrations are considered	Pond bottom and sides assumed frozen during spring freshet.
	Dead storage for sediment	0.5 m	The frequency at which the sediments will need to be removed from the pond during the life of the mine will be evaluated in the next phase of the project. If sediment removal will be required, it will be managed according to all applicable regulations
	Vertical distance between dike crest and spillway invert	1 m	--
	Pond outflow structure	Permeable rockfill dike	--

Type of criteria	Criteria	Value	Comments
	Ice cover during design flood	0.5 m	The Sedimentation ponds will naturally drain by gravity at the end of fall. Thus, there will be no significant build-up of ice cover during winter. Sedimentation pond H3 receives water continuously from pit dewatering operation, even during winter. Thus, it is assumed that a 1 m ice cover will remain at the peak of spring flood.
	Return Period of design flood for emergency spillway	100 years	According to Canadian Safety Dam recommendation for Significant Dam Class.
	Return period of design flood for pond routing and sedimentation	25 years	--
	Design flood for pond routing and sedimentation	The worst of either : A 24 hours summer-fall 25 year return period rainfall; or Combinations of a 24-hour 25 year return period rainfall with the melting of a 25 year return period snowpack over 30 days.	--
Sedimentation criteria	Design flow	Average 24 hour inflow during the peak of the design flood	--
	Specific gravity of particle to settle	2.7	--
	Design particle size to settle for Sedimentation pond no. H1 (receive run-off on natural ground)	0.1 mm (100 microns)	Particle size selected assuming run-off on natural sandy ground. Pond designed to ensure a minimum residence time of approximately 5 h and that the minimal sedimentation area is available.
	Design particle size to settle for Sedimentation ponds no. H2 and H3 (receive dewatering water and site and pit run-off)	0.01 mm (10 microns)	Particle size selected according to assumed particle size analysis for overburden and waste rock.
	Length to width ratio of the Sedimentation ponds	Minimum 3 to 1	--

6.0 WATER MANAGEMENT STRATEGY

The adopted water management strategy is based on the following concepts:

- Minimize impacts on environment;
- Use existing infrastructures as much as possible;
- Clean and contaminated water separation;
- Water treatment for suspended sediments;

Impacts on the environment need to be minimized by avoiding construction in sensitive areas such as wetlands as much as possible and by minimizing flow variations in existing natural creeks. Another way to mitigate impacts on the environment is to use existing infrastructures, like Timmins 4 Sedimentation pond 3, as much as possible. Separation of clean water, collected by diversion ditches, from contaminated water, collected by collection ditches, allows for specific water treatment before release towards existing streams. Water treatment mainly consists of removing suspended sediments by the means of Sedimentation ponds (refer to section 3 for comments on water quality).

The following section 6.1 describes the proposed site layout and Section 6.2 presents alternatives layouts that were also considered.

6.1 Proposed Site Layout

The site layout is presented on Map 1 (Appendix B). The layout was designed to minimize impacts on the natural watersheds on which the project will be constructed and to distribute the pit runoff and the pit dewatering water in the most suitable watershed. Map 2 (Appendix B) shows the natural watershed limits and Map 3 (Appendix B) presents the modified watershed boundaries. The future infrastructures watersheds are shown on Map 4 (appendix B) and on Table 6-1.

Table 6-1 : Planned Infrastructures Watershed Area

Infrastructure	Watershed area
Sedimentation pond no. H1	50 ha
Sedimentation pond no. H2	181 ha
Transfer pond	52 ha
Howse pit	81 ha

Water management infrastructures consist in a drainage network made of ditches, four Sedimentation ponds, including the existing Timmins 4 Sedimentation pond 3, and one transfer pond. Drawing 622834-40DD-0001 (Appendix B) shows the detailed plan view of ditches and ponds. The following figure schematically describes the water management plan infrastructures and water fluxes between them.

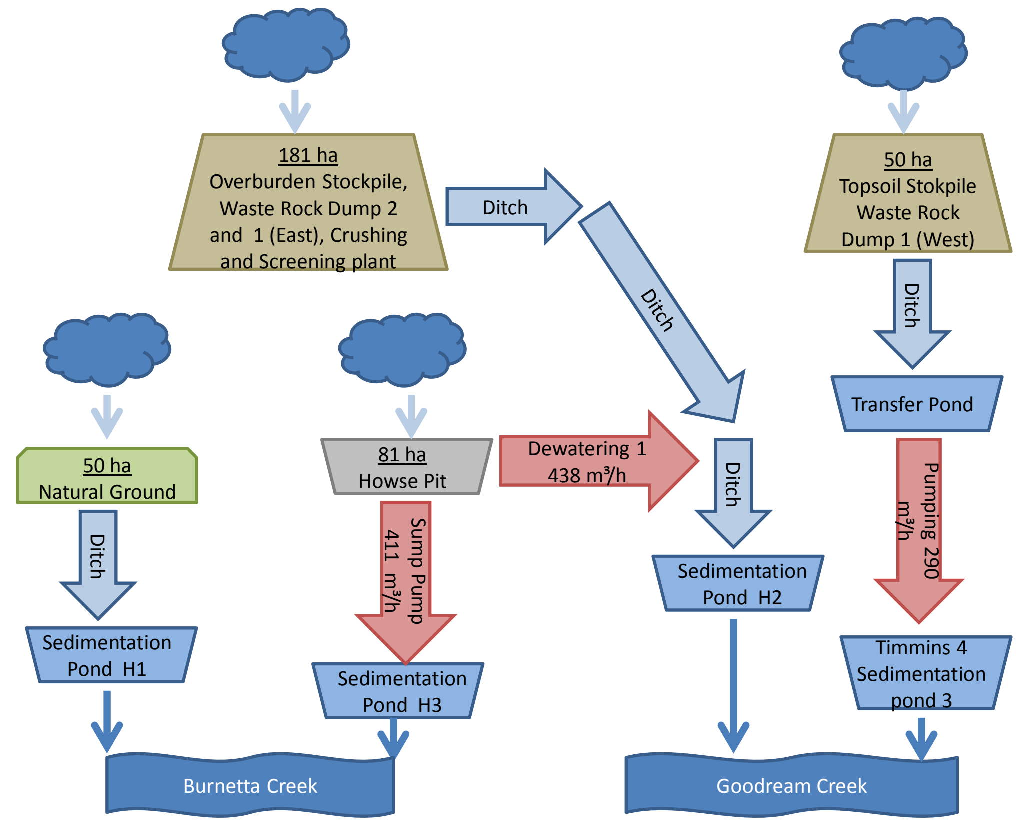

Figure 6-1: Water Management Plan Schematic

6.2 Considered Options

Several options were analyzed before selecting the approach presented in Map 1 (Appendix B). The following sections present a short description of these options and the reasons why they were not selected for the present stage of the project.

6.2.1 Use of Existing Timmins 4 Sedimentation Pond 3 for Treatment of Pit Runoff and Dewatering Water

The opportunity of using the existing Timmins 4-Sedimentation pond-3 to discharge run-off or dewatering water from Howse property was evaluated. However, according to design criteria selected for the preparation of the Howse water management plan, this existing pond is not large enough to allow for an acceptable sedimentation considering the additional flow from Howse pit dewatering. The pond would have to be enlarged or treatment with chemical aids would be necessary.

6.2.2 Turning the Transfer Pond into a Sedimentation Pond

Another option is the possibility to turn the transfer pond into a Sedimentation pond and discharge treated water to Pinette Lake despite the stakeholders concern. The goal of this option would be to maintain the actual Pinette lake watershed size in order to minimize possible impacts on lake level and fish habitat. This option was not selected because it is against the stakeholders' will; it would require an additional effluent to monitor, and there would always be a risk of discharging red water in Pinette Lake in case of a flood event exceeding the design criteria.

6.2.3 Treatment of Pit Runoff and Dewatering Water in Sedimentation Pond H3

Another option is the possibility to treat pit runoff and pit dewatering water in Sedimentation pond H3, then release the treated water into Burnetta Creek. The capacity of Burnetta Creek to receive such relatively large additional flow was assessed by Groupe Hémisphère (GH, 2014b) who concluded that Burnetta Creek could not support it without major erosion.

6.2.4 Comparison of Options

The adopted water management strategy is the option having the least impacts on Goodream Creek and Burnetta Creek in terms of global incremental watersheds area changes. The use of Timmins-4 Sedimentation pond 3 to treat water from the Transfer pond allows for the release of some water into the intermittent part of Goodream Creek. This limits the risk of drying completely the intermittent part of the creek, from which most of the actual runoff will be intercepted by a collection ditch (see Map 3 and 4 in Appendix B).

The adopted water management strategy also has the least impacts on the fish habitat in Goodream Creek. The dewatering water from the pit area should have less suspended solid and no dissolved contaminants compared to the sump water. By sending the dewatering water to Goodream Creek, there will be no impact on the fish habitat since there are no dissolved contaminants in this water. The sump water from the pit has an higher risk of containing dissolved contaminants, such as ammonia and nitrate. The receiving Burnetta Creek has no fish habitat upstream from Burnetta Lake.

The following table summarizes existing watersheds incremental area variations for the different water management options:

Table 6-2: Existing Watershed Area Variations

Receiving Water Body	Drainage area variation for the selected option	Drainage area variation if Timmins 4-Sedimentation pond 3 was used to manage dewatering and run-off water from Howse pit	Drainage area variation if water from Transfer Pond was discharged in Pinette Lake	Drainage area variation if pit runoff and pit dewatering was discharged in Burnetta Creek (*)
Goodream Creek	+ 22 ha	+ 100 ha	+ 48 ha	+22
Burnetta Creek	+ 39 ha	- 40 ha	+ 37 ha	+39
Pinette Lake	- 61 ha	- 61 ha	- 4 ha	-61
(*) For this option, the variation of the drainage area is the same as the selected option. However, the pit dewatering would be discharged in Burnetta Creek instead of Goodream Creek.				

6.3 Summary of Designed Infrastructures

The following sections describe the different infrastructures designed for this project.

6.3.1 Sedimentation Pond H1

Sedimentation pond H1 (see Drawing 622834-4000-40DD-0006 in Appendix B) is used to treat runoff water from the natural area located on the south-west side of Howse pit. This pond will be located on the west side of Howse pit and treated water will be discharged into Burnetta Creek. The pond will be located in a natural slope of about 5% and the downstream side of the pond will have to be confined with a dike. Section 7.2 summarizes the design of Sedimentation pond H1.

6.3.2 Transfer Pond

The Transfer pond (see Drawing 622834-4000-40DD-0004 in Appendix B) is necessary to collect contaminated runoff water from a 52 ha area flowing naturally in Pinette Lake watershed, before pumping this water into existing Timmins 4 Sedimentation pond 3 for treatment. The Transfer pond will be built in a depression located on the south side of the topsoil stockpile. It will be completely excavated with no dike. Section 7.3.4 summarizes the design of the Transfer pond.

6.3.3 Sedimentation Pond H2

Sedimentation pond H2 (see Drawing 622834-4000-40DD-0005 in Appendix B) will receive runoff from a 181 ha area, including the overburden stockpile, waste rock dump 2, part of waste rock dump 1, and water pumped from the peripheral well used for Howse pit dewatering. This pond will be located on the north-west side of the overburden stockpile, in a natural slope, and the downstream side of the pond will have to be confined with a dike. Treated water will be discharged into Goodream Creek. Section 7.3.5 summarizes the design of Sedimentation pond H2.

6.3.4 Sedimentation Pond H3

Sedimentation pond H3 (see Drawing 622834-4000-40DD-0006 in Appendix B) will be used for the treatment of the sump water that will be pumped out of the pit. Both Sedimentation ponds H1 and H3 will release treated water into Burnetta Creek using the same outflow ditch. Sedimentation pond H3 will be located in a natural slope of about 5% and the downstream side of the pond will have to be confined with a dike. Section 7.3.6 summarizes the design of Sedimentation pond H3.

6.3.5 Timmins 4 Sedimentation pond 3 (Existing)

Timmins 4 Sedimentation pond 3 is an existing Sedimentation pond located on the east side of Howse project. It will be used to receive pumped water from the Transfer pond.

6.3.6 Ditches

There is one diversion ditch collecting natural runoff, flowing from the south-west towards the mine pit, and conveying this water into Sedimentation pond H1 for treatment. A network of collection ditches is used to collect contaminated runoff from the whole mine site, including Haul Road, Crushing and Screening Plant, Topsoil Stockpile, part of Waste Rock Dump 1, Waste Rock Dump 2, and Overburden Stockpile. The collected contaminated water is conveyed into Sedimentation pond H2 for treatment. Ditches plan view is presented on Drawing 622834-4000-4GGD-0001-0001 and Map 2 (Appendix B), and ditches profiles are presented on Drawings 622834-4000-40DD-0002 and 622834-4000-40DD-0003 (Appendix B).

It was chosen to include the relatively small wetland area located between the Overburden Stockpile and Waste Rock Dump 2 in the area collected by the collection ditches and treated it into Sedimentation pond 2. This decision was based on the facts that:

- It will not be possible to avoid the contamination of this area due to its close location between two stockpiles;
- It would be technically difficult to cross the outlet of this area with the collection ditch necessary to collect runoff from Waste Rock Dump 2.

6.3.7 Inlet and Outlet Structures

The water inlet structures of Sedimentation ponds H1 and H2 will be designed to promote an even distribution of the flow over the pond width (see Drawing 622834-4000-40DD-0005 in Appendix B). Ditches will be widened at the Sedimentation pond entrance, and water will flow into the pond via an impervious ditch section with the use of a HDPE plastic membrane. This impervious section will avoid the formation of preferential channels at the pond entrance.

For Sedimentation pond H3, an inlet distribution pipe will be used to distribute the pumped water from the pit over the entire width of the pond.

The outflow structure for all Sedimentation ponds will be made of a permeable rockfill dike sized to avoid any spill over the emergency spillway during the 25-yr sedimentation design flood (see Drawing 622834-4000-40DD-0005 in Appendix B). The emergency spillway will be integrated within the rockfill in a way allowing for the passage of vehicles.

The outlet structure of existing Timmins 4 Sedimentation pond 3 will have to be modified into a permeable rockfill dike and an emergency spillway similar to those for Sedimentation ponds H1, H2, and H3. This is necessary to ensure the good functioning of the pond with the additional pumped discharge from the Transfer pond, based on the same design criteria as the new ponds.

Downstream of the permeable rockfill dike, treated water from the Sedimentation ponds will be collected and conveyed toward the receiving stream with ditches. These ditches will have a small longitudinal slope to ensure low flow velocities at the entrance of the receiving streams. If needed, energy dissipation measures could also be put in place at the entrance of natural streams to avoid unwanted disturbance to the existing creeks.

6.3.8 Dikes Construction Material

For the present project stage, it is assumed that the dikes on the downstream side of Sedimentation ponds H1, H2 and H3 will be built with compacted material, using overburden available on site (cut and fill). The suitability of this material for construction will be confirmed in the next phase of engineering, based on more detailed sieve analysis of the material and its percentage of fines. Permeable rockfill dike and riprap will be built using non-acid generating material.

7.0 WATER MANAGEMENT INFRASTRUCTURE DESIGN

The methodology, design criteria and detailed design of each infrastructure is presented in the next sections.

7.1 Ditches

Ditches are used to collect runoff water and convey it into sedimentation basins before being released towards existing natural streams.

7.1.1 Methodology

Ditches peak discharge is computed using the rational method:

$$Q = \frac{CIA}{360}$$

Where:

Q: Peak discharge [m^3/s].

C: Runoff coefficient [-].

I: Rainfall intensity corresponding to the watershed time of concentration [mm/h].

A: Drainage area [ha].

Ditches dimensions are determined using the Manning equation:

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

Where:

Q: Peak discharge [m^3/s].

n: Manning's coefficient [$s/m^{1/3}$].

A: Flow area [m^2].

R: Hydraulic radius [m]. R = A/P, where P is the wetted perimeter [m].

S: Ditch slope [%].

7.1.2 Design Criteria

The following design criteria were adopted for the ditches:

- A design flood return period of 100 years;
- A runoff coefficient of 1.0;
- A trapezoidal section is adopted. Typically ditches will be 1.5 m deep, have a 1.0 m base width, and 2H:1V side slopes;
- Ditches will be protected against erosion with a layer of riprap. If the required riprap layer exceeds 0.5 m, a gabion mattress will be used to replace the riprap;
- A Manning's n coefficient between 0.028 and 0.037 is used function of riprap mean diameter;
- A minimum longitudinal slope of 0.5 % is adopted;
- Culverts used for road crossings are assumed to be made of corrugated steel with an inlet projecting from fill.

7.1.3 Results

Ditches location is presented on drawing 622834-4000-40DD-0001. The following table summarizes ditches and culvert characteristics:

Table 7-1: Ditches and Culvert Characteristics

		CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10	DD1
Drainage area	[ha]	33.9	19.0	15.0	5.7	11.9	116.0	4.0	2.8	52.5	175.7	49.7
Return period	[year]	100	100	100	100	100	100	100	100	100	100	100
Runoff coefficient	[-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Peak discharge	[m³/s]	2.6	3.6	1.6	0.9	1.8	6.2	0.7	0.4	3.7	9.2	3.8
Culvert type				Corrugated								
Culvert inlet type				Projecting from fill								
Number of culverts	[-]			1								
Diameter	[mm]			1600								
Channel lateral slope	H: 1V	2	2	2	2	2	2	2	2	2	2	2
Channel base width	[m]	1.0	1.0	1.0	1.0	1.0	1.5	1.0	1.0	1.0	3.0	1.0
Channel depth	[m]	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Max channel longitudinal slope	[%]	12.0%	10.9%	5.7%	1.3%	0.5%	5.9%	9.1%	13.0%	5.1%	2.2%	5.7%
Min channel longitudinal slope	[%]	0.5%	0.5%	1.1%	0.8%	0.5%	0.9%	0.7%	0.8%	0.6%	0.5%	0.8%
Maximum flow depth	[m]	0.82	0.98	0.52	0.38	0.62	0.98	0.40	0.29	0.90	1.06	0.87
Minimum freeboard - Design	[m]	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Minimum freeboard - Actual	[m]	0.68	0.52	0.98	1.12	0.88	0.52	1.10	1.21	0.60	0.44	0.63
Maximum flow velocity	[m/s]	3.79	3.92	2.71	1.49	1.29	3.68	2.57	2.53	3.20	2.89	3.31
Minimum riprap D_{50}	[mm]	Gabion	Gabion	250	100	50	Gabion	200	200	Gabion	250	Gabion
Minimum riprap depth	[mm]	Mattress	Mattress	500	300	300	Mattress	400	400	Mattress	500	Mattress

Note that in the above table, the actual minimum freeboard corresponds to the ditch section with the minimum longitudinal slope, and maximum flow velocity and riprap or gabion mattress protection correspond to the ditch section with the maximum longitudinal slope.

7.2 Transfer Basin

A transfer basin is necessary to collect runoff water that cannot be drained with ditches directly into sedimentation basin H2. In spite, this water is collected in a Transfer basin then pumped into ditch CD5. Drawing 622834-4000 40DD-0004 presents the location of the Transfer basin.

7.2.1 Methodology

Flood routing computations were used to determine the Transfer basin volume and pumping capacity. A larger volume was selected, based on site configuration, to minimize the required pumping capacity.

7.2.2 Design Criteria

The following design criteria were adopted for the Transfer basin:

- A design flood return period of 25 years was selected. A spring flood and a summer-fall flood were compared. A runoff coefficient of 0.5 was assumed for the summer-fall flood. For the spring flood, a runoff coefficient of 1.0 was assumed considering a frozen or water saturated ground. The spring flood, composed of a 24 h spring rainfall, occurring the last day of the melting of a 25 years snow cover over a 35 days period, resulted in the largest Transfer basin volume;
- The spring flood adopted equals to 33.1 mm of rain plus 407.5 mm of snowmelt, for a total of 440.6 mm over a 35 days period;
- A square basin, with a minimum depth of 5.0 m, and 3H:1V side slopes was adopted;
- The pump intake was assumed to be located 0.5 m above the basin bottom elevation;
- No backwater allowed in the ditches;
- No evaporation is considered during floods;
- No ice accumulation is assumed at the bottom of the basin during a spring flood because the basin will be empty at the start of winter;
- No infiltration is considered.

7.2.3 Results

A 6.5 m deep, square basin, with a top side length of 100 m, 3H:1V side slopes, and a pumping capacity of 290 m^3/h are required to contain the 25 years design flood (Table 7-2). No emergency spillway is required as the basin is entirely built in excavation. If a flood more important than the design flood occurs, water will accumulate in the basin and incoming ditches before overflowing towards Pinette Lake.

Table 7-2: Transfer Basin Characteristics

		Transfer basin
Drainage area	[ha]	52
Basin top length	[m]	100
Basin top width	[m]	100
Basin depth	[m]	6.5
Basin side slopes	H:1V	3
Basin volume	[m³]	21 300 (1)
Outlet type		Pumping station

(1) Between basin bottom and CD1 ditch invert elevations.

The following figure presents the design flood routing, through the Transfer basin, during a three days period centered on the 24h spring rainfall happening during the last day of a 35 days snow melt.

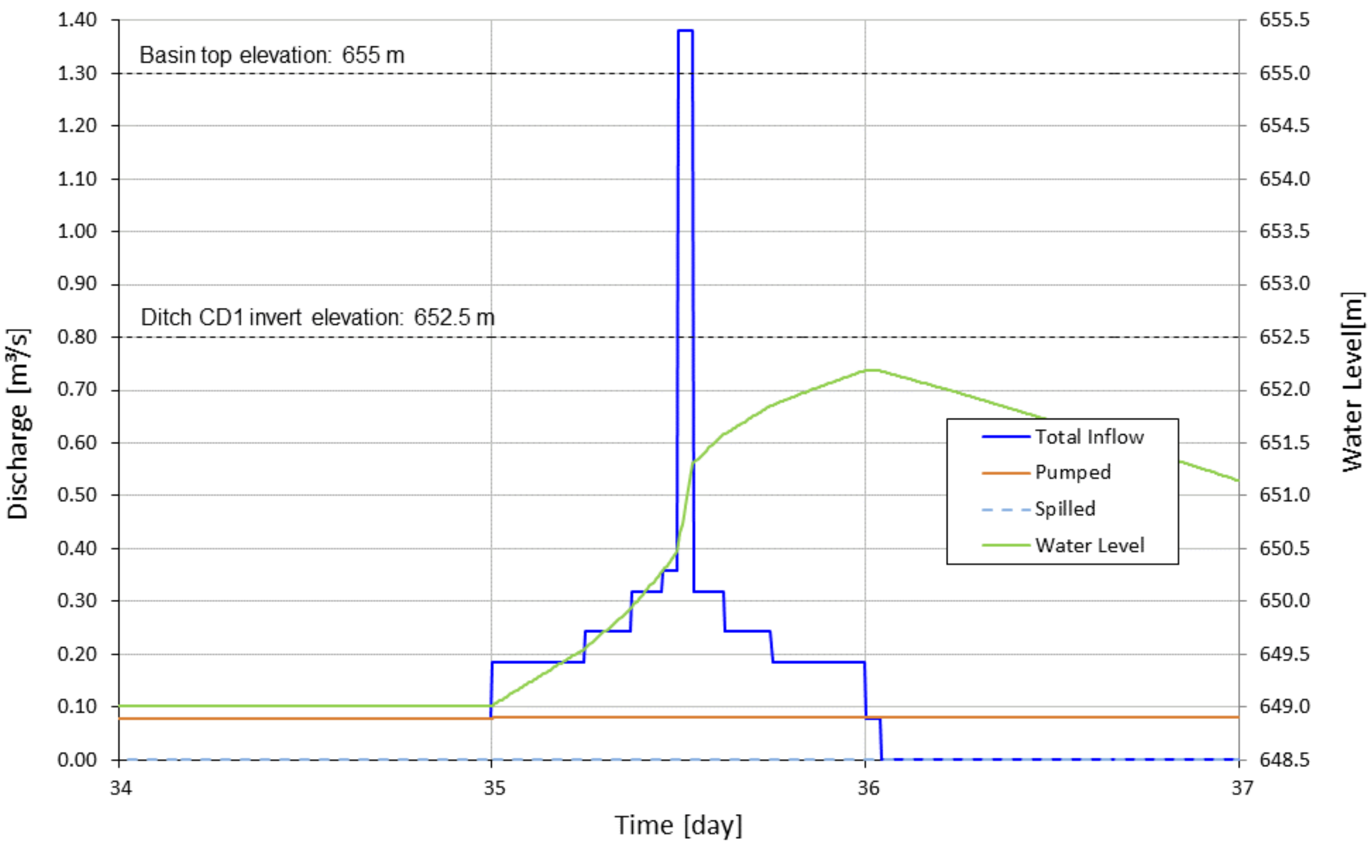

Figure 7-1: 25 Years Flood Routing through the Transfer Basin

7.3 Sedimentation Ponds

Sedimentation ponds are used to treat runoff water by reducing their content of total suspended solids before releasing the treated water in an existing natural stream.

7.3.1 Methodology

First, the minimum basin area necessary for the proper settling of the design particles is computed based on the sedimentation basin inflow and Stokes law:

$$A_{min} = a \frac{Q}{V_s}$$

Where:

A_{min}: Minimum sedimentation basin area [m^2]. To be conservative, the sedimentation basins bottom area was selected to be equal or larger than Amin.

a: Safety factor for particle shape being different than perfect spheres: a = 1.2.

Q: Design discharge [m^3/s].

V_s: Settling velocity [m/s].

$$V_s = \frac{(d_s - d_f)g}{18v} D^2$$

Where:

d_s: Sediment density: d_s = 2700 kg/m^3.

d_f: Fluid density. For water at 4°C, d_f = 1000 kg/m^3.

g: Gravity: 9.81 m/s^2.

v: Fluid viscosity. For water at 4°C, v = 0.00157 kg/m*s.

D: Particle diameter [m].

Then, flood routing computations are used to determine the sedimentation basin volume and outlet capacity for the design flood. The adopted outlet, for all Sedimentation ponds, is a permeable dike made of rockfill. This choice was based on the good resistance to freezing of such rockfill dikes. Rockfill dikes discharge capacity was computed based on Rollings (1997) as follows:

$$Q = h * L * V$$

Where:

Q: Discharge [m^3/s].

h: Hydraulic head [m].

L: Rockfill dike length [m].

V: Flow velocity [m/s].

$$V = n * W * \sqrt{m} * {i_{eff}}^{0.54}$$

Where:

n: Porosity [-].

W: Williamson coefficient = 5.243.

m: Hydraulic mean radius [m].

i_{eff}: Effective hydraulic gradient [-].

With:

$$m = \frac{e * d}{6 * rsae}$$

Where:

e: Void ratio [-]. Note that n = e/(1+e).

d: Nominal particle diameter [m].

rsae: Relative particle surface area efficiency [-].

And:

$$i_{eff} = 0.8 * A_r^{-3/2} * \left(\frac{h}{H}\right)^{1.4}$$

Where:

A_r: Embankment aspect ratio [-].

H: Rockfill dike height [m].

With:

$$A_r = \frac{1}{H} * \left(B_u + B_c + \frac{B_d}{2}\right)$$

Where:

B_u: Base length of the upstream part of the rockfill dike [m].

B_c: Base length of the central part of the rockfill dike [m].

B_d: Base length of the downstream part of the rockfill dike [m].

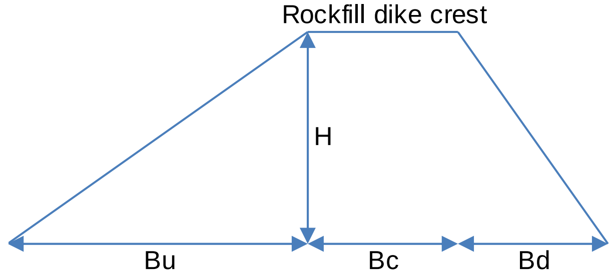

Figure 7-2: Rockfill Dike Cross-Section Sketch

7.3.2 Design Criteria

The following design criteria were adopted for the sedimentation basins:

- A design flood return period of 25 years was selected. A spring flood and a summer-fall flood were compared. A runoff coefficient of 0.5 was assumed for the summer-fall flood. For the spring flood, a runoff coefficient of 1.0 was assumed considering a frozen or water saturated ground. The spring flood, composed of a 24 h spring rainfall, occurring the last day of the melting of a 25 years snow cover over a 35 days period, resulted in the largest sedimentation basins volumes;
- The spring flood adopted equals to 33.1 mm of rain plus 407.5 mm of snowmelt, for a total of 440.6 mm over a 35 days period;
- A rectangular shape, with a length to width ratio of 4, and 3H:1V side slopes were adopted;
- A design particle size of 0.01 mm was adopted for sedimentation basins H2 and H3 used to treat runoff water from the mine site, and a design particle size of 0.1 mm was adopted for sedimentation basin H1 used to treat runoff water from natural ground;
- Design discharge for sedimentation is the average inflow during the 24 h rainfall;
- A permeable rockfill dike section was adopted as outlet. The bottom of the rockfill is located 0.5 m above the basin bottom elevation. This dead storage is used to collect sediments, and it is assumed frozen during the flood routing computations involving spring floods;
- A void ratio of 1.0 (corresponding to a porosity of 0.5), a nominal diameter of 0.2 m, and a relative surface area efficiency of 1.8 were assumed for the rockfill stones;
- Rockfill dike side slopes are 3H:1V, and the dike crest, Bc, is 4.0 m wide;
- An emergency spillway was designed to safely pass a 100 years flood. A trapezoidal weir, assuming a discharge coefficient of 0.35, and side slopes of 10H:1V to allow traffic when the spillway is not in use, was adopted;
- Evaporation is not considered during floods;
- No infiltration is considered for the new ponds.

7.3.3 Existing Timmins 4 Sedimentation Pond 3

Timmins 4 Sedimentation pond 3 is an existing Sedimentation pond located on the east side of Howse project (Map 1).

This Sedimentation pond has a top length of approximately 195 m, a top width of approximately 75 m, and a depth of 4.0 m. Water is conveyed into the pond by two ditches, draining approximately 82 ha, located on the upstream end of the pond. An outlet, made of a corrugated steel culvert with a 0.9 m diameter and an invert elevation of 660.6 m, is located on the downstream end of the pond. Treated water flows out of the pond through the spillway. Then, it is directed towards Goodream creek through a small ditch.

To test the capacity of the existing pond, flood routing computations were performed considering natural runoff from the 82 ha watershed plus the constant discharge from the pumping of pit dewatering (1438 m^3/h, see Section 4.0) and pit runoff (411 m^3/h). It was found that this pond does not meet the minimum area requirements for sedimentation (10 600 m^2 available versus 19 300 m^2 required), and the minimum available freeboard during the design flood (0.14 m) is too small to protect the surrounding dike against wave erosion. For these reasons, it was decided to use the existing pond with a modified outlet structure for the treatment of water pumped from the transfer pond, build a new Sedimentation pond, H3, for pit runoff, and treat pit dewatering in Sedimentation pond H2.

The modified outlet structure is a combination of a permeable rockfill dike, 30 m wide and 2.0 m high, and a trapezoidal weir spillway, with a 15 m wide crest and 1V:10H side slopes for allowing traffic when the spillway is not in use. The following table presents the existing Sedimentation pond characteristics when used to treat water pumped from the Transfer pond.

Table 7-3: Timmins 4 Sedimentation Pond 3 Characteristics

		Existing Timmins 4 sedimentation 3
Drainage area	[ha]	82
Design discharge	[m³/s]	0.52
Time of residence	[h]	16.3
Minimum required area	[m²]	10 500
Basin bottom area	[m²]	10 600
Basin top length	[m]	195
Basin top width	[m]	75
Basin depth	[m]	4.0
Basin side slopes	H:1V	2
Basin volume	[m³]	36 200 (1)
Outlet type		Rockfill dike
Outlet width	[m]	30
Spillway type		Trapezoidal weir
Spillway crest length	[m]	15

(1) Between pond bottom and spillway invert elevations.

The following figure presents the design flood routing, through the existing Timmins 4 Sedimentation 3 pond, during a three days period centered on the 24h spring rainfall happening during the last day of a 35 days snow melt.

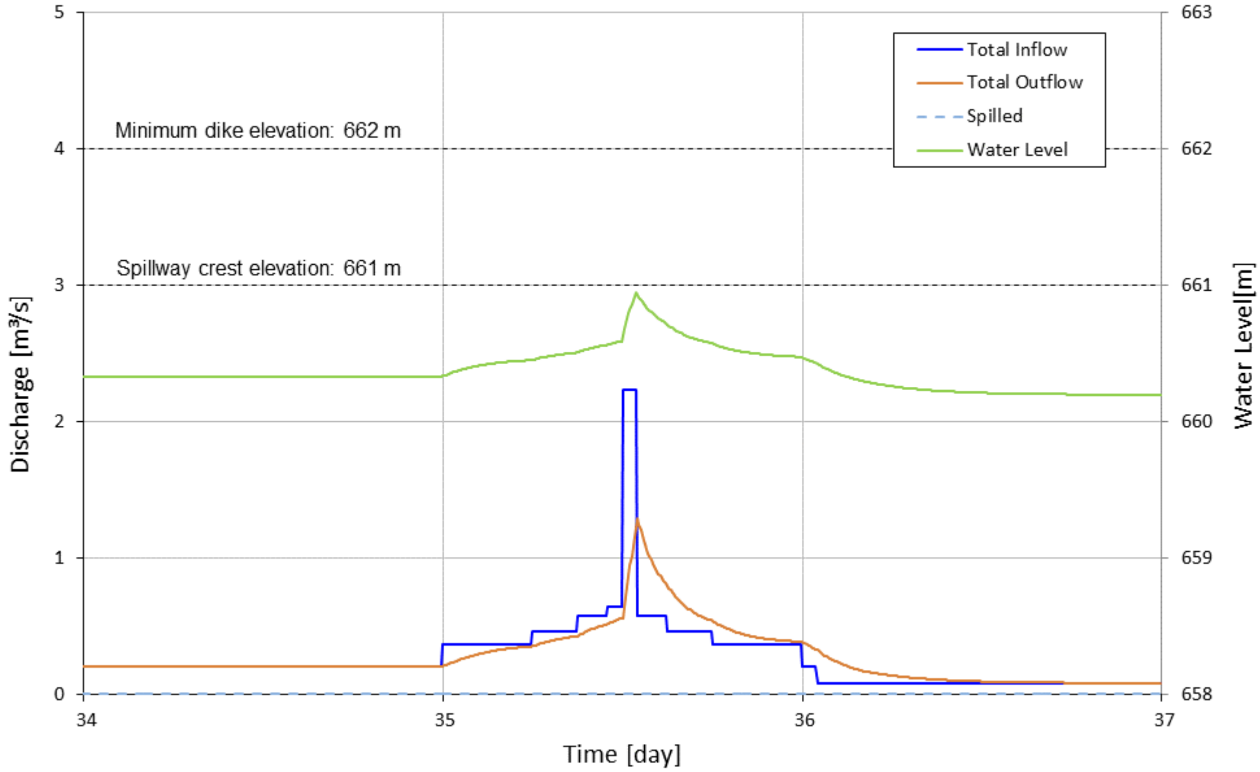

Figure 7-3: 25 Years Flood Routing through Timmins 4 Sedimentation Pond 3

7.3.4 Sedimentation Pond H1

Sedimentation pond H1 (drawing 622834-4000-40DD-0006) is used to treat water collected by a diversion ditch. This ditch is used to collect runoff water from an area of approximately 50 ha located on the south side of the mine pit. Because this water will not be in contact with the mining site, a sedimentation design particle size of 0.1 mm was adopted, resulting in a relatively small minimum area required for proper sedimentation. In this case, the Sedimentation pond dimensions were selected to ensure a residence time of approximately 5 h for the design discharge. The adopted pond dimensions are 160 m long by 40 m wide by 3.0 m deep. All characteristics of sedimentation pond H1 are presented in Table 7-4.

A 10 m wide permeable rockfill dike is necessary to adequately pass the 25 years return period sedimentation design flood without any spill over the emergency spillway. An emergency spillway made of a trapezoidal weir with a 10 m wide crest, located 1.0 m below the elevation of the dike lowest point will be necessary to protect adequately the dikes from a 100 years return period flood.

Table 7-4: Sedimentation Pond H1 Characteristics

		Sedimentation pond H1
Drainage area	[ha]	50
Design discharge	[m³/s]	0.27
Time of residence	[h]	4.9
Minimum required area	[m²]	100
Basin bottom area	[m²]	3 100
Basin top length	[m]	160
Basin top width	[m]	40
Basin depth	[m]	3.0
Basin side slopes	H:1V	3
Basin volume	[m³]	8 400 (1)
Outlet type		Rockfill dike
Outlet width	[m]	10
Spillway type		Trapezoidal weir
Spillway crest length	[m]	10

(1) Between pond bottom and spillway invert elevations.

The following figure presents the design flood routing, through Sedimentation pond H1, during a three days period centered on the 24h spring rainfall happening during the last day of a 35 days snow melt.

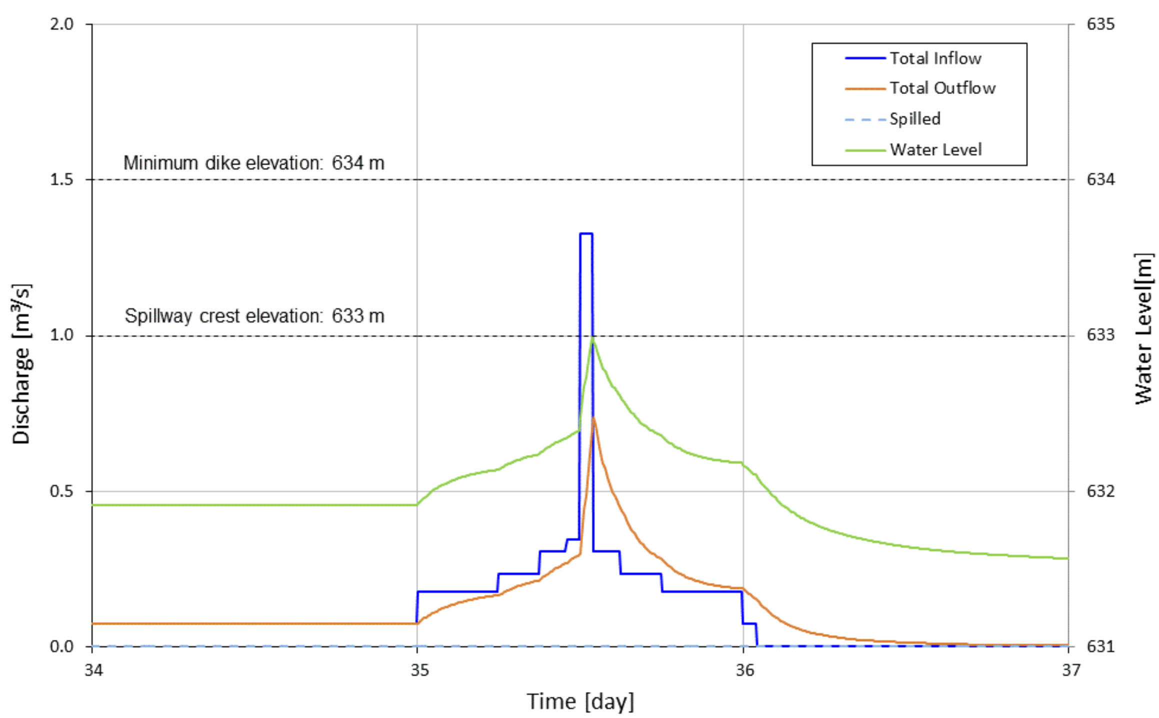

Figure 7-4: 25 Years Flood Routing through Sedimentation Pond H1

7.3.5 Sedimentation Pond H2

Sedimentation pond H2 (drawing 622834-4000-40DD-0005-00) is used to treat runoff water from the Howse mine site, including the overburden stockpile and the waste rock dumps, and pit dewatering water (1438 m^3/h, see section 4.0). This water is collected by a network of collection ditches covering an area of approximately 181 ha. Because this water will be in contact with fine rock particle on the mine site, a sedimentation design particle size of 0.01 mm was adopted, resulting in a relatively large minimum area required for proper sedimentation.

The adopted Sedimentation pond H2 dimensions are: 420 m long by 105 m wide by 4.0 m deep. A 10 m wide permeable rockfill dike is necessary to adequately pass the 25 years return period sedimentation design flood without any spill over the emergency spillway. An emergency spillway made of a trapezoidal weir with a 40 m wide crest, located 1.0 m below the elevation of the dike lowest point, will be necessary to protect adequately the dikes from a 100 years return period flood. Characteristics of Sedimentation Pond H2 are described in Table 7-5.

Table 7-5: Sedimentation Pond H2 Characteristics

		Sedimentation pond H2
Drainage area	[ha]	181
Design discharge	[m³/s]	1.36
Time of residence	[h]	18.4
Minimum required area	[m²]	27 600
Basin bottom area	[m²]	32 100
Basin top length	[m]	420
Basin top width	[m]	105
Basin depth	[m]	4.0
Basin side slopes	H:1V	3
Basin volume	[m³]	109 600 (1)
Outlet type		Rockfill dike
Outlet width	[m]	10
Spillway type		Trapezoidal weir
Spillway crest length	[m]	40

(1) Between pond bottom and spillway invert elevations.

The following figure presents the design flood routing, through Sedimentation pond H2, during a three days period centered on the 24h spring rainfall happening during the last day of a 35 days snow melt.

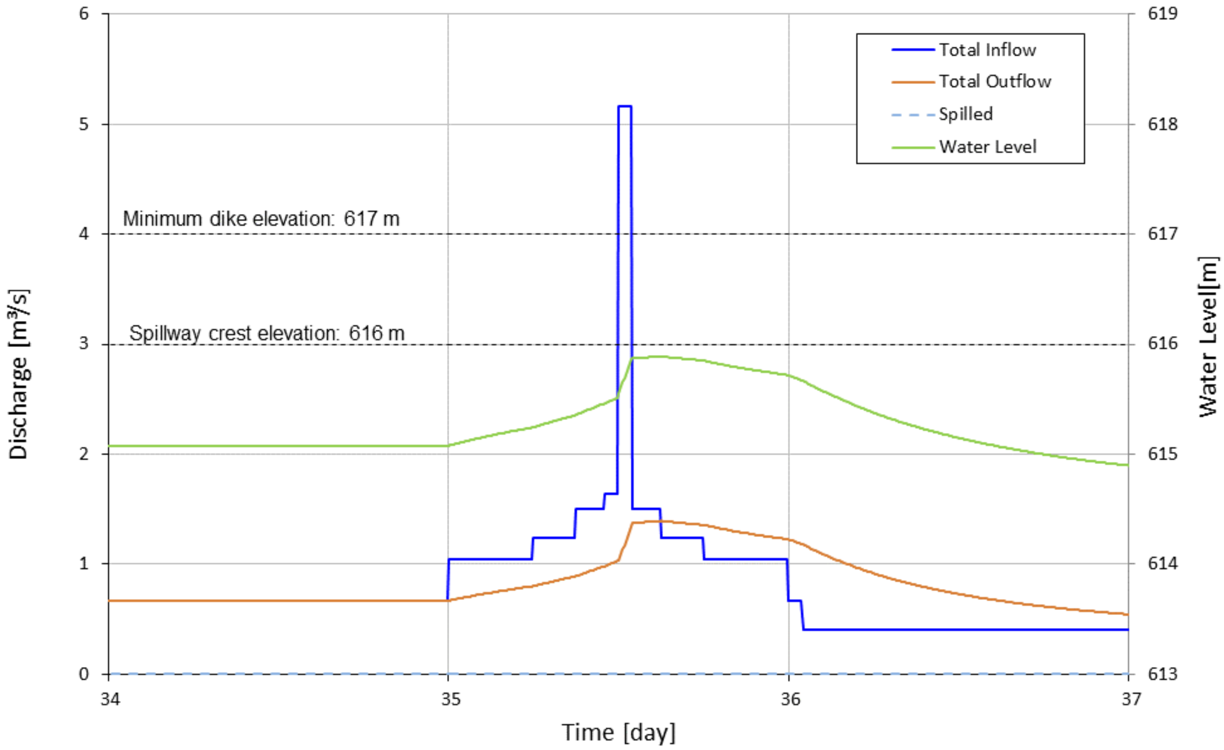

Figure 7-5: 25 Years Flood Routing through Sedimentation Pond H2

7.3.6 Sedimentation Pond H3

Sedimentation pond H3 (drawing 622834-4000-40DD-0006) is used to treat the mine pit runoff water that is pumped from the pit into the pond. Because this water will be in contact with small rock particles on the mine site, a sedimentation design particle size of 0.01 mm was adopted. This pond receives pumped pit runoff, direct precipitations on its own area, and runoff from a small area of approximately 4 ha.

It was estimated that a 411 m^3/h pumping capacity was necessary, to pump runoff water out of the mine pit, based on the following assumptions:

- Snow is assumed to accumulate during the months of October to April and completely melt during the month of May.
- It is assumed that pumping can only happen during the summer months. Therefore, inflow from October to May is pumped out of the mine Pit in May

The adopted pond dimensions are 160 m long by 40 m wide by 2.5 m deep. A 10 m wide permeable rockfill dike is necessary to adequately pass the 25 years return period sedimentation design flood without any spill over the emergency spillway. An emergency spillway made of a trapezoidal weir with a 5 m wide crest, located 0.8 m below the elevation of the dike lowest point will be necessary to protect adequately the dikes from a 100 years return period flood. Table 7-6 presents all characteristics of Sedimentation Pond H3.

Table 7-6: Sedimentation Pond H3 Characteristics

		Sedimentation pond H3
Drainage area	[ha]	4
Design discharge	[m³/s]	0.13
Time of residence	[h]	13.9
Minimum required area	[m²]	2 700
Basin bottom area	[m²]	3 600
Basin top length	[m]	160
Basin top width	[m]	40
Basin depth	[m]	2.5
Basin side slopes	H:1V	3
Basin volume	[m³]	7 700 (1)
Outlet type		Rockfill dike
Outlet width	[m]	10
Spillway type		Trapezoidal weir
Spillway crest length	[m]	5

(1) Between pond bottom and spillway invert elevations.

The following figure presents the design flood routing, through Sedimentation pond H3, during a three days period centered on the 24h spring rainfall happening during the last day of a 35 days snow melt.

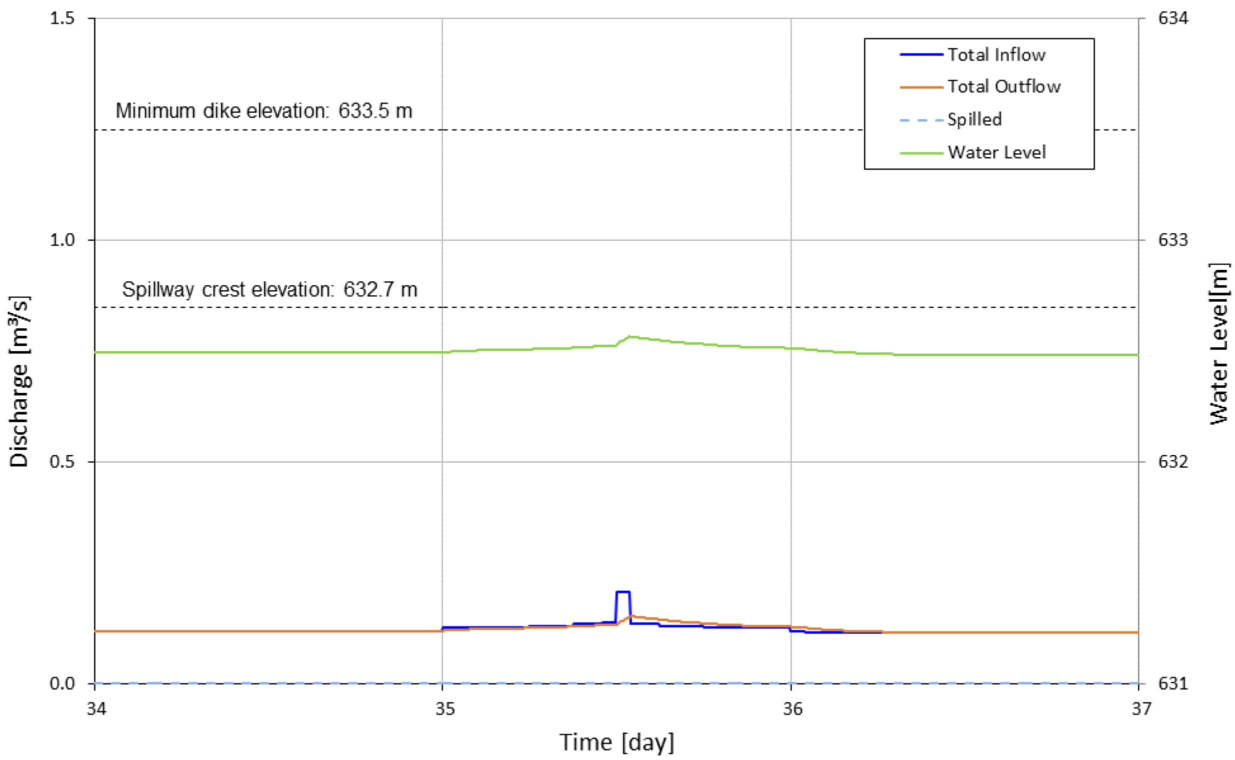

Figure 7-6: 25 Years Flood Routing through Sedimentation Pond H3

7.4 Water Management Infrastructures Main Characteristics Summary

The following Table summarizes the main characteristics of the transfer basin and Sedimentation ponds:

Table 7-7: Transfer Basin and Sedimentation Ponds Characteristics

Basins characteristics summary table

		Transfer basin	Existing Timmins 4 sedimentation 3	Sedimentation pond H1	Sedimentation pond H2	Sedimentation pond H3
Drainage area	[ha]	52	82	50	181	4
Design discharge	[m³/s]		0.52	0.27	1.36	0.13
Time of residence	[h]		16.3	4.9	18.4	13.9
Minimum required area	[m²]		10 500	100	27 600	2 700
Basin bottom area	[m²]		10 600	3 100	32 100	3 600
Basin top length	[m]	100	195	160	420	160
Basin top width	[m]	100	75	40	105	40
Basin depth	[m]	6.5	4.0	3.0	4.0	2.5
Basin side slopes	H:1V	3	2	3	3	3
Basin volume	[m³]	21 300 (2)	36 200 (1)	8 400 (1)	109 600 (1)	7 700 (1)
Outlet type		Pumping station	Rockfill dike	Rockfill dike	Rockfill dike	Rockfill dike
Outlet width	[m]		30	10	10	10
Spillway type			Trapezoidal weir	Trapezoidal weir	Trapezoidal weir	Trapezoidal weir
Spillway crest length	[m]		15	10	40	5

(1) Between pond bottom and spillway invert elevations.

(2) Between basin bottom and CD1 ditch invert elevations.

Other key water management infrastructures characteristics:

- Transfer pond pumping capacity: 290 m³/h (Section 7.2);
- Mine pit sump pump capacity: 411 m³/h (Section 7.3.6);
- The ditches typical dimensions are: 1.0 m base width, 1.5 m deep, with lateral slopes of 2H:1V. Exceptions are ditch CD-6 which with a 1.5 m base width and ditch CD-10 which a 3.0 m base width. The location of all ditches is presented on Drawing 622834-4000-4GGD-0001-00 (Appendix B);
- Ditches are protected against erosion with riprap or gabions if the required riprap layer exceeds 0.5 m;
- Ponds emergency spillways have 10H:1V lateral slope to allow traffic when they are not in use.

8.0 WATER BALANCE

Water balance computations were made for an average year representative of average hydrological conditions.

8.1 Methodology and Assumptions

Monthly average values for snowfall, rainfall, lake evaporation and evapotranspiration are presented in Section 2.1. These values were used with the considered drainage areas to determine the corresponding monthly average volumes of water. The following assumptions were made:

- Snow is assumed to accumulate during the months of October to April and completely melt during the month of May.
- It is assumed that pumping can only happen during the summer months. Therefore, inflow from October to May is pumped out of the Transfer basin or mine Pit in May.
- Actual evapotranspiration could be limited by water availability in the ground during the summer months. For this reason, actual evapotranspiration is computed as being the minimum between net runoff and evapotranspiration.
- A runoff coefficient of 1.0 is assumed for the months of October to May to take into account frozen or saturated ground conditions. A runoff coefficient of 0.4 is assumed for the months of June to September. The resulting average annual runoff coefficient of 0.8 is comparable to that of larger watershed in the area (Rollings, 1997).

8.2 Water Management Infrastructures

Water balance computations were made for an average year for Howse mine Pit (77 ha), Timmins 4 Sedimentation pond 3, and the proposed future Transfer basin (52 ha) and Sedimentation ponds H1 (50 ha), H2 (181 ha), and H3 (4 ha), all presented in Table 8-1 to Table 8-6:

Table 8-1: Average Year Monthly Water Balance – Howse Mine Pit

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	34 462	0	0	0	0	0	0.0
Feb	28 326	81	0	81	0	81	0.0
Mar	34 234	297	0	297	0	297	0.1
Apr	34 978	3 682	0	3 682	0	3 682	1.4
May	18 168	21 585	0	295 997	0	295 997	110.5
Jun	2 779	53 407	33 712	22 474	22 474	0	0.0
Jul	0	77 980	46 788	31 192	26 411	4 781	1.8
Aug	424	73 552	44 386	29 591	18 865	10 726	4.0
Sep	7 493	62 248	41 845	27 897	12 397	15 500	6.0
Oct	36 134	21 854	0	21 854	0	21 854	8.2
Nov	50 224	2 033	0	2 033	0	2 033	0.8
Dec	37 886	127	0	127	0	127	0.0
Year	**285 109**	**316 845**	**166 730**	**435 223**	**80 147**	**355 076**	**11.3**

Table 8-2: Average Year Monthly Water Balance – Transfer Basin

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	23 452	0	0	0	0	0	0.0
Feb	19 277	55	0	55	0	55	0.0
Mar	23 297	202	0	202	0	202	0.1
Apr	23 803	2 506	0	2 506	0	2 506	1.0
May	12 364	14 689	0	201 432	0	201 432	75.2
Jun	1 891	36 344	22 941	15 294	15 294	0	0.0
Jul	0	53 067	31 840	21 227	17 973	3 253	1.2
Aug	289	50 054	30 205	20 137	12 838	7 299	2.7
Sep	5 099	42 361	28 476	18 984	8 436	10 548	4.1
Oct	24 590	14 872	0	14 872	0	14 872	5.6
Nov	34 178	1 383	0	1 383	0	1 383	0.5
Dec	25 782	86	0	86	0	86	0.0
Year	**194 022**	**215 619**	**113 463**	**296 178**	**54 542**	**241 636**	**7.7**

Table 8-3: Average Year Monthly Water Balance – Sedimentation Pond H1

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	22 512	0	0	0	0	0	0.0
Feb	18 504	53	0	53	0	53	0.0
Mar	22 363	194	0	194	0	194	0.1
Apr	22 849	2 405	0	2 405	0	2 405	0.9
May	11 868	14 100	0	193 359	0	193 359	72.2
Jun	1 816	34 888	22 022	14 681	14 681	0	0.0
Jul	0	50 940	30 564	20 376	17 253	3 123	1.2
Aug	277	48 048	28 995	19 330	12 324	7 006	2.6
Sep	4 895	40 663	27 335	18 223	8 098	10 125	3.9
Oct	23 604	14 276	0	14 276	0	14 276	5.3
Nov	32 808	1 328	0	1 328	0	1 328	0.5
Dec	24 749	83	0	83	0	83	0.0
Year	**186 246**	**206 978**	**108 916**	**284 308**	**52 356**	**231 952**	**7.4**

Table 8-4: Average Year Monthly Water Balance – Sedimentation Pond H2

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Pit dewatering [m³]	Inflow [m³]	Inflow [l/s]
Jan	80 828	0	0	0	0	1 069 500	1 069 500	399.3
Feb	66 438	189	0	189	0	966 000	966 189	399.4
Mar	80 295	697	0	697	0	1 069 500	1 070 197	399.6
Apr	82 039	8 636	0	8 636	0	1 035 000	1 043 636	402.6
May	42 613	50 627	0	694 247	0	1 069 500	1 763 747	658.5
Jun	6 519	125 263	79 069	52 713	52 713	1 035 000	1 035 000	399.3
Jul	0	182 898	109 739	73 159	61 946	1 069 500	1 080 713	403.5
Aug	995	172 514	104 105	69 403	44 247	1 069 500	1 094 656	408.7
Sep	17 576	146 000	98 145	65 430	29 077	1 035 000	1 071 354	413.3
Oct	84 750	51 257	0	51 257	0	1 069 500	1 120 757	418.4
Nov	117 797	4 768	0	4 768	0	1 035 000	1 039 768	401.1
Dec	88 861	297	0	297	0	1 069 500	1 069 797	399.4
Year	**668 709**	**743 146**	**391 058**	**1 020 797**	**187 982**	**12 592 500**	**13 425 314**	**425.7**

Table 8-5: Average Year Monthly Water Balance – Sedimentation Pond H3

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Howse Pit pumped runoff [m³]	Inflow [m³]	Inflow [l/s]
Jan	1 566	0	0	0	0	0	0	0.0
Feb	1 288	4	0	4	0	0	4	0.0
Mar	1 556	14	0	14	0	0	14	0.0
Apr	1 590	167	0	167	0	0	167	0.1
May	826	981	0	13 454	0	324 070	337 524	126.0
Jun	126	2 428	1 532	1 022	1 022	0	0	0.0
Jul	0	3 545	2 127	1 418	1 201	4 781	4 998	1.9
Aug	19	3 343	2 018	1 345	858	10 726	11 213	4.2
Sep	341	2 829	1 902	1 268	564	15 500	16 204	6.3
Oct	1 642	993	0	993	0	0	993	0.4
Nov	2 283	92	0	92	0	0	92	0.0
Dec	1 722	6	0	6	0	0	6	0.0
Year	**12 959**	**14 402**	**7 579**	**19 783**	**3 643**	**355 076**	**371 216**	**11.8**

Table 8-6: Average Year Monthly Water Balance – Timmins 4 Sedimentation 3 (Existing with Modified Outlet)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Pumping from Transfer pond [m³]	Inflow [m³]	Inflow [l/s]
Jan	36 547	0	0	0	0	0	0	0.0
Feb	30 041	85	0	85	0	0	85	0.0
Mar	36 306	315	0	315	0	0	315	0.1
Apr	37 095	3 905	0	3 905	0	0	3 905	1.5
May	19 268	22 891	0	313 910	0	220 536	534 446	199.5
Jun	2 948	56 639	35 752	23 835	23 835	0	0	0.0
Jul	0	82 699	49 619	33 080	28 009	3 253	8 324	3.1
Aug	450	78 004	47 072	31 381	20 007	7 299	18 674	7.0
Sep	7 947	66 015	44 377	29 585	13 147	10 548	26 985	10.4
Oct	38 320	23 176	0	23 176	0	0	23 176	8.7
Nov	53 263	2 156	0	2 156	0	0	2 156	0.8
Dec	40 179	134	0	134	0	0	134	0.1
Year	**302 363**	**336 020**	**176 821**	**461 563**	**84 998**	**241 636**	**618 201**	**19.6**

8.3 Impacts on Natural Watersheds

The Howse project is located on the upstream part of Goodream Creek, Burnetta Creek, and Pinette Lake watersheds. The construction of this project will have impacts on these natural watersheds, in terms of drainage area and flow pattern, due to:

- Surface water drainage system, collecting runoff water and releasing it at particular points into the existing creeks (Goodream Creek and Burnetta Creek);
- Pumping of water from the Transfer Pond into Timmins 4 Sedimentation pond 3. Then releasing this water into Goodream Creek;
- Pumping of water from the Mine pit into Sedimentation pond H3. Then releasing this water into Burnetta Creek;
- Pumping of water from pit dewatering, resulting in an additional amount of water (coming from deep water tables) released into Goodream Creek.

In the following sections, water balance computations results for the existing natural conditions and the future modified conditions are presented for Goodream Creek, Burnetta Creek, and Pinette Lake watersheds.

8.3.1 Goodream Creek

The drainage area difference between the existing (316 ha) and the modified (353 ha) Goodream Creek watershed at the junction with Timmins 4 Sedimentation pond 3 outflow is 37 ha (see maps 10 and 11). This represents an increase of approximately 3 % of the existing drainage area at this point, resulting in additional runoff downstream from Timmins 4 Sedimentation pond 3.

Water collected in the transfer pond will be pumped into Timmins 4 Sedimentation pond 3 for treatment. Then, this water will be released into Goodream Creek downstream from Timmins 4 Sedimentation pond 3. At this location, Goodream Creek is mainly considered an intermittent Creek but still a fish habitat (HML, 2014). The upstream part of Goodream Creek watershed, located east from Timmins 4 Sedimentation pond 3, will not be affected by the

Project. Water flowing from this part of the watershed will ensure a minimum flow in the upstream portion of Goodream Creek.

The following table presents estimated monthly natural inflow values, corresponding to an average year representative of average hydrological conditions, for Goodream Creek at a point corresponding to the junction with Timmins 4 Sedimentation pond 3 outflow.

Table 8-7: Goodream Creek Natural Inflow at Junction with Timmins 4 Sedimentation Pond 3 Outflow (316 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	141 337	0	0	0	0	0	0.0
Feb	116 175	330	0	330	0	330	0.1
Mar	140 404	1 219	0	1 219	0	1 219	0.5
Apr	143 454	15 101	0	15 101	0	15 101	5.8
May	74 514	88 527	0	1 213 971	0	1 213 971	453.2
Jun	11 399	219 038	138 262	92 175	92 175	0	0.0
Jul	0	319 818	191 891	127 927	108 319	19 608	7.3
Aug	1 739	301 660	182 040	121 360	77 371	43 989	16.4
Sep	30 733	255 297	171 618	114 412	50 844	63 568	24.5
Oct	148 195	89 629	0	89 629	0	89 629	33.5
Nov	205 982	8 337	0	8 337	0	8 337	3.2
Dec	155 384	520	0	520	0	520	0.2
Year	**1 169 316**	**1 299 476**	**683 811**	**1 784 981**	**328 709**	**1 456 273**	**46.2**

The following table presents estimated monthly modified inflow values after construction of the water management infrastructures, corresponding to an average year representative of average hydrological conditions, for Goodream Creek at the junction with Timmins 4 Sedimentation pond 3 outflow.

Table 8-8: Goodream Creek Modified Inflow at Junction with Timmins 4 Sedimentation Pond 3 Outflow (301 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Pumping from Transfer pond [m³]	Inflow [m³]	Inflow [l/s]
Jan	134 445	0	0	0	0	0	0	0,0
Feb	110 510	314	0	314	0	0	314	0,1
Mar	133 557	1 160	0	1 160	0	0	1 160	0,4
Apr	136 459	14 364	0	14 364	0	0	14 364	5,5
May	70 880	84 210	0	1 154 772	0	220 536	1 375 308	513,5
Jun	10 843	208 356	131 520	87 680	87 680	0	0	0,0
Jul	0	304 222	182 533	121 689	103 037	3 253	21 905	8,2
Aug	1 655	286 950	173 163	115 442	73 598	7 299	49 143	18,3
Sep	29 234	242 848	163 249	108 833	48 364	10 548	71 016	27,4
Oct	140 968	85 258	0	85 258	0	0	85 258	31,8
Nov	195 937	7 931	0	7 931	0	0	7 931	3,1
Dec	147 806	495	0	495	0	0	495	0,2
Year	**1 112 294**	**1 236 107**	**650 465**	**1 697 937**	**312 679**	**241 636**	**1 626 893**	**51,6**

(1) The drainage area of 301 ha corresponds to Goodream Creek modified drainage area at the junction with Timmins 4 Sedimentation pond 3 outflow (353 ha) from which the drainage area of the Transfer pond (52 ha) was subtracted.

Spring monthly maximum flow in Goodream Creek, at a point corresponding to the junction with Timmins 4 Sedimentation pond 3, will increase by approximately 13 %.

The drainage area difference, between the existing (1091 ha) and the modified (1157 ha) Goodream Creek watershed, at the junction with H2 outflow, is 67 ha (see Maps 5 and 6 in Appendix B). This represents an increase of approximately 6 % of the existing drainage area at this point, resulting in additional runoff downstream from Sedimentation pond H2.

Pit dewatering will be treated in Sedimentation pond H2, adding a constant discharge into Goodream Creek downstream from Sedimentation pond H2 as well. At this location, Goodream Creek is considered a permanent watercourse with fish habitat (HML, 2014a). The ditch planned on the south-east part of the Howse Project will intercept natural drainage flowing towards Goodream Creek. However, the release of water pumped from the Transfer pond into Timmins 4 Sedimentation pond 3 will ensure some water will be kept in this section of the creek.

Dewatering water is assumed to reach 34 500 m^3/d at the final pit floor depth. Measurements in the boreholes within the Howse ore body indicate that the water table is relatively deep below the ground surface (between 64 m and 88 m in November, 2013). This indicates that, at the beginning, dewatering will be mainly limited to pit runoff water and/or infiltration through the walls of the pit. The maximum pumping rate will occur when the deep water table is reached, and it will depend on the thickness and duration of mining of each lift. Then, the maximum impact on Goodream Creek will likely occur during a short period of time at the end of Howse pit exploitation.

The following table presents estimated monthly natural inflow values, corresponding to an average year representative of average hydrological conditions, for Goodream Creek at a point corresponding to the junction with Sedimentation pond H2 outflow.

Table 8-9: Goodream Creek Natural Inflow at Junction with H2 Outflow (1091 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	488 280	0	0	0	0	0	0.0
Feb	401 352	1 141	0	1 141	0	1 141	0.5
Mar	485 057	4 213	0	4 213	0	4 213	1.6
Apr	495 595	52 169	0	52 169	0	52 169	20.1
May	257 424	305 835	0	4 193 929	0	4 193 929	1 565.8
Jun	39 380	756 713	477 656	318 437	318 437	0	0.0
Jul	0	1 104 882	662 929	441 953	374 213	67 740	25.3
Aug	6 009	1 042 152	628 896	419 264	267 295	151 969	56.7
Sep	106 173	881 981	592 892	395 262	175 651	219 611	84.7
Oct	511 970	309 641	0	309 641	0	309 641	115.6
Nov	711 609	28 802	0	28 802	0	28 802	11.1
Dec	536 807	1 796	0	1 796	0	1 796	0.7
Year	**4 039 656**	**4 489 325**	**2 362 373**	**6 166 607**	**1 135 596**	**5 031 011**	**159.5**

The following table presents estimated monthly modified inflow values, corresponding to an average year representative of average hydrological conditions, for Goodream Creek at the junction with Sedimentation pond H2 outflow.

Table 8-10: Goodream Creek Modified Inflow at Junction with H2 Outflow (1105 ha [(1)])

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Pit dewatering [m³]	Pumping from Transfer pond [m³]	Inflow [m³]	Inflow [l/s]
Jan	494 591	0	0	0	0	1 069 500	0	1 069 500	399,3
Feb	406 539	1 156	0	1 156	0	966 000	0	967 156	399,8
Mar	491 326	4 267	0	4 267	0	1 069 500	0	1 073 767	400,9
Apr	502 000	52 843	0	52 843	0	1 035 000	0	1 087 843	419,7
May	260 751	309 787	0	4 248 131	0	1 069 500	220 536	5 538 167	2 067,7
Jun	39 888	766 493	483 829	322 553	322 553	1 035 000	0	1 035 000	399,3
Jul	0	1 119 161	671 497	447 664	379 049	1 069 500	3 253	1 141 369	426,1
Aug	6 087	1 055 620	637 024	424 683	270 750	1 069 500	7 299	1 230 732	459,5
Sep	107 546	893 379	600 555	400 370	177 921	1 035 000	10 548	1 267 997	489,2
Oct	518 587	313 643	0	313 643	0	1 069 500	0	1 383 143	516,4
Nov	720 806	29 175	0	29 175	0	1 035 000	0	1 064 175	410,6
Dec	543 745	1 819	0	1 819	0	1 069 500	0	1 071 319	400,0
Year	**4 091 864**	**4 547 344**	**2 392 905**	**6 246 304**	**1 150 273**	**12 592 500**	**241 636**	**17 930 168**	**568,6**

[(1)] The drainage area of 1105 ha corresponds to Goodream Creek modified drainage area at the junction with H2 outflow (1157 ha) from which the drainage area of the Transfer pond (52 ha) was subtracted.

Goodream Creek spring monthly maximum flow, at the junction with Sedimentation pond H2 outflow, will increase by approximately 30 %, which is evaluated as a low magnitude impact by Groupe Hémisphère (GH, 2014b).

8.3.2 Burnetta Creek

The drainage area difference, between the existing (81 ha) and the modified (214 ha) Burnetta Creek watershed at the junction with H1 and H3 outflow, is 133 ha (see Maps 7 and 8 in Appendix B). This represents an increase of approximately 164 % of the existing drainage area at this point, resulting in additional runoff downstream from junction with Sedimentation ponds H1 and H3 outflow.

The mine pit runoff will be pumped into Sedimentation pond H3. Then, this treated water will be released into Burnetta Creek. Burnetta Creek does not host any fish habitat upstream from Burnetta Lake, which is located much downstream from the water release point (HML, 2014a). It is an intermittent creek with a relatively small natural flow.

The following table presents estimated monthly natural inflow values, corresponding to an average year representative of average hydrological conditions, for Burnetta Creek at a point corresponding to the junction with Sedimentation ponds H1 and H3 outflow.

Table 8-11: Burnetta Creek Natural Inflow at Junction with H1 and H3 Outflow (81 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	36 252	0	0	0	0	0	0.0
Feb	29 798	85	0	85	0	85	0.0
Mar	36 013	313	0	313	0	313	0.1
Apr	36 795	3 873	0	3 873	0	3 873	1.5
May	19 112	22 706	0	311 373	0	311 373	116.3
Jun	2 924	56 181	35 463	23 642	23 642	0	0.0
Jul	0	82 031	49 218	32 812	27 783	5 029	1.9
Aug	446	77 373	46 692	31 128	19 845	11 283	4.2
Sep	7 883	65 482	44 019	29 346	13 041	16 305	6.3
Oct	38 011	22 989	0	22 989	0	22 989	8.6
Nov	52 833	2 138	0	2 138	0	2 138	0.8
Dec	39 855	133	0	133	0	133	0.0
Year	**299 919**	**333 305**	**175 392**	**457 832**	**84 311**	**373 521**	**11.8**

The following table presents estimated monthly modified inflow values, corresponding to an average year representative of average hydrological conditions, for Burnetta Creek at the junction with Sedimentation ponds H1 and H3 outflow.

Table 8-12: Burnetta Creek Modified Inflow at Junction with H1 and H3 Outflow (137 ha [(1)])

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Pumping from Pit [m³]	Total Inflow [m³]	Inflow [l/s]
Jan	61 404	0	0	0	0	0	0	0.0
Feb	50 472	144	0	144	0	0	144	0.1
Mar	60 999	530	0	530	0	0	530	0.2
Apr	62 324	6 561	0	6 561	0	0	6 561	2.5
May	32 373	38 461	0	527 413	0	324 070	851 482	317.9
Jun	4 952	95 161	60 068	40 045	40 045	0	0	0.0
Jul	0	138 946	83 367	55 578	47 060	4 781	13 300	5.0
Aug	756	131 057	79 088	52 725	33 614	10 726	29 837	11.1
Sep	13 352	110 915	74 560	49 707	22 089	15 500	43 117	16.6
Oct	64 383	38 939	0	38 939	0	0	38 939	14.5
Nov	89 489	3 622	0	3 622	0	0	3 622	1.4
Dec	67 507	226	0	226	0	0	226	0.1
Year	**508 012**	**564 560**	**297 083**	**775 489**	**142 808**	**355 076**	**987 757**	**31.3**

[(1)] The drainage area of 137 ha corresponds to Burnetta Creek modified drainage area at the junction with H1 and H3 outflow (214 ha) from which the drainage area of the mine pit (77 ha) was subtracted.

After the construction of sedimentation ponds H1 and H3, a relatively large area of Burnetta Creek watershed will be diverted. Rather than flowing naturally into Burnetta Creek some distance downstream from the junction with H1 and H3 outflow, runoff from the diverted area will be collected then released punctually. Consequently, spring monthly maximum flow will increase of approximately 170 %, which corresponds to a very high magnitude impact according to the scale used by Groupe Hémisphère (GH, 2014b).

However, the impact of the Howse project construction on Burnetta Creek is decreasing when the distance downstream from junction with H1 and H3 outflow is increasing. When a point located approximately 650 m downstream from the junction with H1 and H3 outflow is considered, the drainage area difference between actual and future conditions is only 39 ha. At this point, spring monthly maximum flow will increase by approximately 20 %, which corresponds to a low magnitude impact. Therefore, to keep the impact magnitude of Howse construction on Burnetta Creek low, this creek will need to be protected against erosion on a distance of approximately 650 m downstream from junction with H1 and H2 outflow as a mitigation measure.

8.3.3 Pinette Lake

Pinette Lake watershed will be reduced by 61 ha following Howse project construction. This difference represents 25 % of the existing Pinette Lake watershed (237 ha) at the lake outlet (see Map 9 in Appendix B).

The following table presents estimated monthly natural inflow values, corresponding to an average year representative of average hydrological conditions, for Pinette Lake outlet.

Table 8-13: Pinette Lake Outlet Natural Inflow (237 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	106 070	0	0	0	0	0	0.0
Feb	87 186	248	0	248	0	248	0.1
Mar	105 370	915	0	915	0	915	0.3
Apr	107 659	11 333	0	11 333	0	11 333	4.4
May	55 921	66 437	0	911 055	0	911 055	340.1
Jun	8 554	164 382	103 762	69 175	69 175	0	0.0
Jul	0	240 016	144 009	96 006	81 291	14 715	5.5
Aug	1 305	226 389	136 616	91 078	58 065	33 013	12.3
Sep	23 064	191 594	128 795	85 863	38 157	47 706	18.4
Oct	111 216	67 264	0	67 264	0	67 264	25.1
Nov	154 584	6 257	0	6 257	0	6 257	2.4
Dec	116 612	390	0	390	0	390	0.1
Year	**877 542**	**975 225**	**513 183**	**1 339 584**	**246 688**	**1 092 896**	**34.7**

The following table presents estimated monthly modified inflow values, corresponding to an average year representative of average hydrological conditions, for Pinette Lake outlet.

Table 8-14: Pinette Lake Outlet Modified Inflow (176 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	78 725	0	0	0	0	0	0.0
Feb	64 709	184	0	184	0	184	0.1
Mar	78 205	679	0	679	0	679	0.3
Apr	79 904	8 411	0	8 411	0	8 411	3.2
May	41 504	49 309	0	676 180	0	676 180	252.5
Jun	6 349	122 004	77 012	51 341	51 341	0	0.0
Jul	0	178 138	106 883	71 255	60 334	10 922	4.1
Aug	969	168 024	101 396	67 597	43 096	24 502	9.1
Sep	17 118	142 200	95 591	63 727	28 320	35 407	13.7
Oct	82 544	49 923	0	49 923	0	49 923	18.6
Nov	114 731	4 644	0	4 644	0	4 644	1.8
Dec	86 548	290	0	290	0	290	0.1
Year	**651 307**	**723 806**	**380 881**	**994 231**	**183 090**	**811 141**	**25.7**

The decrease of Pinette Lake inflow is relatively important. According to Groupe Hémisphère (GH, 2014b) an inflow decrease is beneficial, from an ecosystemic perspective, because an oligotrophic lake like Pinette Lake could benefit from a longer water renewal time.

As a follow-up measure, a field survey will be planned for the summer of 2015 to characterize Pinette Lake natural outflow, and to determine if lowering the water level would have a significant impact on fish habitat. If necessary, following the field survey, the water management plan could be updated.

9.0 ENVIRONMENTAL MONITORING PLAN

The environmental monitoring program will consist of three main types of sampling: Real-time monitoring, Effluent Monitoring (sedimentation pond discharge), and Water Chemistry Analysis of Groundwater, Surface Water of Natural Water Courses and Drainage Ditches.

The environmental monitoring program will be planned in accordance with the following protocols and regulations: Environmental Control Water and Sewage Regulations (2003); Protocols Manual for Real Time Water Quality Monitoring in Newfoundland and Labrador (2013); Metal Mining Effluent Regulations (Canada).

The Environmental Monitoring Plan has been developed based on preliminary information, and should be considered a conceptual design only. The Environmental Monitoring Plan is subject to change based on the final site plan, consultations, site visits, and feasibility. The monitoring plan presented in this section and on map 12 is organized to be easily integrated to the TSMC DSO overall monitoring plan.

9.1 Real-time water quality/quantity monitoring

The environmental monitoring program will provide effective real-time monitoring at the Howse Property Project Site (the Site) in accordance with the Canada-Newfoundland Water Quality Surveys Agreement. Real-time Water Quality (RTWQ) monitoring provides continuous water quality data, which can provide a better insight to the effect the mining operations are having on receiving waters than traditional grab samples alone.

Typical parameters measured by RTWQ stations are: temperature, pH, specific conductivity, dissolved oxygen and turbidity, which can be used to further calculate additional parameters such as total dissolved solids (TDS) and percent saturation. Additional sensors may be added to provide supplementary measured parameters, if needed. Water quantity data can also be measured by RTWQ stations (i.e., discharge, using stage height and velocity data).

Three monitoring stations currently exist within the area of interest and consideration will be given to implementing them into the environmental monitoring program for the site. The provincial and federal government will be responsible for the installation or relocation of real-time monitoring stations, as well as data collection and maintenance, as part of the Environment Canada/Government of Newfoundland and Labrador’s Real-time Water Quality Monitoring Program.. The stations and their intended use in the environmental monitoring program are listed below.

9.1.1 IHH1

Hydrometric station IHH1 monitors Burnetta Creek, downstream of the proposed sedimentation ponds H1 and H3. This station currently only monitors water quantity and requires that manual readings be taken. Water quality should also be monitored at this location, to provide insight on any contaminates of concern present in Burnetta Creek caused by the discharge from Sedimentation Ponds H1 and H3 or other mining influences. The proposed surface water monitoring HSW1 located at IHH1 station will fulfill this function (see Table 9-4).

9.1.2 IHH3

Hydrometric station IHH3 is located at an intermittent stream flowing to Pinette Lake. This station is located downstream of the site and water quality in this stream may be impacted by the mining operations at the Howse Property Project Site. Currently IHH3 also requires that manual readings of stage height and velocity be taken. Surface water sampling for quality parameter is already taken with sampling location COA SW13, part of Timmins 4 project. This sampling should continue with the Howse project, to provide insight on any contaminates of concern which may be entering into Pinette Lake from the Site.

9.1.3 NF03OB0040

RTWQ monitoring station NF02OB0040 (Goodream Creek 2 km Northwest of Timmins 6) is already part of the Real-time Water Quality Monitoring Program in Newfoundland and Labrador. It is currently located upstream of Sedimentation Pond H2. This monitoring station could be moved downstream of the sedimentation pond in order to monitor contamination from both the Howse Property Project Site, and the HML DSO 3 site. If it is determined that the relocation of the monitoring station is not feasible or beneficial to the monitoring of both project sites, an additional monitoring station will be installed in Goodream Creek somewhere downstream of the Sedimentation Pond H2 discharge point, ideally close to Triangle Lake where road access is available.

9.2 *Effluent Monitoring*

Effluent Discharge Criteria (EDC) parameters are usually tested weekly from the effluent grab samples. Acute Lethality Test (ALT) parameters are only required to be tested monthly. An overview of the effluent monitoring schedule, including monitoring locations is presented in Table 9-1.

Table 9-1: Effluent Monitoring Schedule

Monitoring Location	Parameters	Frequency
1. Sedimentation Pond H3 discharge into Burnetta Creek 2. Sedimentation Pond H2 discharge into Goodream Creek 3. Sedimentation Pond H1 discharge into Burnetta Creek 4. Timmins 4 – Sedimentation Pond 3 discharge into Goodream Creek	EDC (excluding ALT) See Table 9-2 for specific parameters and limits.	Weekly (minimum of 24 hours apart)
	ALT (conducted as per Environment Canada's Environmental Protection Service reference method EPS/1/RM-13 Section 5 or 6)	Monthly (minimum of 15 days apart)

Monitoring locations were chosen to ensure all effluent diverted to receiving waters is monitored regularly. All measured parameters will be compared to the Effluent Discharge Criteria specified by the Certificate of Approval from the Government of Newfoundland and Labrador. The expected parameters and concentrations are presented in Table 9-2 below, but may change after the Certificate of Approval is received.

Table 9-2: Effluent Discharge Criteria (EDC)

Parameter	Maximum Authorized Monthly Mean Concentration	Maximum Authorized Concentration in a Composite Sample	Maximum Authorized Concentration in a Grab Sample
Arsenic	0.50 mg/L	0.75 mg/L	1.00 mg/L
Copper	0.30 mg/L	0.45 mg/L	0.60 mg/L
Lead	0.20 mg/L	0.30 mg/L	0.40 mg/L
Nickel	0.50 mg/L	0.75 mg/L	1.00 mg/L
Zinc	0.50 mg/L	0.75 mg/L	1.00 mg/L
TSS	15.00 mg/L	22.50 mg/L	30.00 mg/L
Radium 224	0.37 Bq/L	0.74 Bq/L	1.11 Bq/L
pH	Allowable Range 5.5 – 9.0 units		
ALT	Toxic pass		

Sampling frequency decrease or increase depending on the results of previous consecutive tests, as specified by the Certificate of Approval. The expected conditions leading to sampling frequency changes are outlined in Table 9-3 below.

Table 9-3: Changes in sampling/testing frequency

Parameter	Test results	New testing frequency
Arsenic	Parameter's monthly mean concentration in the effluent is less than 10% of the maximum authorized mean concentration for the 12 months immediately preceding the most recent test	Once per calendar quarter
Copper		
Lead		
Nickel		
Zinc		
Radium 224	Concentration of radium 226 is less than 0.037Bq/L in 10 consecutive tests	

Parameter	Test results	New testing frequency
ALT	Effluent is not determined to be acutely lethal over a period of 12 consecutive months.	
pH	Parameter testing frequency cannot be reduced.	
TSS	Parameter testing frequency cannot be reduced.	

The Department of Environment and Conservation will be notified in writing at least 30 days in advance of a reduction in the frequency of testing for any parameter. If during the next testing event, these test results are no longer met for a certain parameter, the parameter must be tested at the original frequency shown in Table 9-3.

If ALT determines that any sample is acutely lethal, a grab sample must be collected from the final discharge point of the failing site. An ALT must be performed, and an aliquot of the failing sample must be analyzed for the parameters in Table 9-3. Samples should then be collected twice per month until three consecutive tests determine that the effluent is no longer acutely lethal. After the third consecutive non-acutely lethal test, the ALT's must be conducted following the original testing frequency.

If three consecutive ALT's are performed and the results determine the effluent is acutely lethal, a Toxicity Identification Evaluation (TIE) must be performed to determine the specific toxin causing the problem. A report outlining the measures to prevent or reduce the toxin must then be submitted to the Director within 60 days of the third consecutive failed test.

Flow measurements at the effluent discharge of each sedimentation pond will be monitored through the installation of a Parshall flume located in the ditches downstream of the permeable rockfill dikes of the pond. A reading of the measurement from the Parshall flume will be taken at the same time when a water sample is collected.

9.3 Water Chemistry Analysis (Surface and Groundwater)

In addition to the real-time monitoring system and effluent monitoring, groundwater and surface water grab samples will be collected four times per year and analyzed by a laboratory that has been certified by the Canadian Association for Environmental Analytical Laboratories. Monitoring locations and parameters to be tested are presented in Table 9-4. As the monitoring program continues, it may be appropriate to relocate, add, or remove monitoring locations as needed.

Table 9-4: Water Chemistry Analysis Program

Sample Type	Station number	Monitoring Locations	Parameters
Surface Water	HSW1	Burnetta Creek, downstream of Sedimentation Pond H1/H3	<u>General Parameters</u>: temperature, dissolved oxygen (DO), nitrate + nitrite, nitrate, nitrite, pH, TSS, colour, sodium,
	HSW2	Burnetta Creek, upstream of Sedimentation Pond H1/H3	

Sample Type	Station number	Monitoring Locations	Parameters
	HSW3	Goodream Creek, Downstream of Sedimentation Pond H2	potassium, calcium, sulphide, magnesium, ammonia, alkalinity, sulphate, chloride, turbidity, reactive silica, orthophosphate, phenolics, carbonate (CaCO2), hardness (CaCO3), bicarbonate, TPH Metals Scan: aluminium, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, mercury, nickel, selenium, silver, strontium, thallium, tin, titanium, uranium, radium, vanadium, zinc.
	HSW4	Goodream Creek, Northeast of Waste Rock Dump 2	
	COA SW12 (Timmins)	North of Timmins 4, Sedimentation Pond 3 (COA SW12 from Timmins Site)	
	HSW5	GDR3 stream between Overburden Stockpile and Waste Rock Dump 2	
	HSW6	GDR4 stream Northeast of Timmins 4, Sedimentation Pond 3	
	HSW7	GDR2 stream flowing into Goodream Creek, Northeast of Sedimentation Pond H2	
	HSW8	Drainage ditch North of Overburden Stockpile	
	COA SW8 (Timmins)	Goodream Creek, Northeast of Overburden Stockpile (COA SW8 - Timmins Site)	
	COA SW13	Stream North of Pinette Lake (COA SW13 -Timmins Site)	
	HSW9	Drainage ditch North of Waste Rock Dump 2	
Groundwater	HGW1	Northwest of Howse Pit	
	HGW2	East of Overburden Stockpile and Goodream Creek	
	HGW3	West of Overburden Stockpile	
	COA GW5 (Timmins)	Southeast of Timmins 4, Sedimentation Pond 3 (COA GW5 -Timmins Site)	
	HGW3	West of Howse Pit	
		TSS analysis not required for groundwater samples. TPH analysis to be performed on sedimentation pond samples.	

Groundwater will be accessed using monitoring wells. Monitoring wells location will be selected not only to obtain groundwater samples, but also to monitor the depth to groundwater and fluctuation of the water table and changes in groundwater flow direction that could be caused by pit dewatering, changes in surface drainage, and permafrost melting. The installation of additional monitoring wells may be required if it is discovered that the current wells are not suitable for the purposes of groundwater sampling/monitoring based on hydrogeologic/geologic data, well depth, and well condition. Monitoring wells will be chosen and installed in areas that may be impacted by potential mine influences and also in areas that will allow background sample collection. A minimum of one monitoring well will be required as a reference well up-gradient within each watershed of concern and away from all potential mine influences.

The number of surface water sampling sites required and their locations was determined based on the hydrological and geological characteristics of the area, the characteristics of the expected contaminants, anthropologic influences, and ease of access. Sampling sites are to be established downstream of contamination points, and reference sites will also be established upgradient of potential contamination points.

9.4 Quality Assurance / Quality Control (QA/QC)

QA/QC samples will be taken regularly to ensure proper field and laboratory techniques have been followed and to ensure the integrity of the results. A minimum of 10% of the samples submitted will be QA/QC samples, such as field duplicates, split samples, trip blanks, and/or field blanks. Before each sampling event, discussions with the laboratory analyzing the samples will help determine the QA/QC protocols to be followed.

10.0 DISCUSSION

10.1 Data Needed for Next Phase of Engineering

The following tasks should be performed in the next phase of engineering to optimize the water management infrastructure layout presented in this document, to optimize the infrastructures size, and to refine the characterization of the expected effluent quality on Howse property:

- Actualize H2 pond design with final hydrogeological modeling, which should confirm pit dewatering flow. Actual design is based on a conservative assumption;
- Perform particle size distribution analysis of the overburden and waste rock expected at the Howse property;
- Perform settling test to assess the settling rate of the suspended solids from surface runoff coming from the waste rock dump, the overburden, and the pit dewatering water at Timmins 4;
- Timmins 4 Sedimentation pond 3 sedimentation capacity should be checked once more data on sediment size distribution is available;
- Perform a complete water quality assessment, including total and dissolved metals, chloride, sulfate, pH, alkalinity, ammonia, nitrate, etc., once per week or every 2 weeks on the following samples:
  - Surface runoffs on the Timmins 4 property coming from the waste rock pile and overburden pile;
  - Pit surface runoffs and pit dewatering water from the Timmins 4 property.
- Perform a wind analysis to determine wind setup and wave run-up and validate the minimum freeboard for all the ponds build with a dike;
- Design outlet channels for sedimentation ponds H1, H3, and H2, and bring all ponds inlet structures to the level of engineering required for the next phase of the project.

10.2 Geotechnical Infrastructure Design

Presently, no waterproofing measures are planned at the bottom of the sedimentations ponds because the only expected environmental issue is the amount of total suspended solid. However, depending on the nature of the soil on which ponds H1 and H3 will be built, a sealing material may be required to avoid leakage of the water back into the pit, as these ponds will be located beside the pit. If the till in place is made of about 10-15% fine particles, the ponds would be impervious enough and this would not be an issue.

The suitability of the excavated material to be used for dike construction will have to be addressed. For ponds H1, H2 and H3 dike construction, stability issues due to seepage could occur if the material used is too pervious,. Geotechnical investigations at the pond location will have to be performed to assess this material. Standard geotechnical tests such as sieve analysis and Proctor tests will be required. If the material in place is too permeable, it will be possible to cover the bottom and slopes of the ponds with suitable compacted silty material available on site, or to use a geosynthetic membrane to seal the ponds.

11.0 CONCLUSION

SNC-Lavalin Inc. (SLI) was mandated by Howse Minerals Canada Ltd to conceive, at a conceptual engineering level, Howse project's water management plan. The adopted water management strategy is based on the following concepts:

- Minimize impacts on environment;
- Use existing infrastructures as much as possible;
- Clean and contaminated water separation;
- Water treatment for suspended sediments.

The necessary water management infrastructures consist in clean water derivation ditches, contaminated water collection ditches, a transfer pond, and several sedimentation ponds. Different options were analyzed for the collection and treatment of water from the site runoff and pit dewatering.

The adopted layout is made of a network of collection ditches, one diversion ditch, three sedimentation ponds and one transfer pond. Sedimentation pond H1 is used to treat water collected by the diversion ditch, located on the south-west side of the mine pit, before releasing treated water into Burnetta Creek. The Transfer pond is used to collect runoff water naturally flowing into Pinette Lake watershed. Then, this water is pumped into the existing Timmins 4 Sedimentation pond 3 for treatment before being released into Goodream Creek. Sedimentation pond H3 is used for the treatment of the pit runoff that is pumped from the pit bottom into Sedimentation pond 3. Once treated, this water is released into Burnetta Creek. Runoff water from the remaining of the mine site as well as pit dewatering water are collected and conveyed by a network of collection ditches into Sedimentation pond H2 for treatment. Once treated, this water is released into Goodream Creek.

A few options were studied, and the adopted layout is the option that has the least impact on the environment. Overall, existing watershed drainage areas are the least modified, and the release of treated water is split between Goodream Creek and Burnetta Creek to minimize impacts on their respective flow patterns and water quality.

The water management infrastructures were designed, at a conceptual level, based on a series of design criteria approved by HML, and a series of assumptions. These assumptions will need to be validated in the project next engineering phases. The validation of several assumptions concerning water quality and available material for pond construction will need to be made based on a series of data that will need to be collected on the future Howse mine site or on existing sites nearby.

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APPENDIX A

Schefferville A Intensity-Duration-Frequency Data

Environment Canada/Environnement Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2011/05/17

==

SCHEFFERVILLE A QC 7117825

Latitude: 54 48'N Longitude: 66 49'W Elevation/Altitude: 521 m

Years/Années : 1965 - 1992 # Years/Années : 23

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Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

****

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1965	3.6	4.1	4.1	4.3	8.4	13.2	17.8	23.6	24.9
1966	2.8	4.1	4.6	7.1	10.2	17.3	29.5	30.5	30.5
1967	4.8	8.1	8.6	9.1	10.9	15.2	35.1	43.2	47.2
1969	3.6	5.3	6.1	6.3	8.4	10.4	11.7	17.3	22.1
1972	4.1	5.3	5.8	7.1	8.6	11.2	20.1	22.6	25.9
1973	6.6	10.2	12.4	14.5	14.5	16.5	20.6	20.6	21.3
1974	2.3	3.6	4.8	5.1	6.1	8.6	16.8	24.1	39.1
1975	11.4	12.4	14.0	17.8	22.1	22.6	27.7	34.0	40.1
1976	6.1	8.6	8.9	10.4	10.4	10.4	17.3	29.2	42.2
1978	2.6	3.5	4.4	5.8	9.8	10.5	20.0	23.2	32.8
1979	8.6	9.0	9.0	9.0	9.8	15.0	22.5	23.7	30.7
1980	5.4	8.9	11.2	13.7	17.9	22.2	28.5	42.5	56.6
1981	-99.9	-99.9	-99.9	7.9	9.8	10.1	18.3	29.7	37.9
1982	2.8	4.4	4.4	5.4	9.9	12.7	18.1	22.1	29.4
1983	5.1	6.8	7.3	8.9	12.9	16.6	26.4	33.1	38.8
1984	5.6	7.3	7.8	8.2	8.2	11.0	23.8	26.4	31.5
1985	1.3	2.0	2.4	2.6	4.0	6.6	13.1	18.7	20.7
1986	2.5	3.0	3.8	4.8	9.1	13.1	21.8	25.5	35.1
1987	3.5	5.3	5.5	5.5	8.6	13.5	30.1	45.5	47.7
1988	2.0	3.2	3.3	5.5	7.8	11.1	20.2	26.1	50.1
1989	2.9	5.5	8.0	12.4	17.2	17.7	32.2	47.8	59.1
1990	1.3	2.4	3.7	7.1	13.0	21.2	33.9	53.3	83.4
1991	1.9	2.9	4.1	6.0	9.1	16.3	27.8	33.8	37.0
1992	3.7	5.8	7.1	8.9	9.7	14.7	27.5	37.9	56.2
# Yrs.	23	23	23	24	24	24	24	24	24

Années									
Mean	4.1	5.7	6.6	8.1	10.7	14.1	23.4	30.6	39.2
Moyenne									
Std. Dev.	2.4	2.8	3.1	3.6	3.9	4.2	6.4	9.8	14.6
Écart-type									
Skew.	1.50	0.76	0.92	1.15	1.34	0.50	0.12	0.82	1.24
Dissymétrie									
Kurtosis	5.91	3.23	3.57	4.49	5.45	3.09	2.49	3.07	5.45

*-99.9 Indicates Missing Data/Données manquantes

****

Table 2a : Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	3.7	5.8	7.3	9.0	10.4	11.7	23
10 min	5.3	7.7	9.3	11.4	12.9	14.4	23
15 min	6.1	8.8	10.6	12.8	14.5	16.2	23
30 min	7.5	10.6	12.7	15.4	17.3	19.3	24
1 h	10.0	13.5	15.8	18.8	20.9	23.1	24
2 h	13.4	17.1	19.5	22.6	24.9	27.2	24
6 h	22.3	28.0	31.7	36.5	40.0	43.5	24
12 h	29.0	37.7	43.4	50.7	56.1	61.5	24
24 h	36.8	49.7	58.2	69.0	77.1	85.0	24

****

Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	44.5	70.1	87.1	108.5	124.3	140.1	23
	+/- 10.9	+/- 18.3	+/- 24.7	+/- 33.3	+/- 39.9	+/- 46.4	23
10 min	31.6	46.2	55.9	68.1	77.2	86.2	23
	+/- 6.2	+/- 10.4	+/- 14.1	+/- 19.0	+/- 22.7	+/- 26.5	23
15 min	24.3	35.1	42.2	51.3	58.0	64.6	23
	+/- 4.6	+/- 7.7	+/- 10.4	+/- 14.0	+/- 16.8	+/- 19.6	23
30 min	14.9	21.3	25.5	30.7	34.7	38.6	24
	+/- 2.6	+/- 4.4	+/- 6.0	+/- 8.1	+/- 9.6	+/- 11.2	24
1 h	10.0	13.5	15.8	18.8	20.9	23.1	24
	+/- 1.4	+/- 2.4	+/- 3.3	+/- 4.4	+/- 5.3	+/- 6.2	24
2 h	6.7	8.5	9.8	11.3	12.5	13.6	24
	+/- 0.8	+/- 1.3	+/- 1.8	+/- 2.4	+/- 2.8	+/- 3.3	24

6 h		3.7	4.7	5.3	6.1	6.7	7.3	24
	+/-	0.4 +/-	0.7 +/-	0.9 +/-	1.2 +/-	1.4 +/-	1.7	24
12 h		2.4	3.1	3.6	4.2	4.7	5.1	24
	+/-	0.3 +/-	0.5 +/-	0.7 +/-	0.9 +/-	1.1 +/-	1.3	24
24 h		1.5	2.1	2.4	2.9	3.2	3.5	24
	+/-	0.2 +/-	0.4 +/-	0.5 +/-	0.7 +/-	0.8 +/-	1.0	24

****

Table 3 : Interpolation Equation / Équation d'interpolation: R = A*T^B

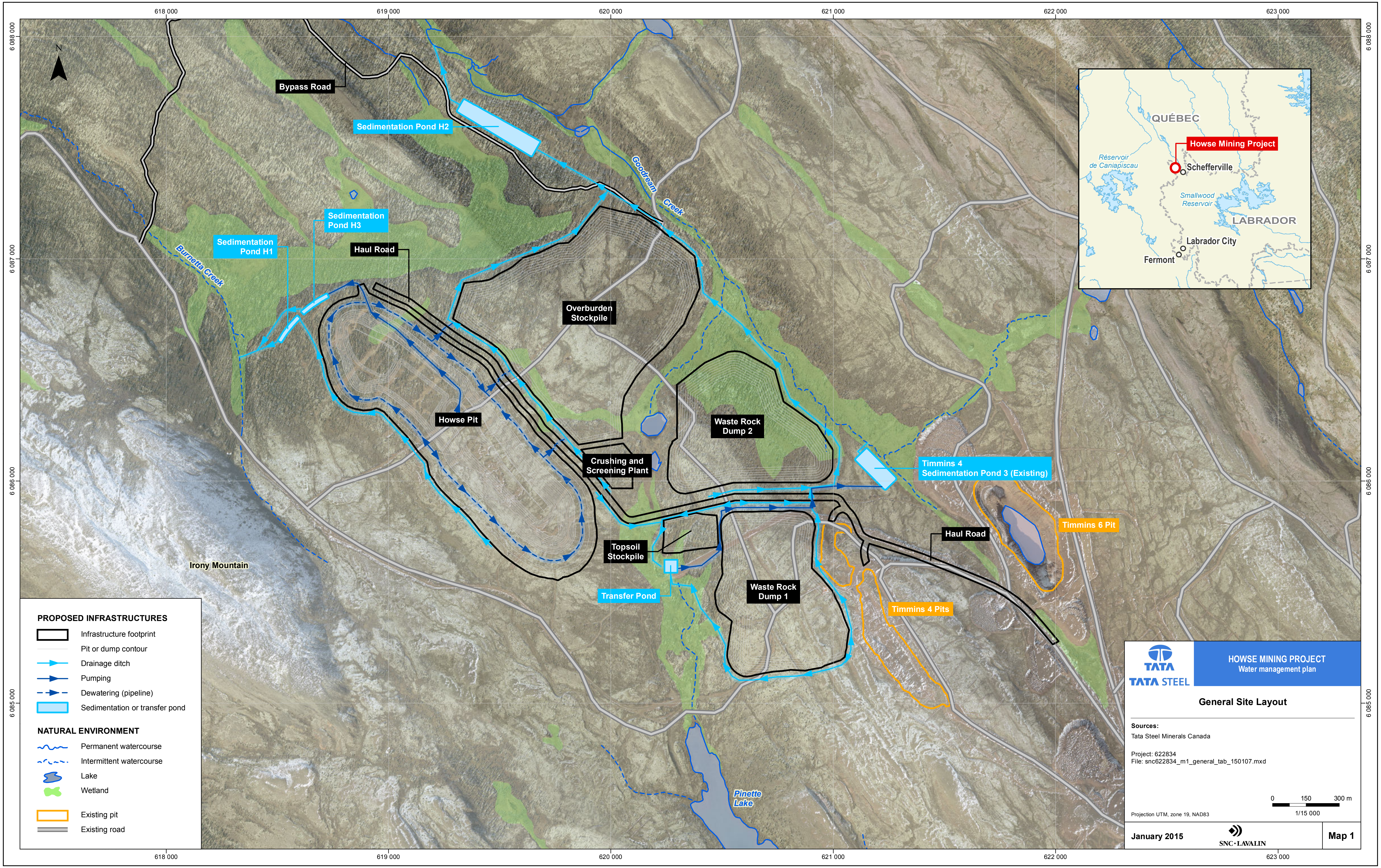
R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	15.5	22.7	27.5	33.5	38.0	42.5
Std. Dev. /Écart-type (RR)	15.0	23.4	29.0	36.1	41.3	46.5
Std. Error/Erreur-type	0.8	1.3	2.1	3.1	3.9	4.6
Coefficient (A)	10.4	14.4	17.0	20.3	22.7	25.2
Exponent/Exposant (B)	-0.595	-0.625	-0.637	-0.648	-0.654	-0.659
Mean % Error/% erreur moyenne	3.2	4.3	5.5	6.5	7.1	7.6

APPENDIX B

Maps and Drawings



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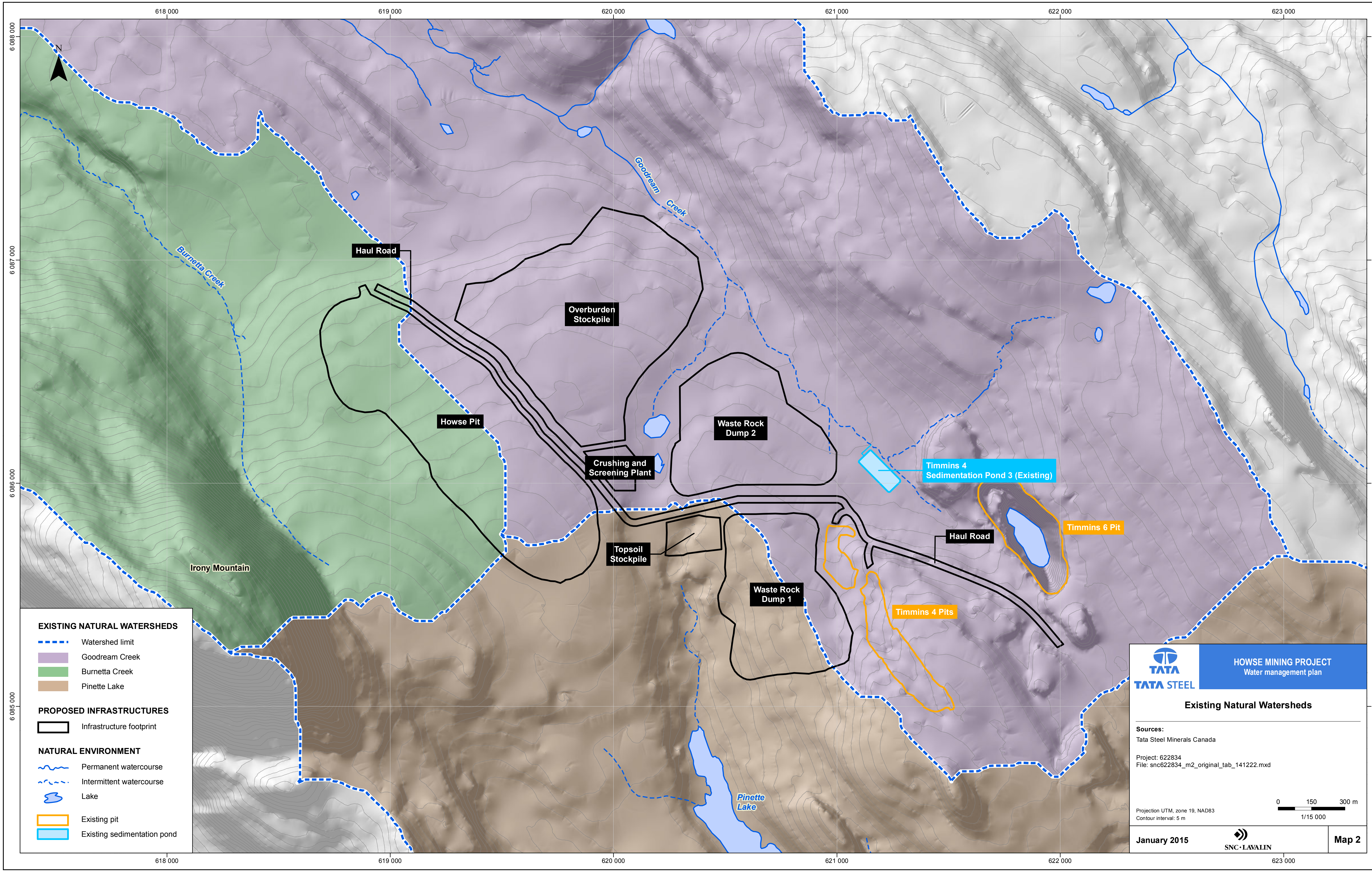

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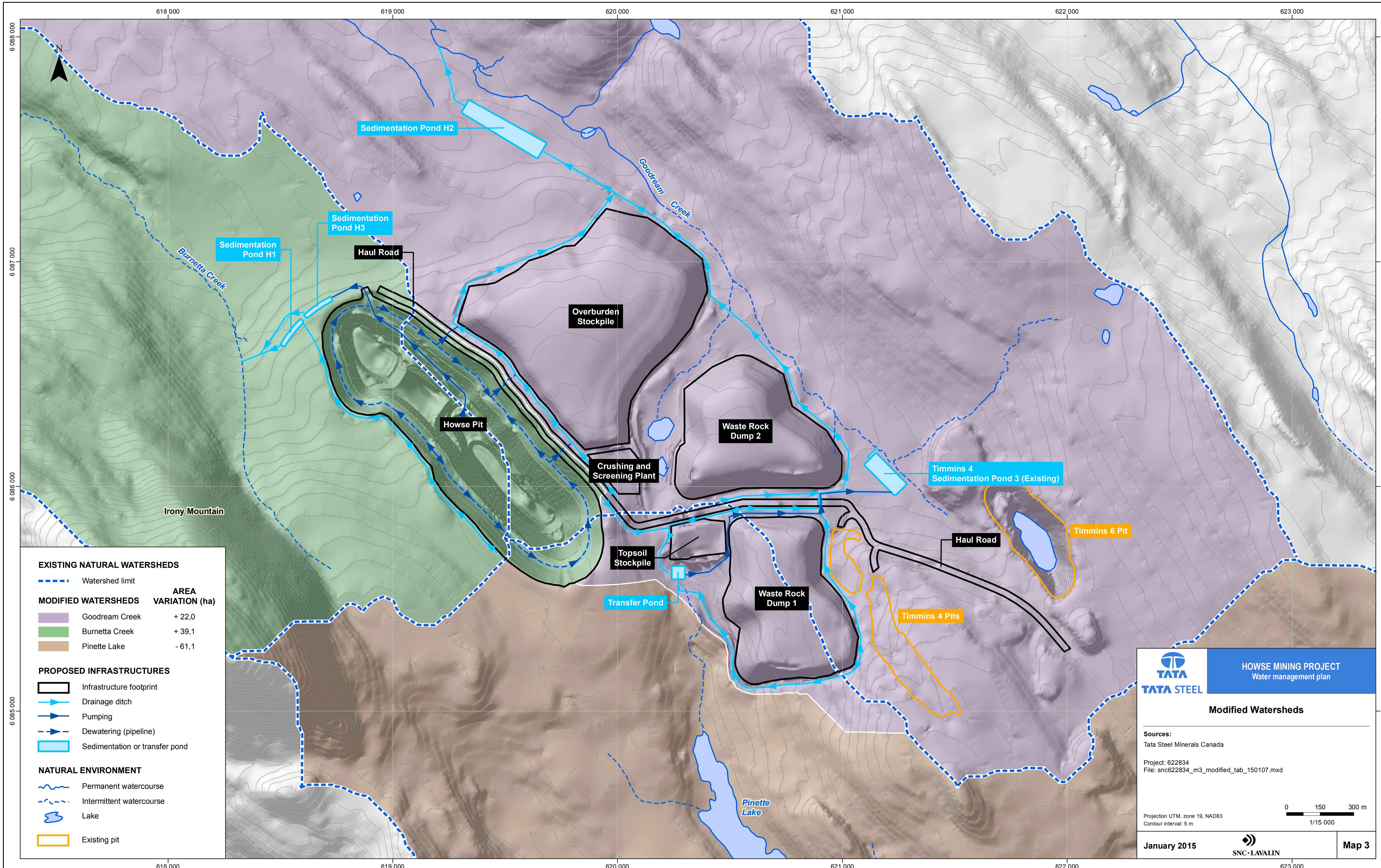

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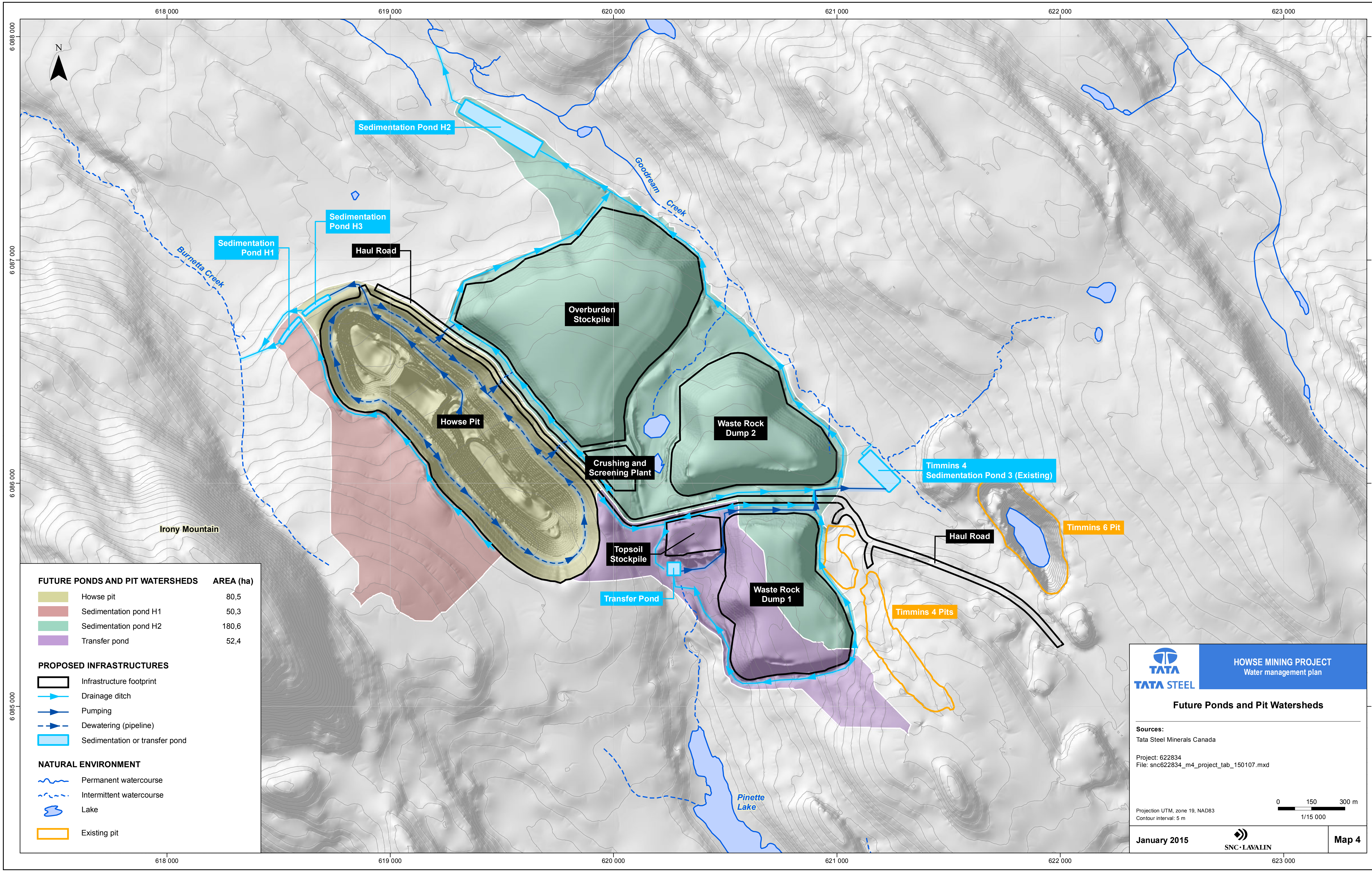

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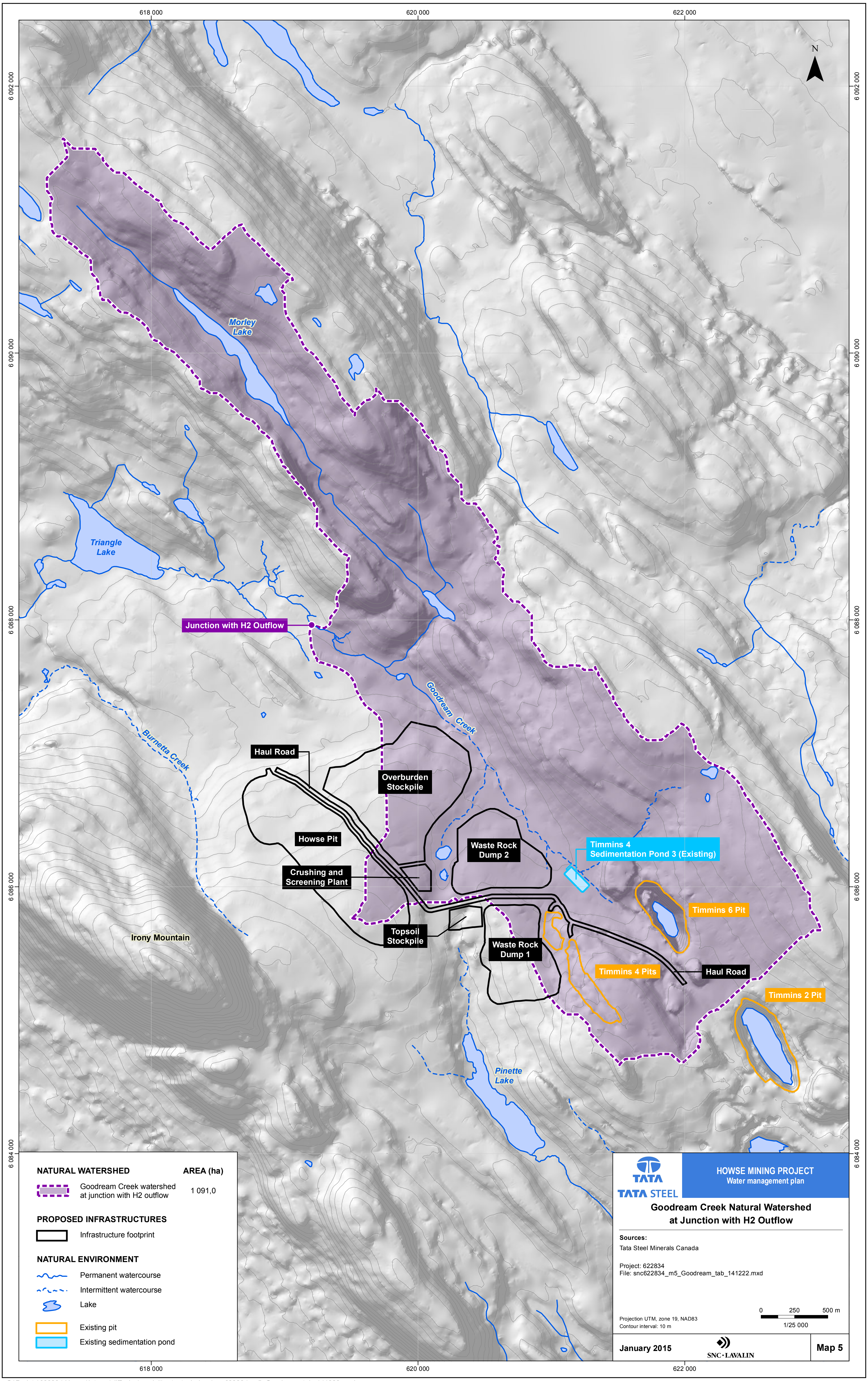

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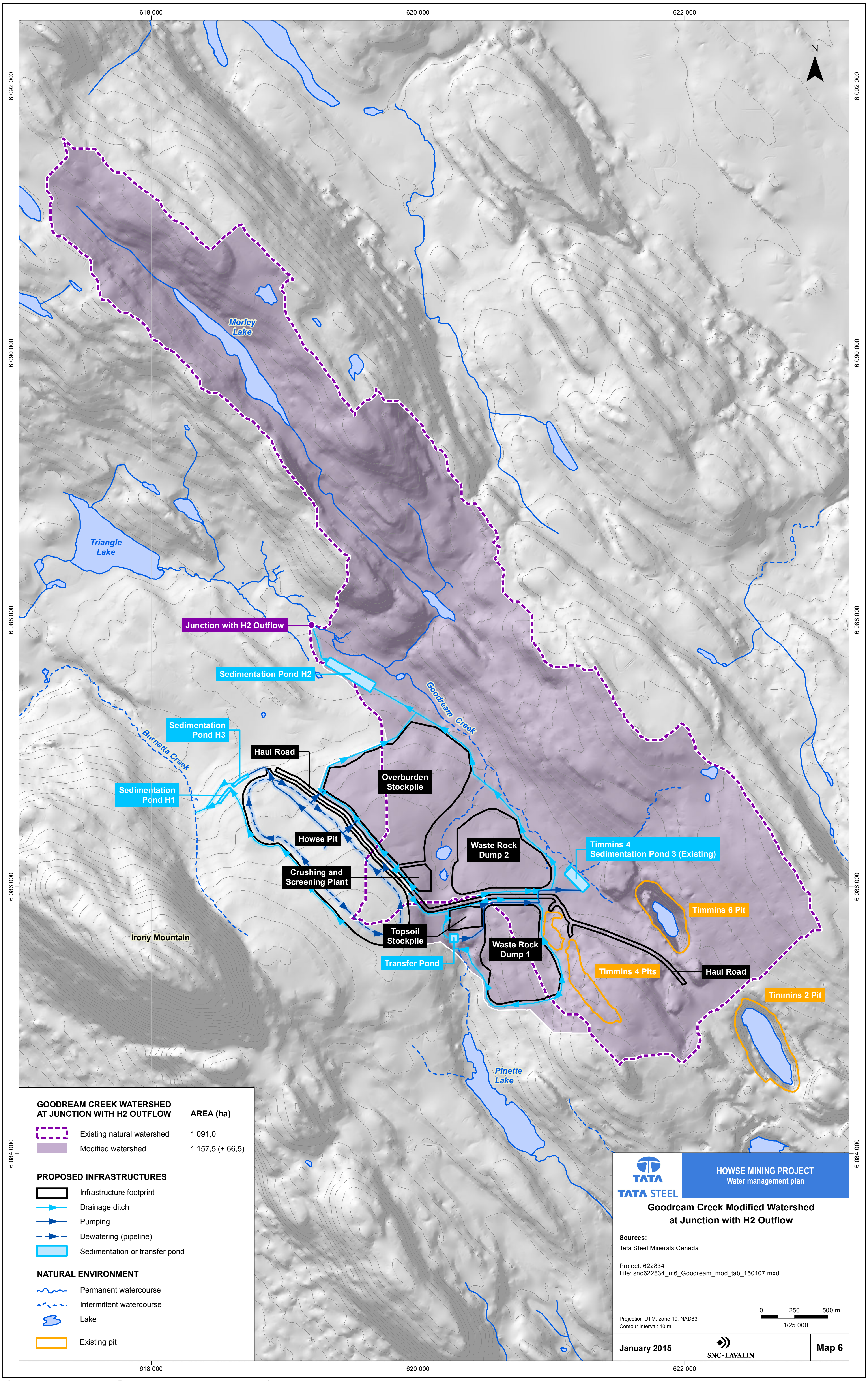

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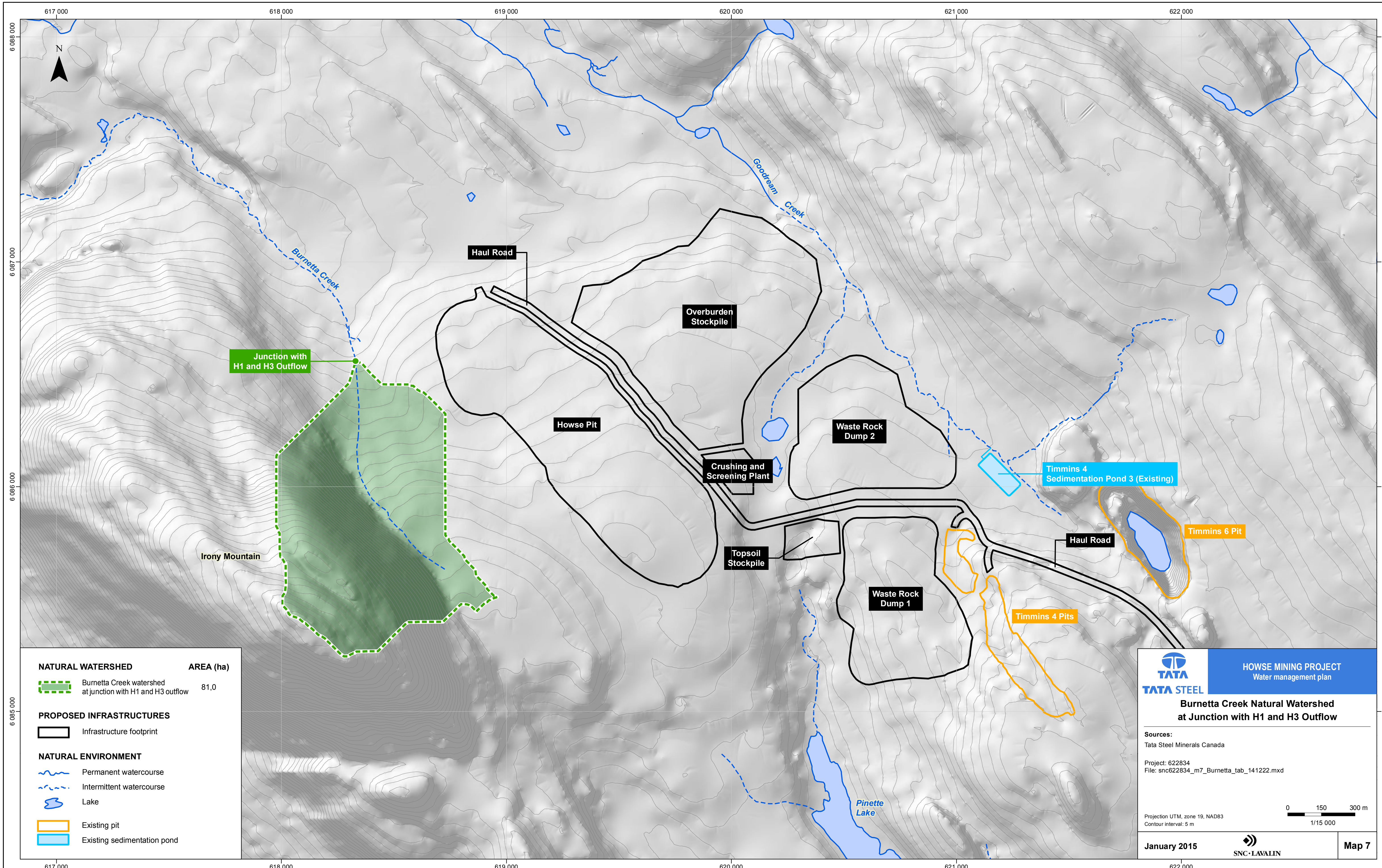

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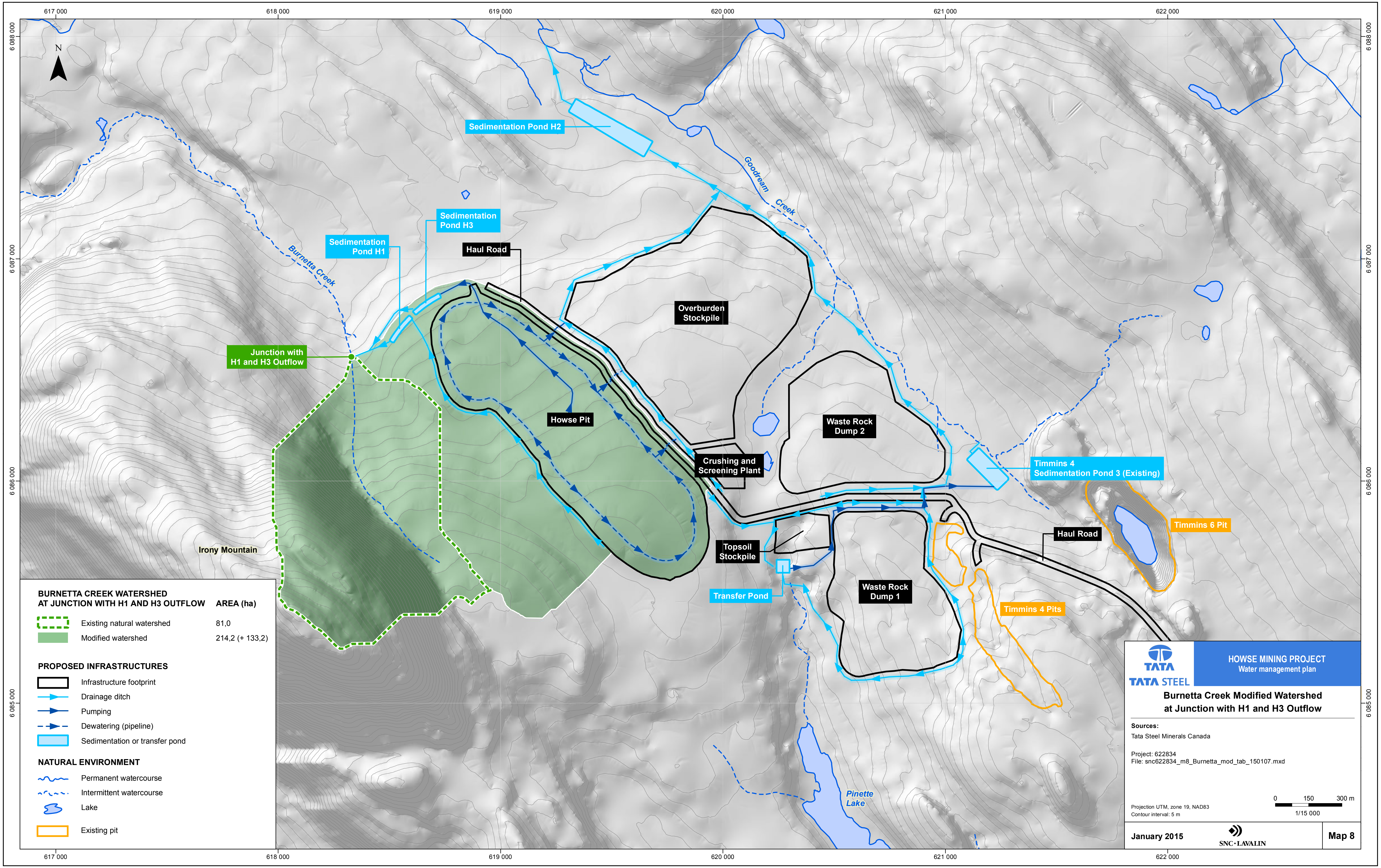

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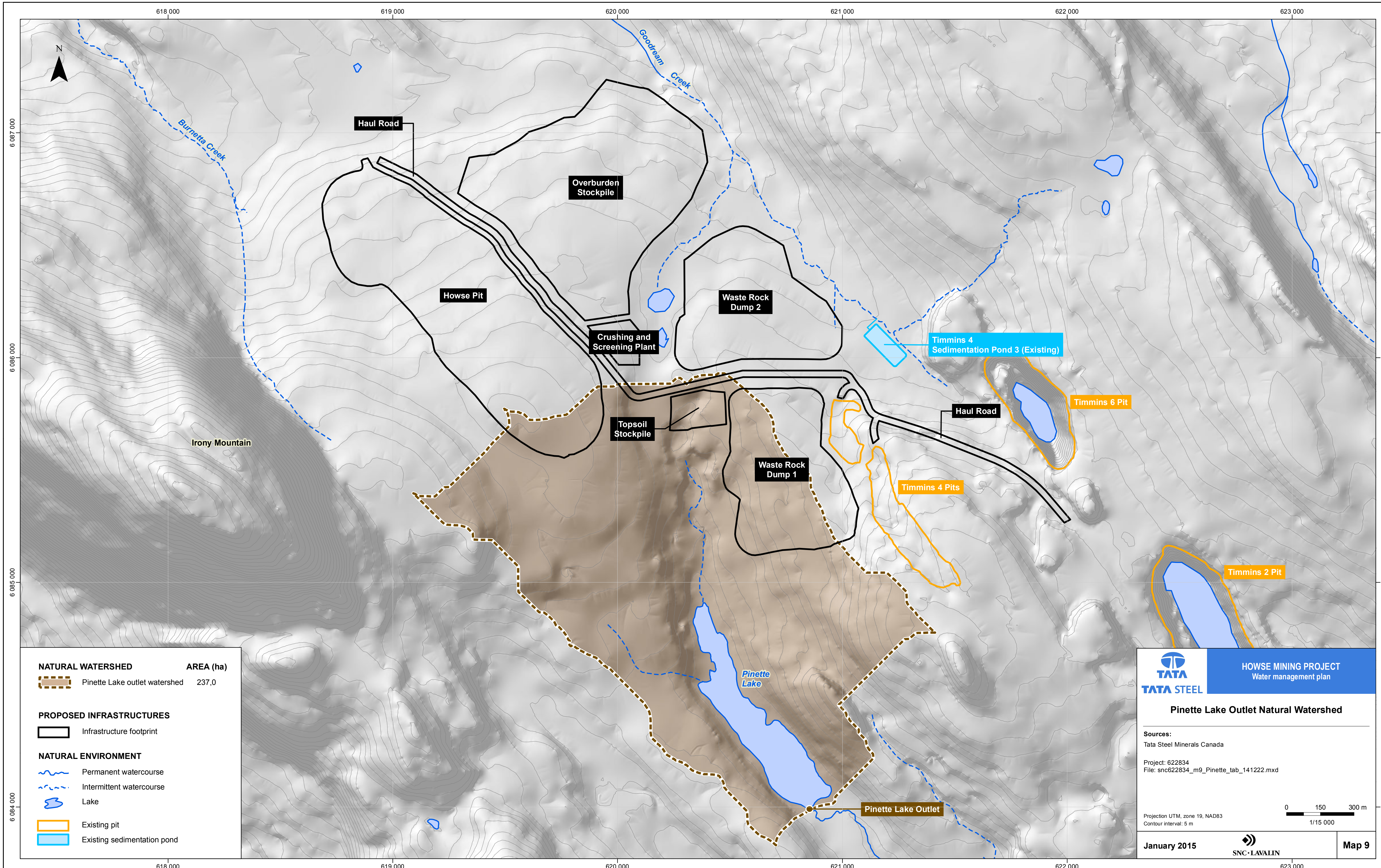

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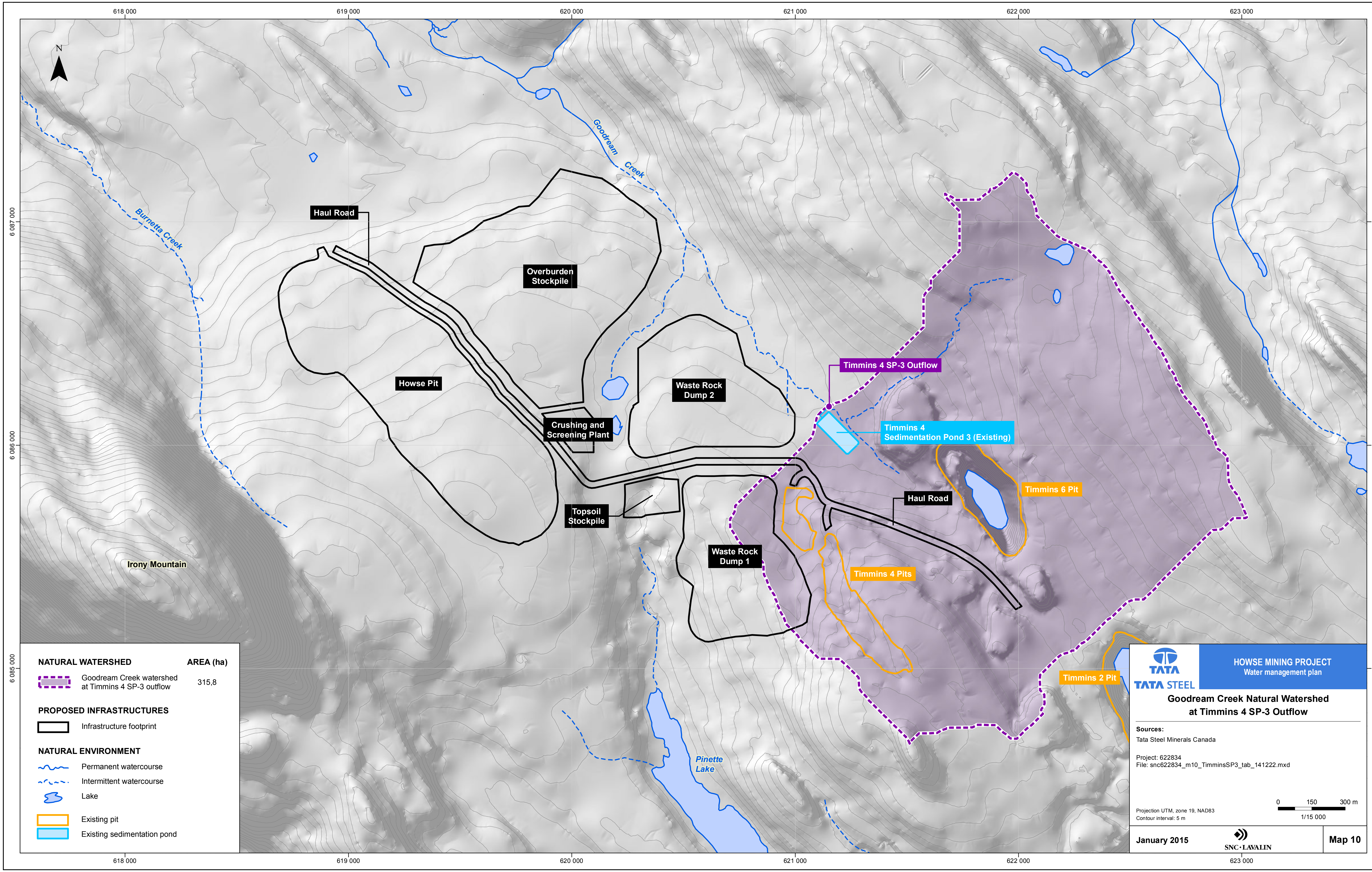

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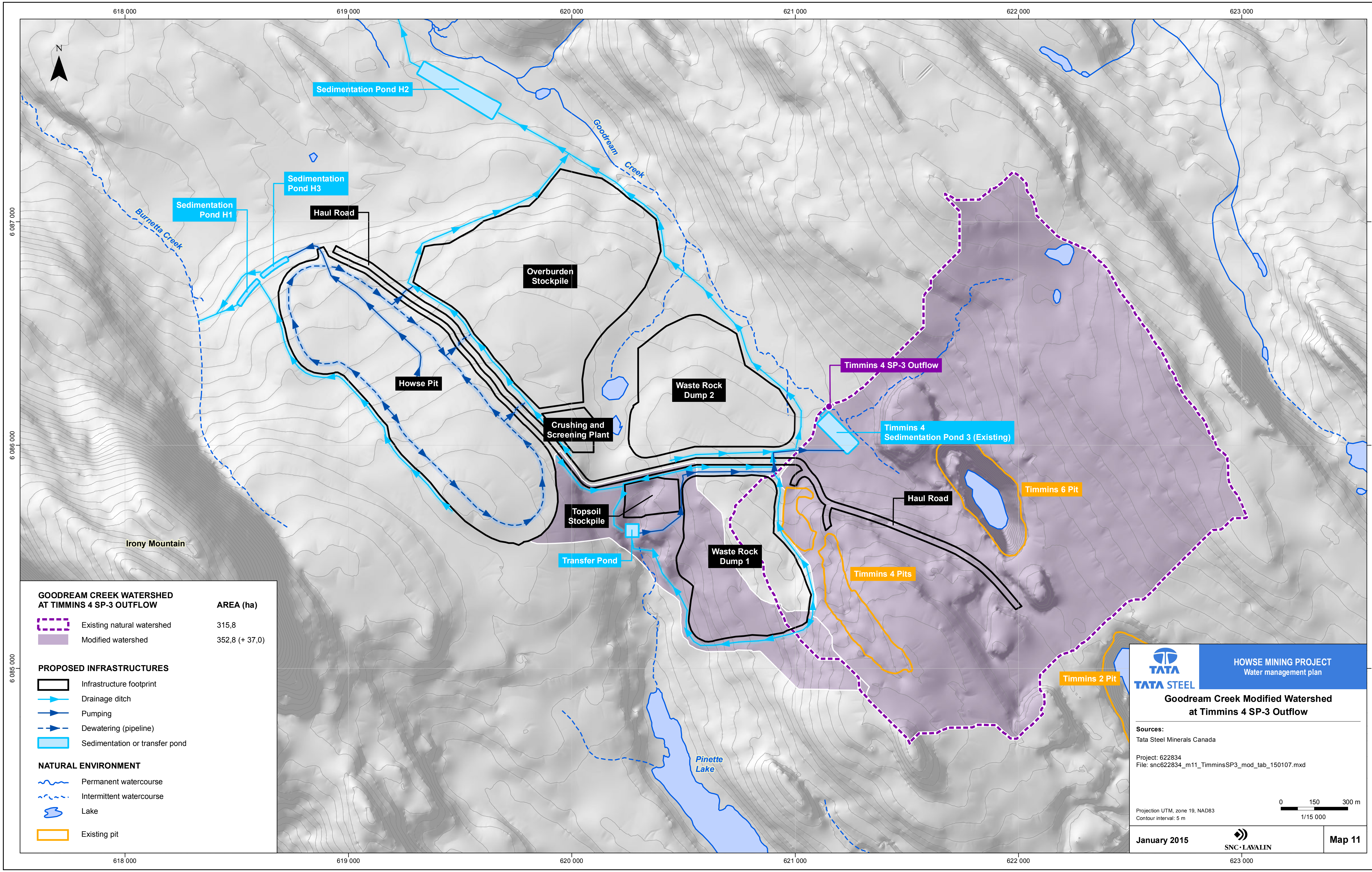

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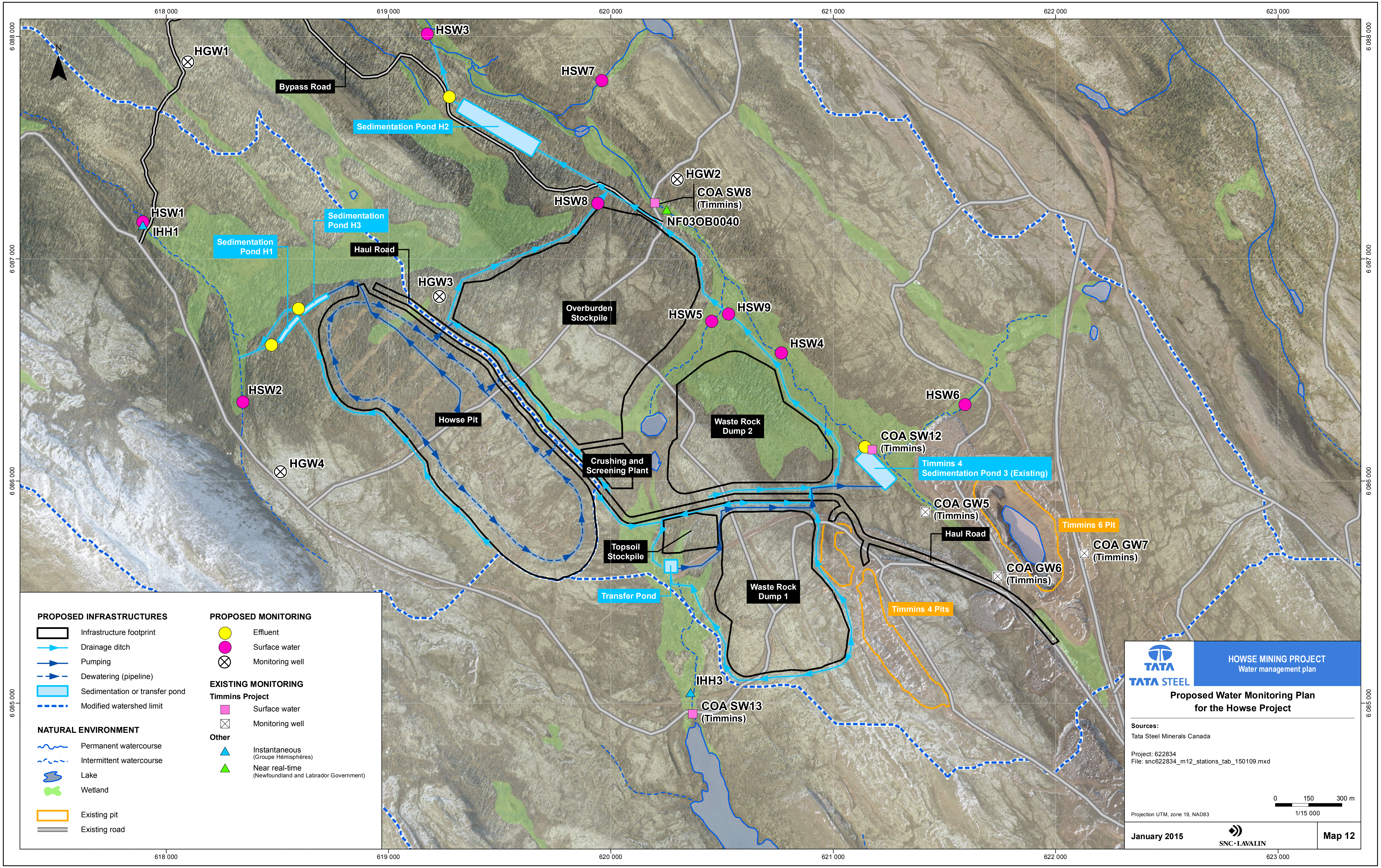

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2	PB	2014/11/14	ISSUED FOR CLIENT REVIEW	
1	PA	2014/11/06	ISSUED FOR INTERNAL REVIEW	

ISSUE REGISTER — ISSUE REGISTER — REVISION REGISTER (No, REVISION DESCRIPTION, DATE (Y/M/D), INITIALS: * DESIGNED ** APPROVED) — REVISION REGISTER

No	REFERENCE DRAWINGS NUMBER
01	AU-2013-028-501-MN-REVD (OPTION 3, DEC.5, 2013)

PROFESSIONAL SEAL

SNC·LAVALIN
Sustainable Mine Development
Global Mining & Metallurgy
SNC LAVALIN INC.
455, Boul. René-Lévesque Ouest
Montreal (Quebec)
Canada H2Z 1Z3

PREPARATION	APPROVAL
DESIGNED: M.H. Paquette	PROJECT DISCIPLINE ENGINEER: L. Didillon
DRAWN: D. Lan	CLIENT
CHECKED: P. Scholz	DATE: 2014-10-20
SCALE: 1 : 7 500 (100 0 100 200 300m)	

CLIENT: HOWSE MINERALS CANADA LIMITED

PROJECT: WATER MANAGEMENT PLAN HOWSE PROJECT

TITLE: GENERAL SITE LAYOUT

PROJECT No	SUBDIVISION	SUBJECT	SERIAL	REV.
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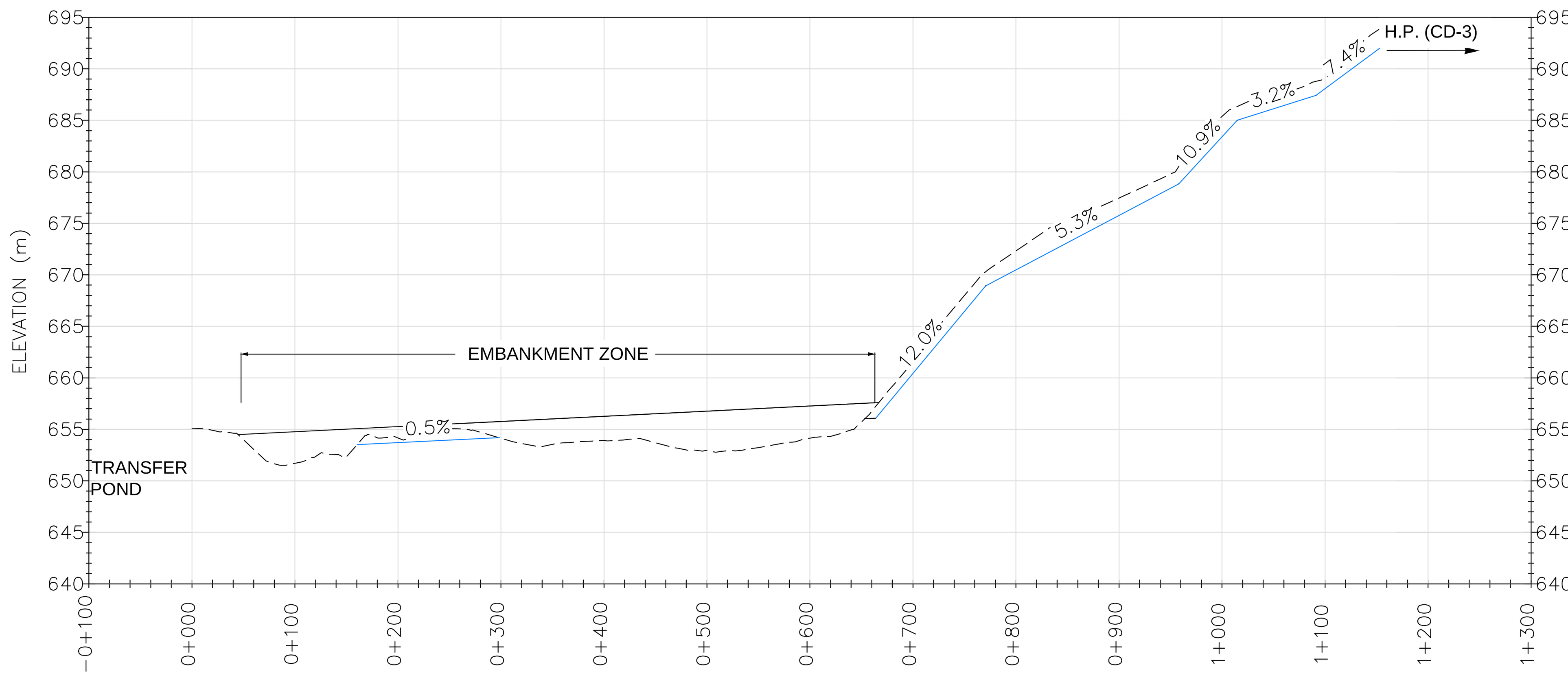

LONGITUDINAL PROFILE - DITCH CD-1

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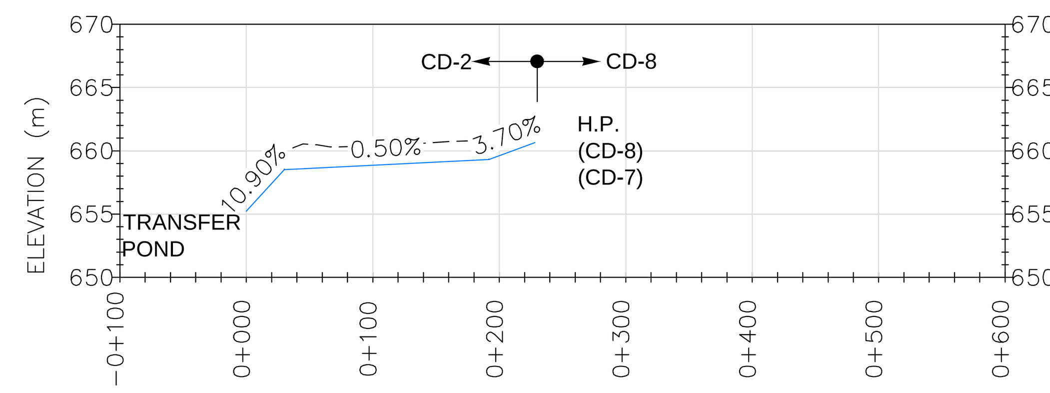

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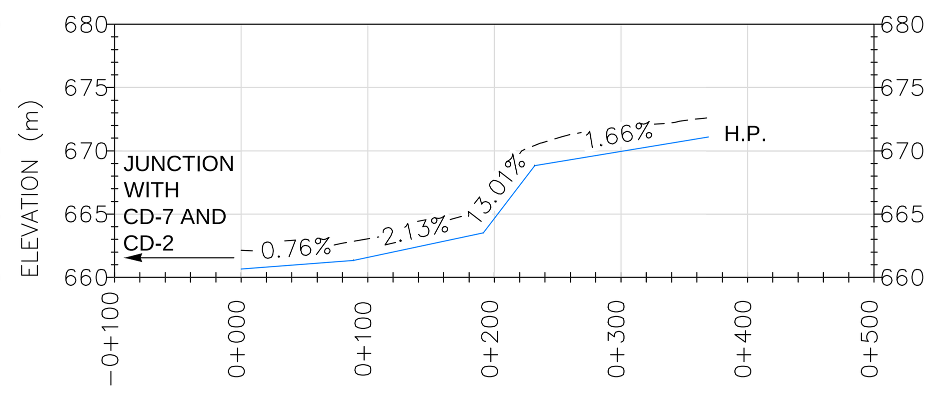

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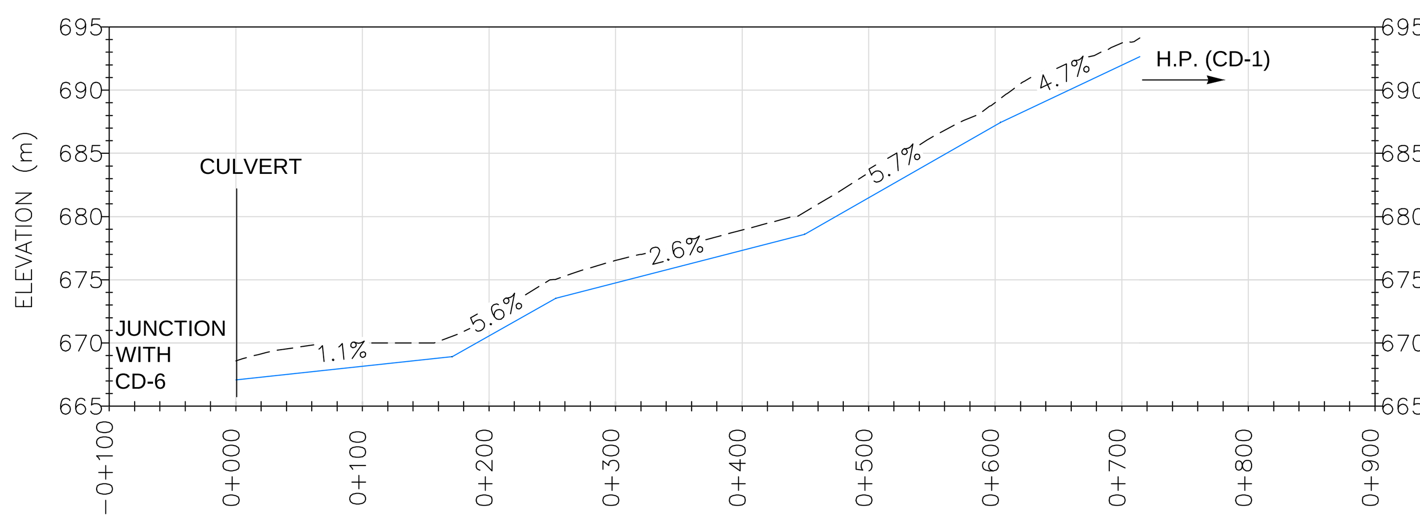

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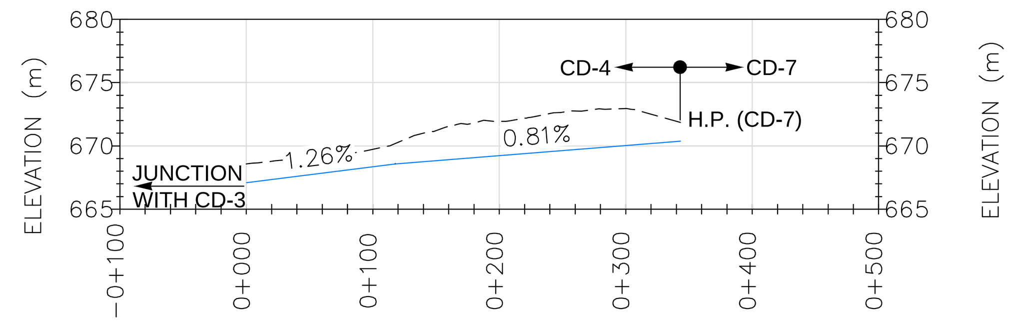

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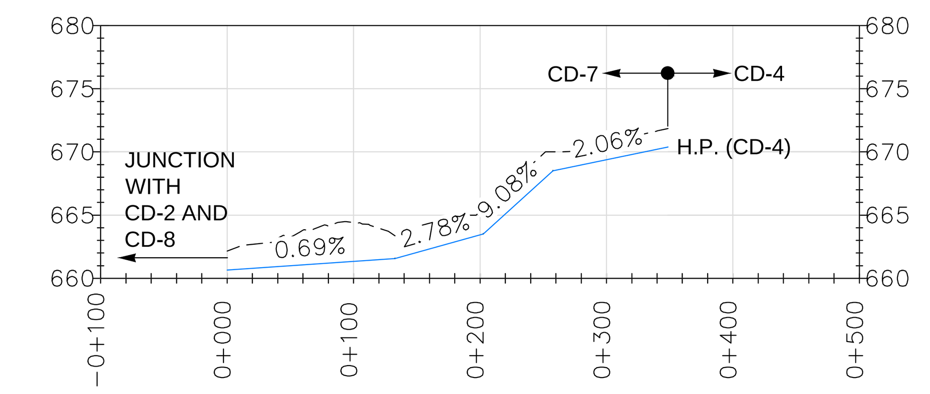

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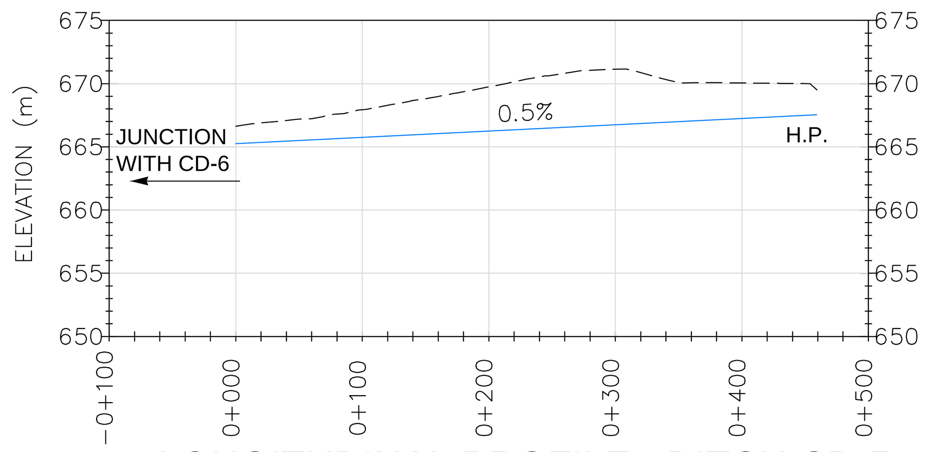

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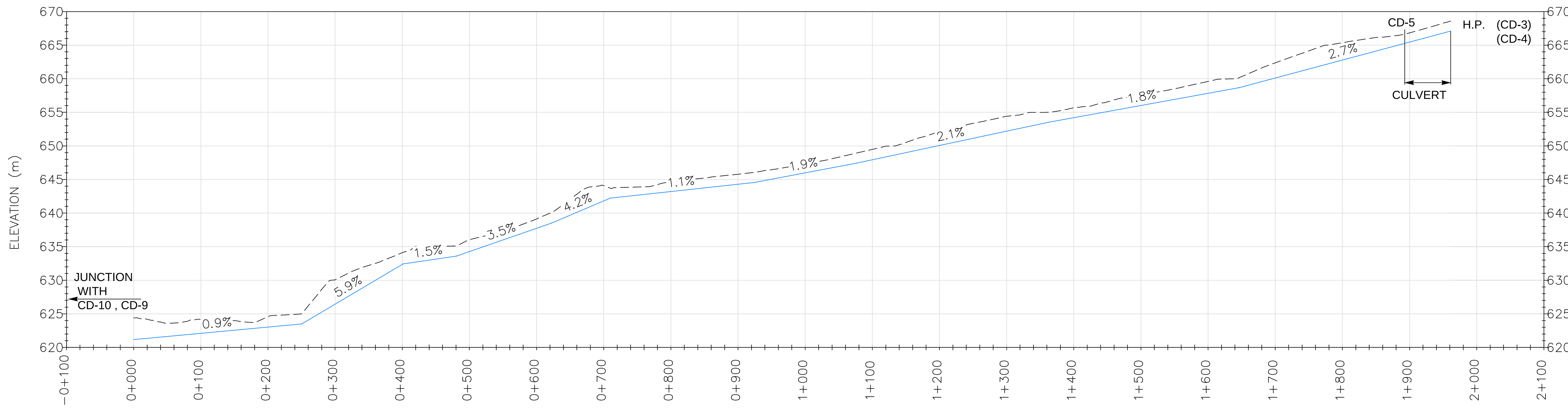

LONGITUDINAL PROFILE - DITCH CD-6

SCALE: H: 1:5000
V: 1:500

NOTE: DITCHES WILL BE PROTECTED AGAINST EROSION.

LEGEND

- – – – – NATURAL GROUND
- ——— DITCH INVERT
- H.P. HIGH POINT

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ISSUE REGISTER

ISSUE No	REV.	DATE (Y/M/D)	PURPOSE OF ISSUE	TRANSMISSION LETTER No
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ISSUE No	REV.	DATE (Y/M/D)	PURPOSE OF ISSUE	TRANSMISSION LETTER No

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No	REVISION DESCRIPTION	DATE (Y/M/D)	*	**

INITIALS: * DESIGNED ** APPROVED

REVISION REGISTER

No	REVISION DESCRIPTION	DATE (Y/M/D)	*	**

INITIALS: * DESIGNED ** APPROVED

No	REFERENCE DRAWINGS NUMBER

PROFESSIONAL SEAL

SNC·LAVALIN

Sustainable Mine Development
Global Mining & Metallurgy
SNC LAVALIN INC.
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Canada H2Z 1Z3

PREPARATION		APPROVAL	
DESIGNED	M.H. Paquette	PROJECT DISCIPLINE ENGINEER	L. Didillon
DRAWN	D. Lan	CLIENT	
CHECKED	–	DATE	2014-10-20

SCALE 1 : 5 000 (50 0 50 100 150 200m)

CLIENT: HOUSE MINERALS CANADA LIMITED

PROJECT: WATER MANAGEMENT PLAN HOWSE PROJECT

TITLE: DRAINAGE DITCHES LONGITUDINAL PROFILES (1/2)

PROJECT No	SUBDIVISION	SUBJECT	SERIAL	REV.
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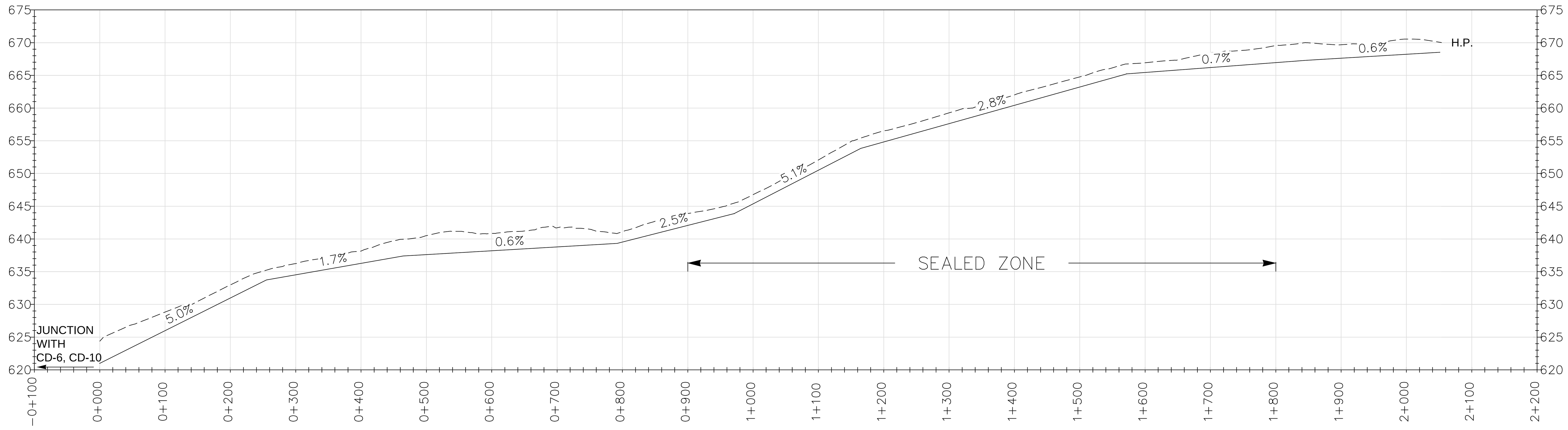

LONGITUDINAL PROFILE - DITCH CD-9

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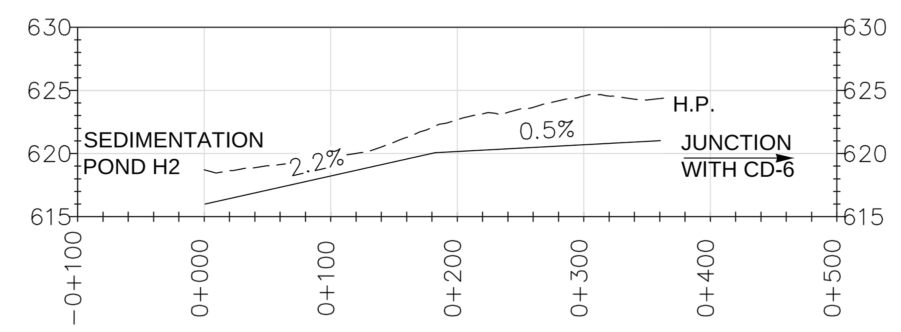
V: 1:500



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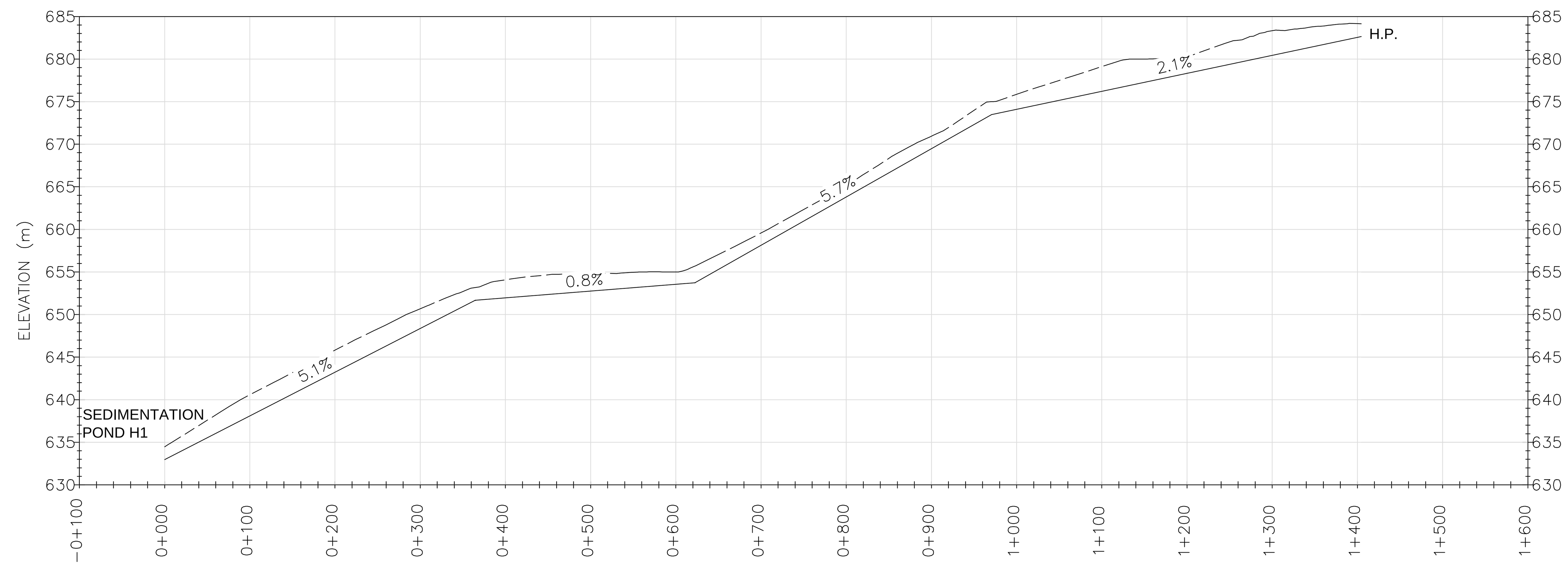

LONGITUDINAL PROFILE - DITCH DD-1

SCALE: H: 1:5000
V: 1:500

LEGEND

- - - - NATURAL GROUND
——— DITCH INVERT
H.P. HIGH POINT

NOT FOR CONSTRUCTION

ISSUE No	REV.	DATE (Y/M/D)	PURPOSE OF ISSUE
4	01	2015/01/08	ISSUED FOR IMPACT STUDY
3	00	2014/12/11	ISSUED FOR IMPACT STUDY
2	PB	2014/11/14	ISSUED FOR CLIENT REVIEW
1	PA	2014/11/06	ISSUED FOR INTERNAL REVIEW

ISSUE REGISTER — ISSUE REGISTER — REVISION REGISTER — REVISION REGISTER — REFERENCE DRAWINGS NUMBER

PROFESSIONAL SEAL

SNC·LAVALIN
Sustainable Mine Development
Global Mining & Metallurgy
SNC LAVALIN INC.
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CLIENT: HOUSE MINERALS CANADA LIMITED

PROJECT: WATER MANAGEMENT PLAN HOWSE PROJECT

TITLE: DRAINAGE DITCHES LONGITUDINAL PROFILES (2/2)

PREPARATION	APPROVAL
DESIGNED: M.H. Paquette	PROJECT DISCIPLINE ENGINEER: L. Didillon
DRAWN: D. Lan	CLIENT
CHECKED: -	DATE: 2014-10-20
SCALE: 1 : 5 000	

PROJECT No	SUBDIVISION	SUBJECT	SERIAL	REV.
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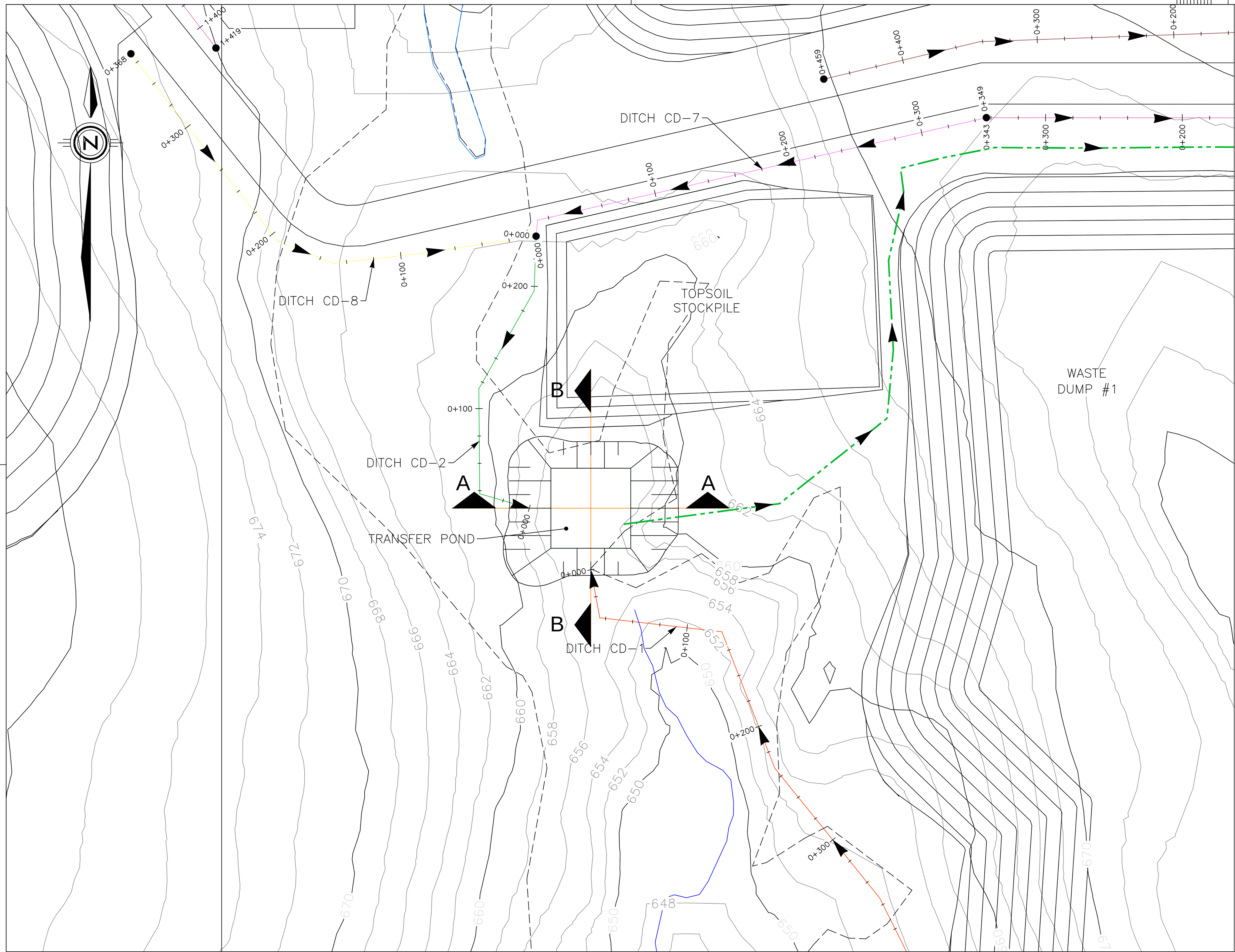

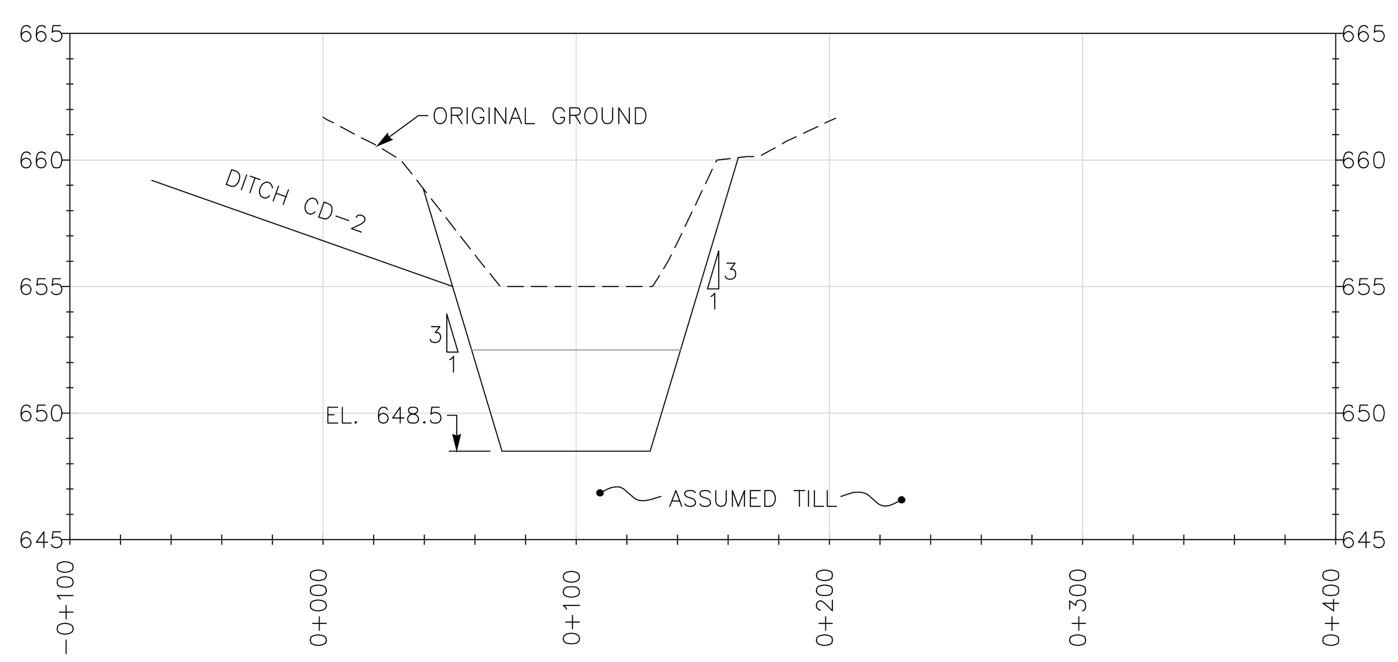

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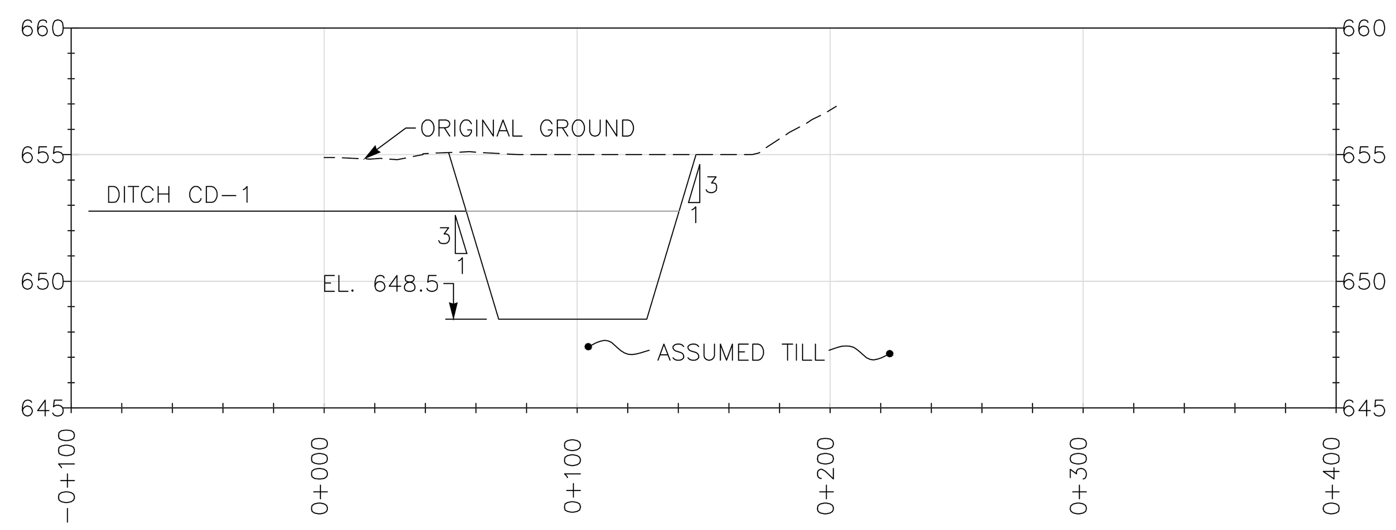
V: 1:250



SECTION B-B - TRANSFER POND
SCALE: H: 1:2500
V: 1:250

LEGEND

- PROPOSED DITCH
- WETLAND
- WATER COURSE
- CD-1 DITCH NUMBER
- PUMPING FROM TRANSFER POND

NOTE:

THE SUITABILITY OF THE EXCAVATED TILL TO BE USED FOR DYKE CONSTRUCTION WILL BE CONFIRMED IN THE NEXT PHASE OF ENGINEERING.

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ISSUE REGISTER

ISSUE No	REV.	DATE (Y/M/D)	PURPOSE OF ISSUE	TRANSMISSION LETTER No
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1	PA	2014/11/06	ISSUED FOR INTERNAL REVIEW	

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REFERENCE DRAWINGS NUMBER

No	REFERENCE DRAWINGS NUMBER
01	AU-2013-028-501-MN-REVD (OPTION 3, DEC.5, 2013)

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PREPARATION	APPROVAL
DESIGNED: M.H. Paquette	PROJECT DISCIPLINE ENGINEER: L. Didillon
DRAWN: D. Lan	CLIENT
CHECKED: P. Scholz	DATE: 2014-10-20
SCALE: 1 : 2 500 (20 0 20 40 60 80 100m)	

CLIENT: HOWSE MINERALS CANADA LIMITED

PROJECT: WATER MANAGEMENT PLAN HOWSE PROJECT

TITLE: TRANSFER POND SECTIONS AND DETAILS

PROJECT No	SUBDIVISION	SUBJECT	SERIAL	REV.
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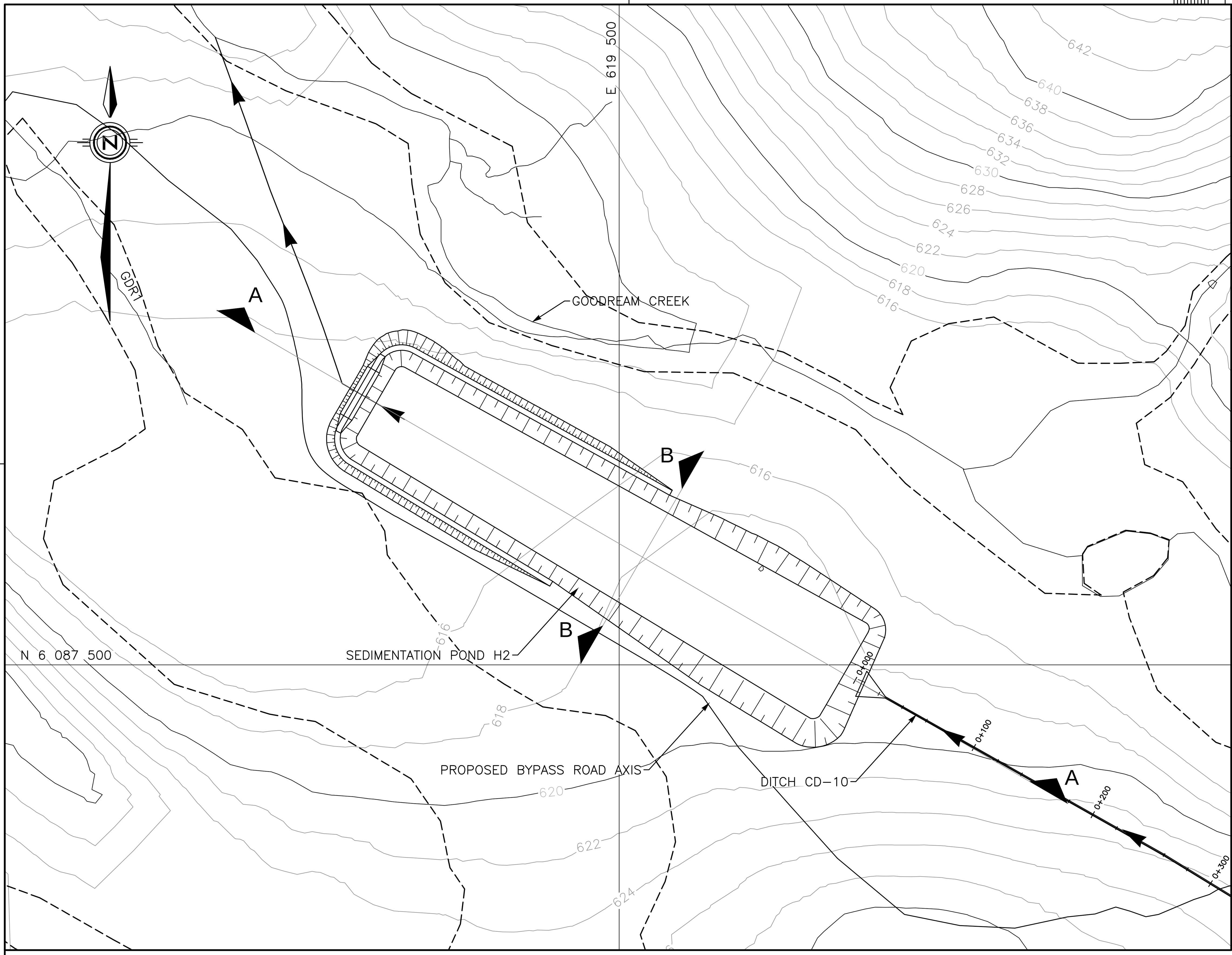
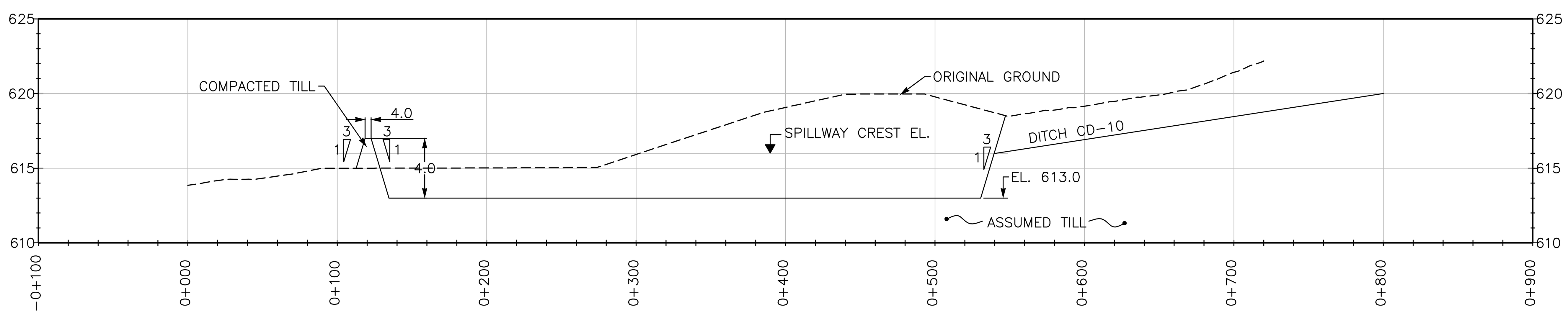


LEGEND

- PROPOSED DITCH
- WETLAND
- WATER COURSE
- CD-1 DITCH NUMBER



SECTION A-A - SEDIMENTATION POND H2

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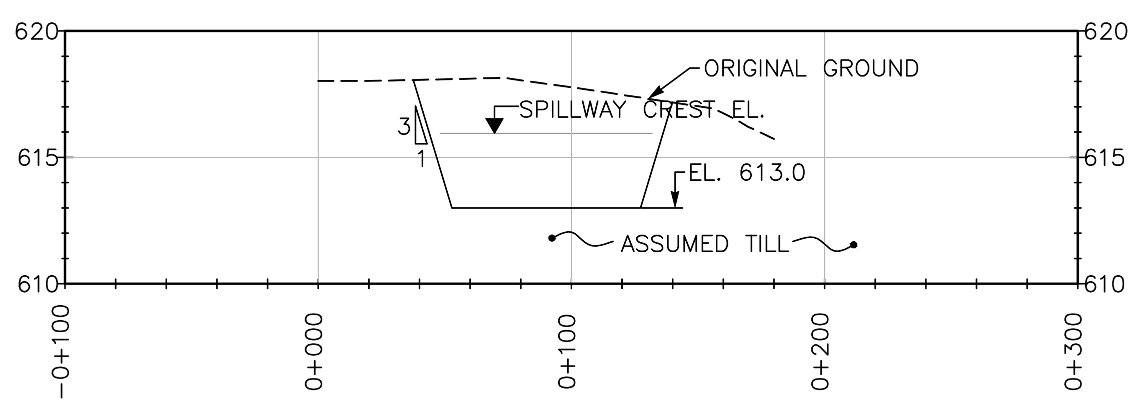

SECTION B-B - SEDIMENTATION POND H2

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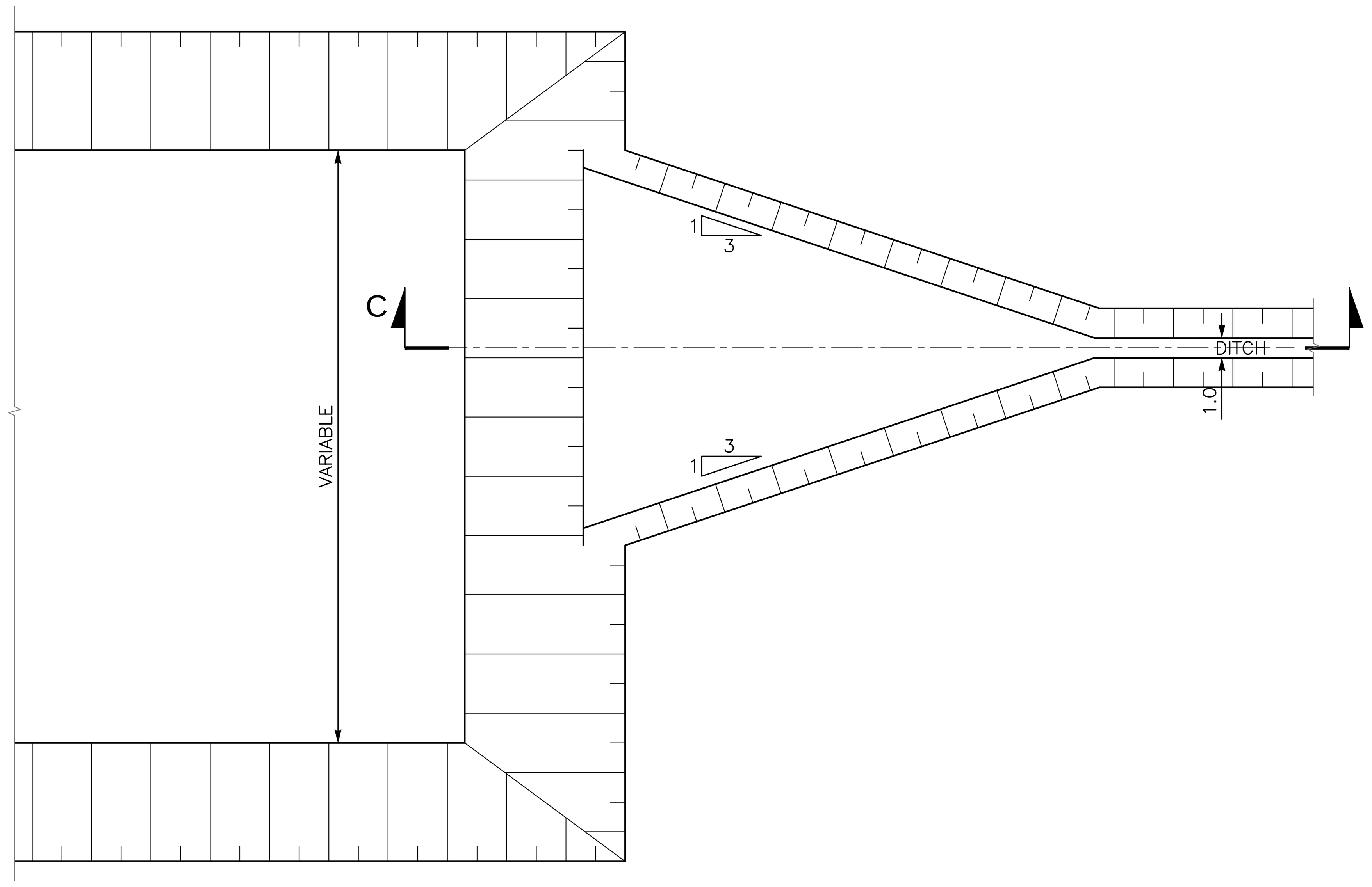
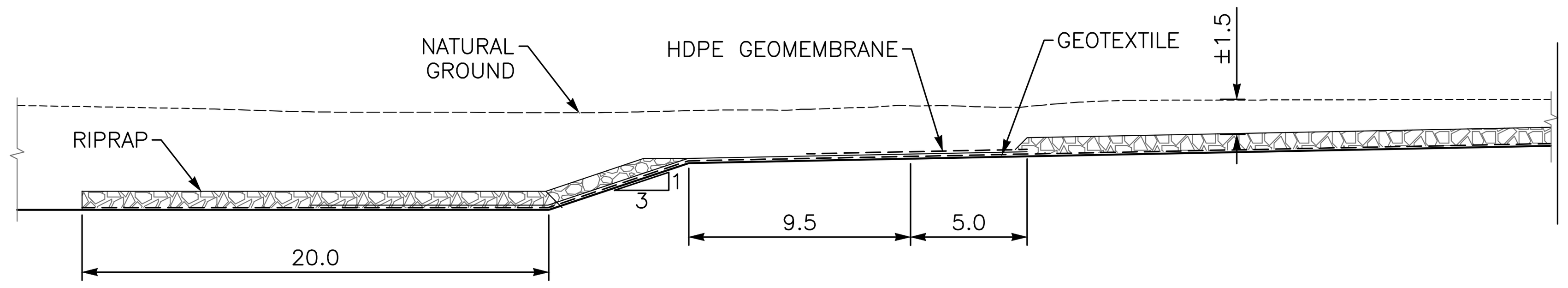
V: 1:250



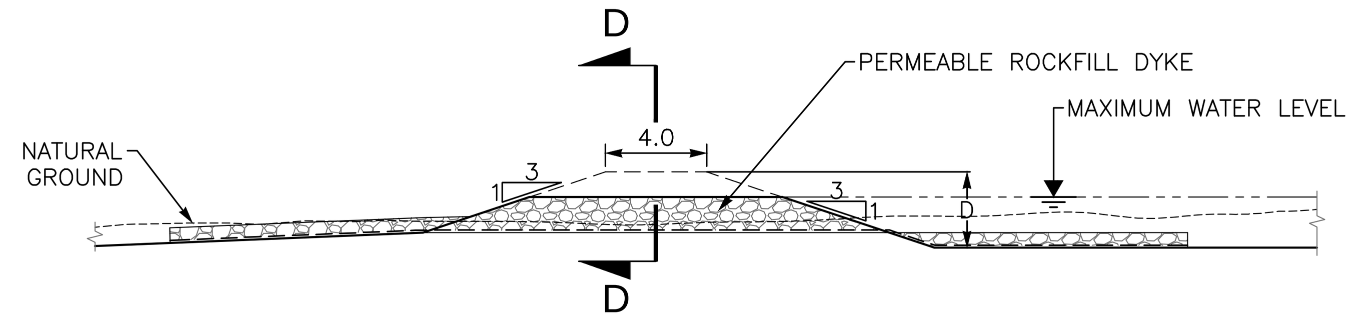
TYPICAL POND ENTRANCE DETAIL (PONDS H1 & H2)

SCALE 1:250



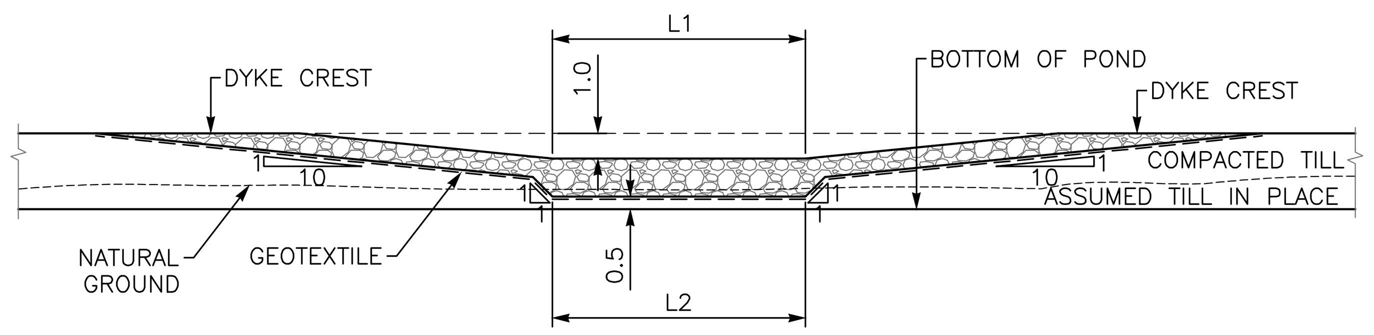
SECTION C-C

SCALE 1:250



TYPICAL SECTION PERMEABLE ROCKFILL DYKE AND EMERGENCY SPILLWAY (PONDS H1, H2 & H3)

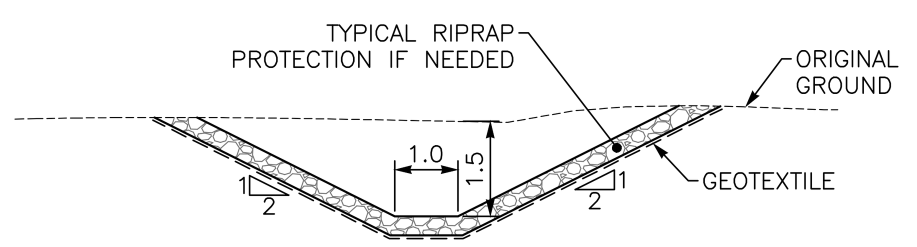
SCALE 1:250



SECTION D-D

SCALE 1:250

	L1 (m)	L2 (m)	D (m)
POND H1	10	10	3
POND H2	40	10	4
POND H3	5	10	2.5
TRANSFER POND	–	–	6.5
TIMMINS 4 POND#3	15	30	4



TYPICAL DITCH SECTION (NOTE 2)

SCALE 1:100

NOTE:

1. THE SUITABILITY OF THE EXCAVATED TILL TO BE USED FOR DYKE CONSTRUCTION WILL BE CONFIRMED IN THE NEXT PHASE OF ENGINEERING.
2. EXCEPT CD-6 (1.5m BOTTOM BASE WIDTH) AND CD-10 (3.0m BOTTOM BASE WIDTH)

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ISSUE REGISTER

ISSUE No	REV.	DATE (Y/M/D)	PURPOSE OF ISSUE
3	00	2014/12/11	ISSUED FOR IMPACT STUDY
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1	PA	2014/11/06	ISSUED FOR INTERNAL REVIEW

REFERENCE DRAWINGS NUMBER

No	REFERENCE DRAWINGS NUMBER
01	AU-2013-028-501-MN-REVD (OPTION 3, DEC.5, 2013)

PROFESSIONAL SEAL

SNC·LAVALIN — Sustainable Mine Development, Global Mining & Metallurgy, SNC LAVALIN INC., 455, Boul. René-Lévesque Ouest, Montréal (Québec), Canada H2Z 1Z3

CLIENT: HOWSE MINERALS CANADA LIMITED

PROJECT: WATER MANAGEMENT PLAN HOWSE PROJECT

TITLE: SEDIMENTATION POND H2, TYPICAL INLET AND OUTLET SECTIONS AND DETAILS

PREPARATION	APPROVAL
DESIGNED: M.H. Paquette	PROJECT DISCIPLINE ENGINEER: L. Didillon
DRAWN: D. Lan	CLIENT:
CHECKED: P. Scholz	DATE: 2014-10-20
SCALE: 1 : 2 500	

PROJECT No	SUBDIVISION	SUBJECT	SERIAL	REV.
622834	4000	40 DD	0005	00

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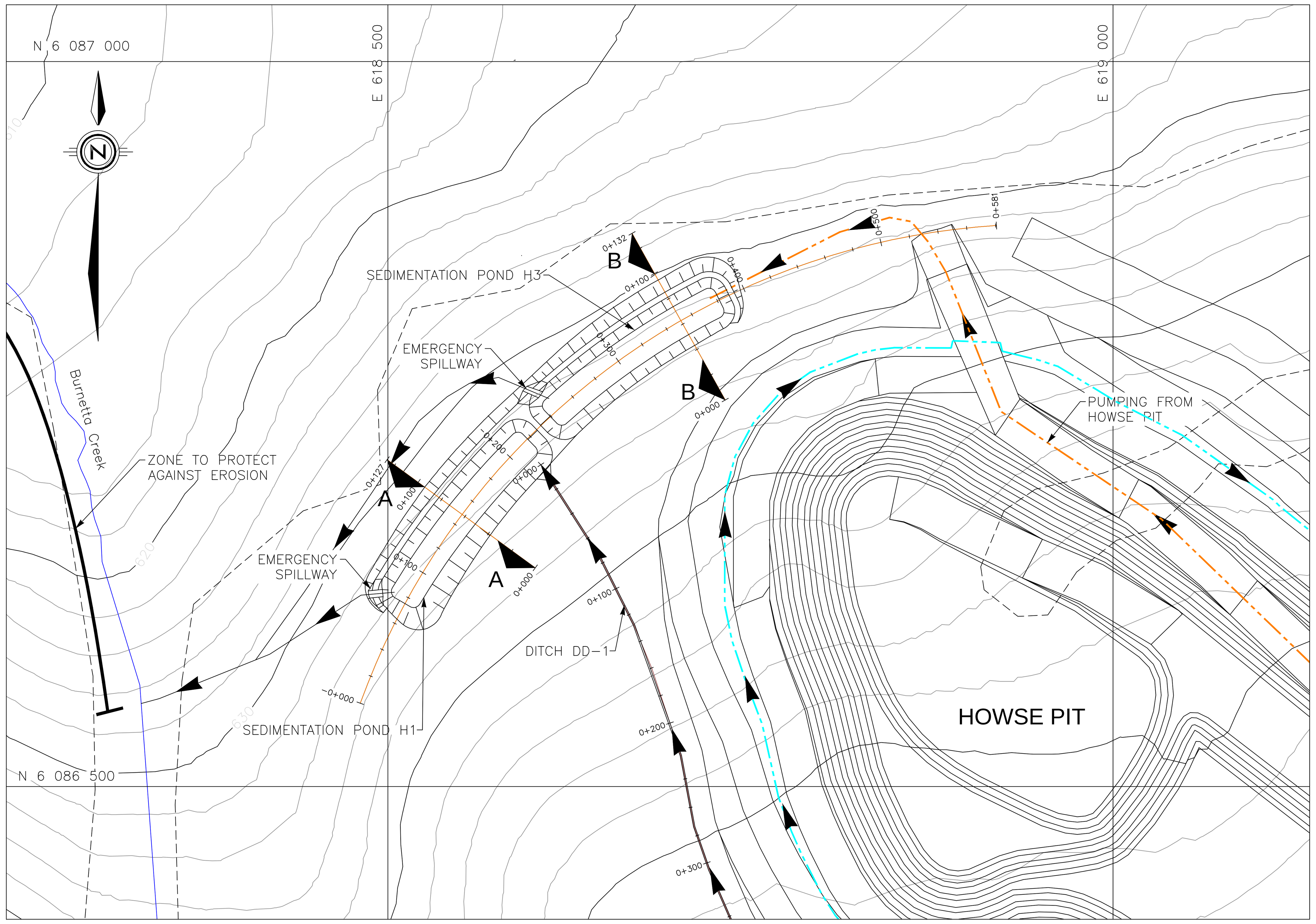
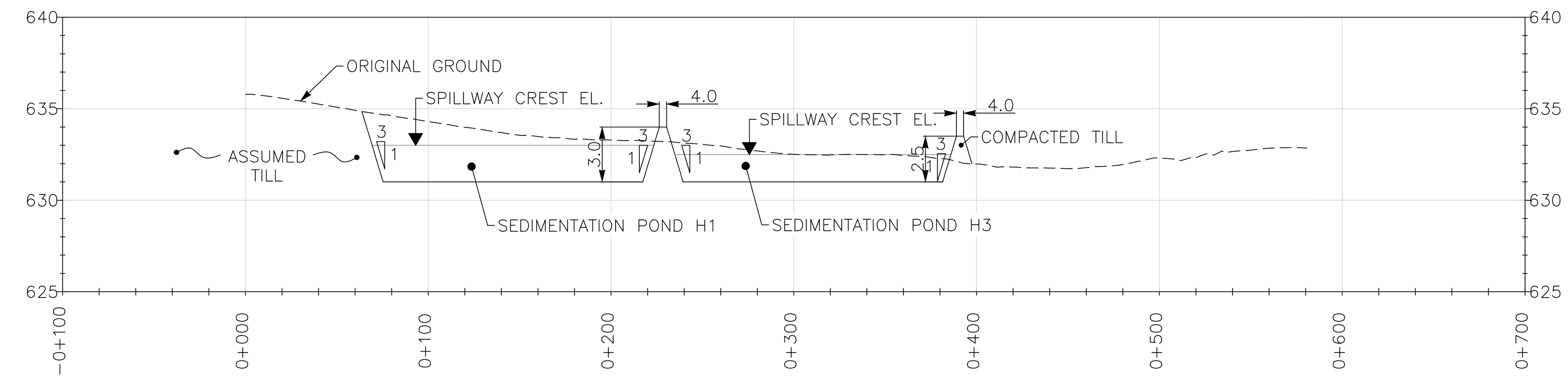
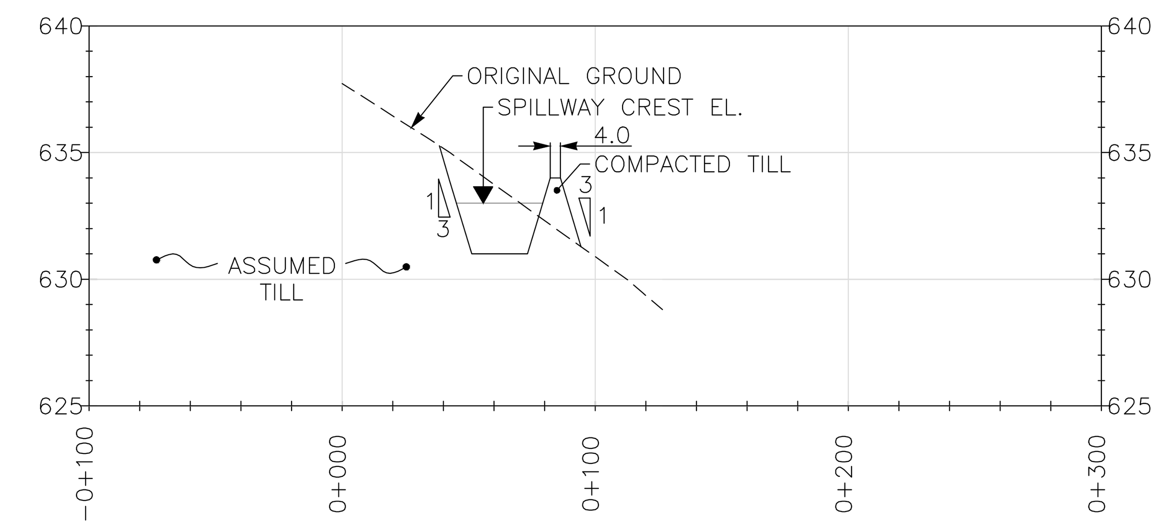




LONGITUDINAL PROFILE - SEDIMENTATION POND H1, H3

SCALE: H: 1:2500
V: 1:250



SECTION A-A - SEDIMENTATION POND H1

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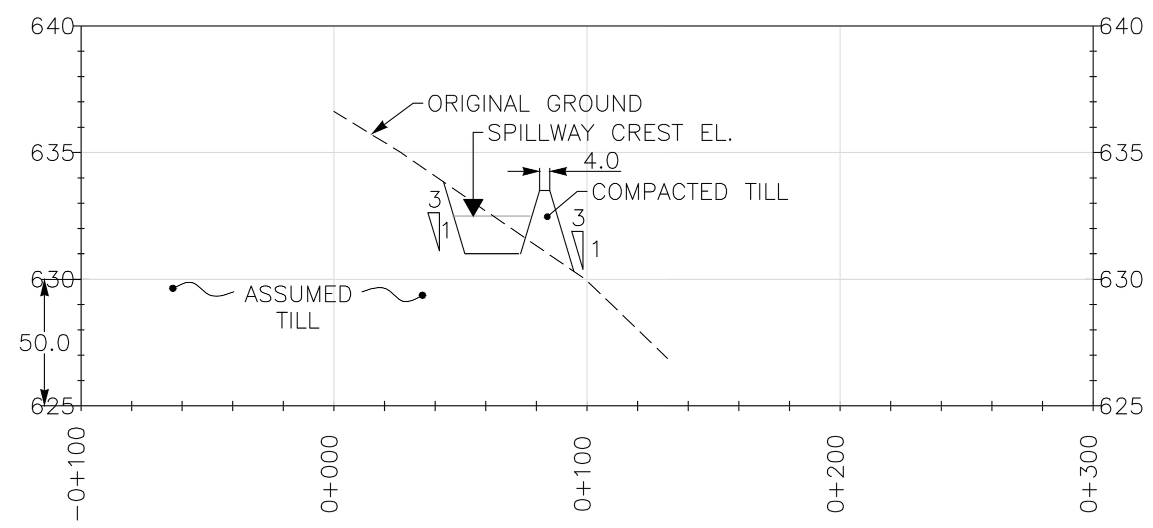

SECTION B-B - SEDIMENTATION POND H3

SCALE: H: 1:2500
V: 1:250

LEGEND

- PROPOSED DITCH
- WETLAND
- WATER COURSE
- CD-1 DITCH NUMBER
- PIT SUMP PUMP
- PIT DEWATERING

NOTE:

THE SUITABILITY OF THE EXCAVATED TILL TO BE USED FOR DYKE CONSTRUCTION WILL BE CONFIRMED IN THE NEXT PHASE OF ENGINEERING.

NOT FOR CONSTRUCTION

ISSUE No	REV.	DATE (Y/M/D)	PURPOSE OF ISSUE	TRANSMISSION LETTER No
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ISSUE REGISTER — ISSUE REGISTER — REVISION REGISTER — REVISION REGISTER

INITIALS: * DESIGNED ** APPROVED

No	REFERENCE DRAWINGS NUMBER
01	AU-2013-028-501-MN-REVD (OPTION 3, DEC.5, 2013)

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SNC·LAVALIN — Sustainable Mine Development, Global Mining & Metallurgy, SNC LAVALIN INC., 455, Boul. René-Lévesque Ouest, Montreal (Quebec), Canada H2Z 1Z3

PREPARATION	APPROVAL
DESIGNED: M.H. Paquette	PROJECT DISCIPLINE ENGINEER: L. Didillon
DRAWN: D. Lan	CLIENT
CHECKED: P. Scholz	DATE: 2014-10-20
SCALE: 1 : 2 500 (20 0 20 40 60 80 100m)	

CLIENT: HOWSE MINERALS CANADA LIMITED

PROJECT: WATER MANAGEMENT PLAN HOWSE PROJECT

TITLE: SEDIMENTATION PONDS H1 & H3 SECTIONS AND DETAILS

PROJECT No	SUBDIVISION	SUBJECT	SERIAL	REV.
622834	4000	40 DD	0006	00

APPENDIX C

Design Criteria

SNC·LAVALIN	TECHNICAL NOTE Design Criteria	Prepared by: PS, ALN, AP, AB, MHP Reviewed by: MHP		
		Rev.	Date	Page
	622834-4000-40EC-0004	00	November 24, 2014	i

Title of document: **DESIGN CRITERIA**

Client: HOWSE MINERALS CANADA LIMITED

Project: WATER MANAGEMENT PLAN – HOWSE PROJECT

<Original signed by>

Prepared by: Patrick Scholz, Eng., M. Eng.
(Hydrology)

Anh-Long Nguyen, Eng. <Original signed by>
(Water Treatment)

Abdel Benlahcen, géo., M.Sc., Ph.D. <Original signed by>
(Hydrogeology)

Andrew Peach, P. Geo., EP. <Original signed by>
(Environment)

<Original signed by>

Reviewed by: Marie-Hélène Paquette, Eng. M. Env.

Approved by: (Client) Loic Didillon

REVISION INDEX

Revision				Pages Revised	Remarks
#	Prep.	Rev.	Date		
PA	PS, ALN, AP, AB	--	October 9, 2014	--	Internal Coordination
PB	PS, ALN, AP, AB	MHP	October 10, 2014	All	Issued for Comments
00	PS, ALN, AP, AB	MHP	November 24, 2014	Tables 7-1, 7-2, 7-3	Issued for Design

NOTICE TO READER

This document contains the expression of the professional opinion of SNC-Lavalin Inc. (“SNC-Lavalin”) as to the matters set out herein, using its professional judgment and reasonable care. It is to be read in the context of the agreement dated may 27th 2014 (the “Agreement”) between SNC-Lavalin and Howse Minerals Canada Ltd (the “Client”) and the methodology, procedures and techniques used, SNC-Lavalin’s assumptions, and the circumstances and constraints under which its mandate was performed. This document is written solely for the purpose stated in the Agreement, and for the sole and exclusive benefit of the Client, whose remedies are limited to those set out in the Agreement. This document is meant to be read as a whole, and sections or parts thereof should thus not be read or relied upon out of context.

SNC-Lavalin has, in preparing estimates, as the case may be, followed accepted methodology and procedures, and exercised due care consistent with the intended level of accuracy, using its professional judgment and reasonable care, and is thus of the opinion that there is a high probability that actual values will be consistent with the estimate(s). Unless expressly stated otherwise, assumptions, data and information supplied by, or gathered from other sources (including the Client, other consultants, testing laboratories and equipment suppliers, etc.) upon which SNC-Lavalin’s opinion as set out herein is based, has not been verified by SNC-Lavalin; SNC-Lavalin makes no representation as to its accuracy and disclaims all liability with respect thereto.

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TABLE OF CONTENTS

LIST OF TABLES

1.0 INTRODUCTION

1.1 Context

Howse Minerals Canada Ltd (HML) plans to mine iron ore within the Howse deposit (Direct-Shipping Ore Howse Property Project) located near the border between the provinces of Quebec and Newfoundland and Labrador, approximately 25 km north of the community of Schefferville, Quebec. One open pit is planned and the anticipated mining period is from 2016 to 2024. Two waste dumps, one overburden stockpile and one topsoil stockpile are also planned for the site. No tailings will be generated in this area since the majority of the ore will only be crushed and screened on-site, with the ore then being directly shipped for secondary processing.

The Water Management Plan of the Howse property will include the design of sedimentation ponds and ditches. The location and purpose of the sedimentation ponds and ditches has already been roughly defined in the Project Registration / Project Description for the DSO-Howse Property Project. The water management plan will confirm those assumptions and the design of the water management infrastructures will be carried out to a conceptual level. Planned water management infrastructures are the following:

- Run-off from surrounding area will be collected by ditches leading to sedimentation pond no. H1.
- Run-off on the waste rock dumps and overburden stockpile will also be collected by ditches leading to sedimentation pond no. H2.
- Water from dewatering and surface runoff into the Howse pit will be diverted, if possible, to the existing Timmins 4-sedimentation pond 3. This assumption will be confirmed in this study.

An environmental monitoring program will also be developed to assess the quality of surface water and groundwater around the Howse property.

1.2 Content

This document presents the design criteria that will be used in the design of the ditches and sedimentation ponds on the Howse property. The source of data used for this mandate will first be presented. Criteria concerning infrastructure location will then be presented, followed by criteria for the design of the ditches and sedimentation ponds for the following disciplines: geotechnical engineering, hydrogeology, hydrology and water treatment. Finally, criteria used to establish the environmental monitoring program will be presented.

The relevant regulations are also presented in each section.

2.0 SOURCE DATA

The following table summarizes the available data used to complete the water management plan.

Table 2-1 : Source Data

Document Name	Provided by	Content	Used for:
Howse DSO Deposit - Project Notice – Mine Site General Layout Drawing no. A4-2013-028-501-MN rev D	Tata Steel	Location of Howse pit, overburden stockpile, waste rock dump, topsoil stockpile	Location of infrastructures
Topographic map	Tata Steel	Topograhpic map, isocontours 5 m	Location of infrastructures
Groupe Hémisphères (March / April 2014) Project Registration / Project Description for the DSA – Howse Property Project. Submitted to Howse Minerals Limited, 223 pp and 4 appendices.	Tata Steel	Section 3.0 Description of the Physical Environment Section 7.0 Potential Environmental Effects and Their Management	Hydrological, hydrogeological, water treatment and geotechnical evaluations
Environment Canada Schefferville A Meteorological Station Data	Environment Canada	Meteorological data	Hydrological calculation
DSO-Timmins Project – Design Criteria Drainage_Design Brief Document no. DSOT-DC-4310-CI-0001 rev A	Tata Steel	Timmins 4 Sedimentation pond-3 design basis	Hydrological calculation
DSO-Timmins Project – Hydrology – Drainage – Flow Measurement – General Location Drawing no. DSOT-DW-4310-CI-0001 rev G	Tata Steel	Delineation of the watershed for the Timmins project and Timmins 4 Sedimentation pond-3	Hydrological calculation
Real Time Water Quality Monitoring Stations Web: http://www.env.gov.nl.ca/env/waterres/rti/stations.html	Newfoundland Labrador Department of Environment and Conservation	Real time water quality data for: - Goodream Creak, 2 km northwest of Timmins 6 (NF03OB0040)	Water treatment
DSO-Timmins Project – Water Monitoring Stations Drawing no. GIS-ML-19-03, 2012-12-10	Tata Steel	Actual monitoring stations for Timmins Project	Monitoring
Stratigraphic Information on Howse Property Drawing no. GIS-EXP-HOWSE-Geofor-01	Tata Steel	Bedrock groundwater level and nature of overburden	Geotechnical and Hydrogeological evaluations Water treatment

Document Name	Provided by	Content	Used for:
Howse Pit Hydrogeological Investigation – Summary of Factual Data in Support of Environmental Impact Assessment Process Document no. 011-13-1221-0104 MTA rev A	Geofor	Packer tests results on two boreholes and piezometric levels results in few existing boreholes	Hydrogeological evaluations
Open Pit Mine Dewatering – Knob Lake. The Canadian Institute of Mining and Metallurgy Bulletin, 58:814-822.	Public	Historical information on mine dewatering of DSO (Knob Lake)	Hydrogeological evaluations
Hydrological and hydrogeological study: survey season 2009, DSOP. Final technical report. March 2010	Groupe Hémisphères	Results of Timmins 3 pit dewatering simulations	Hydrogeological evaluations

3.0 LOCATION OF WATER MANAGEMENT INFRASTRUCTURES

3.1 *Codes, Laws and Regulations*

The followings laws and regulations will be used to define the location of infrastructures at the site:

- Water Resource Act, Newfoundland and Labrador, SNL2002 Chapter W-4.01
- Policy for Development in Wetland, Newfoundland and Labrador , W.R. 97-2

3.2 *Design Criteria*

The location of infrastructures, including water management infrastructures, mining pit, overburden stockpile and waste rock dumps, is governed by regulation, topography, nature of the land and some criteria adopted after consultation between Tata Steel and local stakeholders. The criteria used to define the location of infrastructures at the site are the following:

- A buffer zone of 500 m has to be kept between the infrastructures and Irony Mountain;
- Any alteration of Pinette Lake has to be avoided since it is considered as a sensitive area;
- A 10 to 15 m buffer strip has to be kept between infrastructures and water course and wetlands respectively ;
- When possible avoid any infrastructures in wetlands.

4.0 GEOTECHNICAL ENGINEERING

The geotechnical engineering required for the present mandate mainly consists in designing stable ponds and ditches according to latest state-of-the art practices.

4.1 Codes, Laws and Regulations

- Canadian Dam Association (2007, revised 2013), Dam Safety Guidelines.

4.2 Design Criteria

Depending on the topography at the location of the new sedimentation ponds, the ponds can be a totally excavated construction or partly excavated and partly contained with dykes.

If dykes have to be built, the design of the dykes will be determined in compliance with the design criteria presented in the Dam Safety Guidelines published by the Canadian Dam Association (2007). These guidelines present a methodology for dyke classification depending on the potential consequences of dam failure and allowances that take into account for the design for earthquake and flood conditions.

The following table presents the dam classification evaluation for the dykes that could be built as part of the sedimentation ponds.

Table 4-1 : Dam Classification Evaluation for Sedimentation Pond Dykes

Potential Consequences for :	Dam Class	Comments	Reference
Population at Risk	**Low**	There is no temporary or permanent population living downstream any pond.	Dam Safety Guidelines (2007, revised 2013, table 2-1)
Loss of Life	**Significant**	Unspecified. Loss of life can't be put to zero because employees are present on the site.	
Environmental and Cultural Values	**Low**	Only minimal short term loss could affect flora and fauna.	
Economy	**Low**	No infrastructures downstream.	
Summary of Evaluation : Significant			

Based on the evaluation presented in Table 4-2, with a **Significant** dam class, the return period for the design earthquake condition and design flood condition would be between 1:100 years and 1:1000 years.

Table 4-2 : Design Return Period According to Dam Classification

Dam Class	Return Period for Design Earthquake	Return Period for Design Flood
Low	1/100	1/100
Significant	**Between 1/100 and 1/1000**	**Between 1/100 and 1/1000**
High	1/2475	1/3 between 1/1000 and PMF
Very High	½ between 1/2475 and 1/1000	2/3 between 1/1000 and PMF
Extreme	1/10 000 or MCE	PMF

MCE = Maximum Credible Earthquake

PMF = Probable Maximum Flood

Reference : Table 6-1B, Dam Safety Guidelines (2007, revised 2013)

Design earthquake data are not presented in this study because no stability analysis will be performed at this conceptual level, as there is no information concerning ground stratigraphy at the future pond location.

According to CDA, an emergency spillway must be designed to allow passage of the design flood (see section 6).

Other design criteria concerning the building of ditches and ponds will be determined mainly from state-of-the-art practice and are presented in table 4-3.

Table 4-3 : Geotechnical Design Criteria

Item	Criteria	Note
Minimal ditch slope	0.5%	--
Ditch excavation	Minimize volume of excavation	--
Pond waterproofing	No pond waterproofing necessary	The only issue concerning water quality is total suspended solids (TSS). Refer to Section 7.0 on water treatment.
Factor of Safety for pond slope stability, static condition (downstream slope)	1.5(*)	No stability analysis will be carried out for this study since no information concerning ground stratigraphy at the location of the ponds is available. Therefore pond excavation slopes and dyke slopes will be set to 3H:1V for the purpose of this study.
Factor of Safety for pond slope stability, full or partial rapid drawdown (upstream slope)	1.2 – 1.3 (*)	
Factor of Safety for pond slope stability, pseudo-static condition	1.0(*)	
(*) According to Table 6-2 and 6-3, Dam Safety Guidelines (2007, revised 2013)		

5.0 HYDROGEOLOGY

The hydrogeological characterization of the Howse deposit was ongoing during October 2014, in order to complete the hydrodynamic parameter estimation of the aquifer hosting this deposit.

For the purpose of the conceptual water management plan, the dewatering estimation of the Howse pit will be based on dewatering historical data of other similar mines in the area, and on few assumptions.

An overview of the historical mine dewatering at Knob Lake during previous mining is given in Stubbins & Munro (1965). The studied mines included Wishart, Gagnon, French and Ruth mines, where the dewatering was very much depth correlated and increased with the mine pit floor depth. Table 5-1summarizes the results.

New dewatering simulations were conducted for two new future mines, Timmins 3 and LabMag, located about 5 km to the north-east and south of the site respectively. The results are also summarized in Table 5-1. The simulated dewatering results for these two closer mines are the same order of magnitude to the ones recorded for Wishart and Gagnon mines (dewatering rate between 13000 and 23000 m^3/d).

The relatively lower hydraulic conductivity estimated from geotechnical investigations (Golder, 2014) in comparison to Timmins 3 and LabMag sites, suggests that the dewatering rate of the Howse pit would not exceed the ones estimated for these two closer mines.

Based on these observations, a flow rate of 23000 m^3/d with a safety factor of 50% will be considered a conservative value for the Howse deposit. Therefore, a total dewatering rate of about 34500 m^3/d could be considered for preliminary design criteria.

The dewatering estimate needs to be updated with the results that will be obtained from the future hydrogeological modeling of the dewatering, and that will be based on the ongoing hydrogeological investigation results.

Considering that the water table at the Howse deposit is located between 64 and 88 m in depth, the dewatering during the first years will be greatly lower until the pit floor reaches the water table.

Table 5-1 : Summary of Hydrogeological Data

Type of Data	Mine Site	Floor Depth (m)	Dewatering (m^3/d)	Data References
Historical data of DSO mines	Wishart	69	16874	Stubbins, J. B. and P. Munro. 1965. Historical information on mine dewatering of DSO (Knob Lake). The Canadian Institute of Mining and Metallurgy Bulletin, 58:814-822.
	Gagnon	83	20412	
	French	116	84370	
	Ruth	144	86547	
Simulation Results on new mines	Timmins 3	80	12960	Groupe Hémisphères, march 2010. Hydrological and hydrogeological study: survey season 2009, DSOP. Final technical report.
	LabMag	150	22262	SNC-Lavalin, in preparation. Hydrogeology and mine pit dewatering modeling - LabMag site. New Millenium Iron – TATA Steel
Assumption	Howse	160	34500(*)	--
(*) Including a safety factor of 50%				

6.0 HYDROLOGY

The hydrological part of the present mandate mainly consisted of designing a drainage network, made of ditches and sedimentation ponds, performing water balance computations for the Howse property, including the mine pit.

6.1 Codes, Laws and Regulations

- Canadian Dam Association (2007, revised 2013), Dam Safety Guidelines.
- Environmental code of Practice for Metal Mines (Canada)

6.2 Design Criteria

6.2.1 Ditches

The drainage network will be designed for a 100 years return period flood. The hydrograph of the 100 years flood will be derived from available intensity-duration-frequency (IDF) curves from meteorological station Schefferville A, located approximately 24 km from the Howse property.

Ditches peak discharge will be computed using the rational method:

$$Q = \frac{CIA}{360}$$

Where:

Q: Peak discharge [m^3/s].

C: Runoff coefficient [-].

I: Rainfall intensity corresponding to the watershed time of concentration [mm/h].

A: Drainage area [ha].

Ditches will have a trapezoid section and their dimensions will be determined using the manning equation:

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

Where:

Q: Peak discharge [m^3/s].

n: Manning's coefficient [$s/m^{1/3}$].

A: Flow area [m^2].

R: Hydraulic radius [m]. R = A/P, where P is the wetted perimeter [m].

S: Ditch slope [%].

If necessary, ditches will be protected against erosion with a layer of riprap and culverts will be used for road crossings.

6.2.2 Sedimentation ponds

Sedimentation ponds will be designed with a minimum area determined based on a design particle size (see section 7.0 Water Treatment) and a design flood with a 25 years return period.

The sedimentation ponds will have a 0.5 m dead storage at the bottom of the pond for sediment accumulation, and a 2.0 m dead storage at the top of the pond for ice formation.

Part of the dyke at the downstream side of the pond will be built with coarse rock to make it permeable and allow water to flow out of the pond. This solution was selected to minimize the risks of freezing of the outlet structure.

Finally, an emergency spillway will be designed for a design flood determined accordingly to the dyke classification (Table 4-2), as a trapezoidal weir located on the dyke crest.

Average monthly water balance computations will be performed for the whole Howse property in order to evaluate the flow and residence time at each of the sedimentation ponds.

6.2.3 Summary of Hydrological Criteria

The main hydrological design criteria are the following:

- Impacts on Goodream creek should be minimized as much as possible. If possible, during dewatering the water from Howse pit should be pumped uphill, into the existing Timmins 4 sedimentation pond no. 3 to prevent modification to the Goodream creek water balance;
- The drainage network will be designed for a 100 years return period flood;
- Ditches will be designed using the rational method and manning equation;
- Sedimentation ponds will be designed for a design particle size (section 7.0) and for a 25 years return period flood;
- Sedimentation ponds will have a 0.5 m dead storage for sediments;
- Sedimentation ponds will have a 2.0 m dead storage for ice cover;
- Sedimentation ponds freeboard will be determined based on CDA (2007) guidelines;
- Sedimentation ponds outlet will be located in a permeable dyke able to convey the most critical flood generated by:
  - A summer-fall 25 years return period rainfall.
  - A combination of a 24-hours 25 years return period rainfall with the melting of a 25 years return period snowpack.
- Emergency spillways associated with the sedimentation ponds will be constructed as a trapezoidal weir designed to safely pass an inflow design flood determined according to the dam classification previously presented (see table 4.2);
- Even if water could flow out of the sedimentation ponds by infiltration through the bottom and sides of the pond, the ponds will be designed assuming no infiltration, since no data is presently available to assess infiltration rates.

7.0 WATER TREATMENT

7.1 *Codes, Laws and Regulations*

For this project, the latest revision of the following codes, laws and regulations will be used in the design of the water treatment infrastructures required for the water management:

- Water Resource Act, Newfoundland and Labrador, SNL2002 Chapter W-4.01;
- Environmental Control Water and Sewage Regulations 65/03, 2003;
- Metal Mining Effluent Regulations (Canada) SOR/2002-222, section 3 and 19.1 and 20 and Schedule 4.

7.2 *Design Criteria*

7.2.1 Sources of Effluent to be Treated

There are three effluent sources to be treated on the Howse property

- Natural site runoff;
- Runoff from the overburden stockpile and waste rock dump;
- Pit dewatering water and pit runoff.

7.2.2 Effluent Quality

7.2.2.1 Natural Site Runoff

The natural site runoff at the Howse property is expected to have an effluent quality similar to the water quality found in creeks and lakes that are within the property.

As per the data presented in the report *Project Registration / Project Description for the DSA – Howse Property Project (Groupe Hémisphères, March / April 2014*), *section 3.7,* the surface water around the site is characterized as being soft, with low conductivity and total dissolved solids as well as low concentration of metals. The pH of Goodream Creek, a stream that flows to the north of the property, range from 5.33 to 6.53, while Burnetta Creek located to the west of the property has a pH ranging from 5 to 6. Furthermore, the total suspended solids are generally low. However, the report does note that moderate turbidity events (e.g. 100 to 1000 NTU) could occur and typically coincided with rainfall activity.

Based on the data available to date, the main parameters of concern in the site runoff will be suspended solids, specifically during a rainfall event as well as possibly during a snowmelt event.

The site runoff pH is expected to be in the same range as the pH of the natural waters around the property, and thus could be lower than a pH value of 6.0. Consequently, the minimum pH discharge criterion specified in the *Environmental Control Water and Sewage Regulations* or in the *Metal Mining Effluent Regulations* should not be an issue for this project.

For the purpose of design, the following table presents the assumptions taken with regard to the quality of the suspended solids in the site runoff:

Table 7-1 : Assumptions for Site Runoff Water Quality

Parameters	Units	Value
Type of suspended solid	--	Sand and grit
Minimum particle size to settle	mm (microns)	0.1 (100)
Specific Gravity	--	2.7(*)
(*) Assumption based on typical specific gravity for rock formations in Howse Area (ref. Table 3.5 Project Registration/Project Description for the DSO-Howse Property Project, March/April 2014)		

7.2.2.2 Runoff From Overburden and Waste Rock Dump

The overburden at the Howse DSO property is expected to be mainly composed of sand and gravel. The waste rock is expected to be composed of fine rock particles.

Furthermore, as per the studies presented in the report *Project Registration / Project Description for the DSA – Howse Property Project (Groupe Hémisphères, March / April 2014*), the waste rock and ore is not expected to be acid generating.

Consequently, the main parameter of issue considered for this project is related to suspended solids.

For the purpose of design, the following table presents the assumptions taken with regard to the quality of the suspended solids in the overburden and waste rock dump runoff:

Table 7-2 : Assumption for Overburden and Waste Dump Runoff Water Quality

Parameters	Units	Value
Type of suspended solid	--	Sand, grit and fine rock particles
Minimum particle size to settle	mm (microns)	0.01 (10)
Specific Gravity	--	2.7(*)
(*) Assumption based on typical specific gravity for rock formations in Howse Area (ref. Table 3.5 Project Registration/Project Description for the DSO-Howse Property Project, March/April 2014)		

7.2.2.3 Pit Dewatering Water

The pit dewatering water will consist mainly of groundwater that infiltrates into the pit, as well as surface runoff. Groundwater will be intercepted by pumping wells located around the pit and transferred to the Timmins 4 sedimentation pond no. 3. Surface runoff will flow inside the pit and be collected at several sumps in the pit and transferred to the Timmins 4 sedimentation pond no. 3.

The groundwater and surface runoff around the pit are expected to be of similar quality to the natural site runoff with regard to conductivity, total dissolved solids and pH. Total suspended solids of the pit surface runoff will however be higher due to the mining activity in the pit. The pit surface runoff could also be contaminated with ammonia and nitrate coming from un-exploded explosive residues. The pit surface runoff could also be contaminated with oil and hydrocarbon from the machinery.

In order to minimize the load of ammonia and nitrate that can migrate into the pit surface runoff, proper explosive management will be implemented as described in the *Project Registration / Project Description for the DSA – Howse Property Project (Groupe Hémisphères, March / April 2014).*

To manage any oil and hydrocarbon from the machinery, an oil/water separator will be used to remove the free oil and hydrocarbon from the pit surface runoff before it is transferred to the sedimentation pond.

Consequently, the main parameter of issue considered for this project is related to suspended solids from the pit surface runoff. The groundwater pumped from the wells around the pit is expected to have very little suspended solids.

For the purpose of design, the following table presents the assumptions taken with regard to the quality of the suspended solids in the pit dewatering water:

Table 7-3 : Assumptions for Pit Dewatering and Pit Runoff Water Quality

Parameters	Units	Value
Type of suspended solid	--	Grit and fine rock particles
Minimum particle size to settle	mm (microns)	.01 (10)
Specific Gravity	--	2.7^(*)
(*) Assumption based on typical specific gravity for rock formations in Howse Area (ref. Table 3.5 Project Registration/Project Description for the DSO-Howse Property Project, March/April 2014)		

7.2.3 Treated Effluent Discharge Quality

The water treatment infrastructure will be designed in order to treat the effluent and produce a treated effluent that will meet the discharge quality specified in the following regulations:

- Environmental Control Water and Sewage Regulations 65/03, 2003
- Metal Mining Effluent Regulations (Canada) SOR/2002-222, section 3 and 19.1 and 20 and Schedule 4

The following table summarizes the discharge criteria specified in the above regulations:

Table 7-4 : Water Quality Discharge Criteria

Parameters	Units	Environmental Control Water and Sewage Regulations, 2003	MMER (SOR/2002-222)	
		Max. Concentration	Max. Monthly Mean	Max. Concentration in Grab Sample
pH		5.5 to 9.0	6.0 to 9.5	
Arsenic	mg/L	0.5	0.5	1.00
Copper	mg/L	0.3	0.3	0.6
Cyanide	mg/L	0.025	1.0	2.0
Lead	mg/L	0.2	0.2	0.4
Nickel	mg/L	0.5	0.5	1
Zinc	mg/L	0.5	0.5	1
Total Suspended Solids	**mg/L**	**30**	**15**	**30**
Radium 226	Bq/L	0.37	0.37	1.11
Total dissolved solids	mg/L	1000	----	----
B.O.D.	mg/L	20	----	----
Barium	mg/L	5.0	----	----
Cadmium	mg/L	0.005	----	----
Chromium (VI)	mg/L	0.05	----	----
Chromium (III)	mg/L	1.0	----	----
Iron (total)	mg/L	10	----	----
Mercury	mg/L	0.005	----	----
Nitrates	mg/L	10	----	----
Nitrogen (ammoniacal)	mg/L	2.0	----	----
Phenol	mg/L	0.1	----	----
Phosphate (total as P2O5)	mg/L	1.0	----	----
Phosphorus (elementals)	mg/L	0.0005	----	----
Selenium	mg/L	0.01	----	----
Sulfides	mg/L	0.5	----	----
Silver	mg/L	0.05	----	----

As noted in the Section 7.2.2, the primary parameter of concern is expected to be limited to **total suspended solids** concentrations.

7.2.4 Design Flow Capacity

The design flow rate capacity will be determined based on the design criteria for hydrology and hydrogeology (refer to Sections 5 and 6).

7.2.5 Sedimentation Pond Design

In order to manage the total suspended solids in the three (3) effluents generated at the Howse property, these effluents will be sent to sedimentation ponds to allow for the settling of the suspended solids before they are discharged to the receiving creeks.

There will be a total of three (3) sedimentation ponds:

1. Sedimentation Pond no. H1: Natural site runoff will be directed toward this sedimentation pond located to the north of the pit. The treated water will be discharged to the nearest creek.
2. Sedimentation Pond no. H2: Runoff from the overburden stockpile and waste rock dump will be directed to this sedimentation pond located to the north-west of the overburden stockpile. The treated water will be discharged to the nearest creek.
3. Timmins 4 sedimentation Pond no. 3: If possible, groundwater and surface runoff from the Howse pit will be transferred to an existing sedimentation pond that currently manages the runoff water from Timmins 4. This assumption will be confirmed in this study. The treated water will be discharged to Goodream Creek. The pit surface runoff water will also be treated using an oil/water separator prior to its transfer to this existing sedimentation pond.

Each sedimentation pond will be sized based on the following design parameters:

- Pond designed based on discrete particle settling;
- Terminal settling velocity of the particle evaluated using Stokes' law based on the smallest particle size specified in Section 7.2.2;
- The sedimentation pond will have a rectangular shape, with a length to width ratio of at least 3 to 1;
- Refer to Section 6.0 for additional design criteria for the sedimentation pond.

8.0 ENVIRONMENTAL MONITORING PROGRAM

8.1 Codes, Laws and Regulations

The environmental monitoring program will be planned in accordance with the following protocols and regulations:

- Environmental Control Water and Sewage Regulations (2003);
- Protocols Manual for Real Time Water Quality Monitoring in Newfoundland and Labrador (2013);
- Metal Mining Effluent Regulations (Canada).

8.2 Design Criteria

There are several factors which need to be considered when planning and implementing real time water quality (RTWQ) stations, manual water sampling, and effluent sampling into the water monitoring program.

These factors include:

- The type of data needed to be captured: baseline data, changes in water quality, changes in water quantity;
- Reasons for monitoring water quality/quantity: regulatory management, protection of fragile ecosystems or communities, etc;
- The water bodies of interest, and their characteristics: lake, stream, tailings pond, well, and whether upstream and/or downstream data is required;
- Expected contaminants, parameters of interest, and their characteristics;
- Location of the site, including hydrogeologic/geologic characteristics and anthropologic influences;
- Groups interested in the data: government, non-government, community groups, the public, etc;
- The duration of the monitoring program: temporary or long term. Seasonally or year-round;
- Accessibility to site, and sites accessibility to resources: How will the site be accessed for station installation, maintenance, and or manual sampling (by foot, road vehicle, ATV, boat), how instrumentation will be deployed based on accessibility, and type of equipment suitable for the site chosen (power source, transmission type, monitoring instrumentation, etc.);
- Additional sources of data nearby that may be used to supplement water quality data: Nearby weather stations, and/or water quality/quantity stations.

The provincial and/or federal government will be responsible for the installation or relocation of real-time monitoring stations, as part of the Real-time water quality/quantity monitoring network. The installation of additional monitoring wells may be required if it is discovered that the current groundwater wells are not suitable for the purposes of groundwater sampling/monitoring based on hydrogeologic/geologic data.

9.0 REFERENCES

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APPENDIX D

Water Quality from Timmins 4 project

SAMPLE: COA-SW11

SOURCE: SURFACE WATER FROM FLEMMING 7N AND TIMMINS 7N PIT AREAS, AFTER PASSING THROUGH SEDIMENTATION POND A AND B

				COA-SW11-10	COA-SW11-9	COA-SW11-8	COA-SW11-7	COA-SW11-6	COA-SW11	COA-SW11-5	COA-SW11-4	COA-SW11-4	COA-SW11-3	COA-SW11	COA-SW11	COA-SW11	COA-SW11	COA-SW11
Parameters	**Units**	**CofA**	**MMER (review 10 years)**	May 27 2014	May 19 2014	May 14 2014	May 6 2014	Oct 21 2013	Oct 2 2013	Sep 25 2013	Sep 18 2013	Sep 16 2013	Sep 11 2013	Aug 27 2013	Aug 19 2013	Aug 15 2013	Jun 9 2013	May 5 2013
Arsenic (As)	ug/L	1.0 mg/L	0.2 mg/L	0.5	0.5	1.6	8.1	8.4	1.1	2.4	2.3	2.0	1.8	0.5	0.5	3.3	<1.0	0.5
Copper (Cu)	ug/L	0.6 mg/L	0.1 mg/L	2.5	2.2	2.2	40	21	4.6	3.8	3.5	2.3	3.0	2.4	1.6	4.7	0.55	0.85
Nickel (Ni)	ug/L	1.0 mg/L	0.5 mg/L	1	1	1	28	14	2.1	2.9	2.4	3.0	2.7	1.4	1.1	3.8	n/a	0.5
Lead (Pb)	ug/L	0.4 mg/L	0.1 mg/L	0.64	0.68	0.65	13	5.2	0.58	0.97		0.80	0.79	1.1	0.82	1.5	0.14	0.38
Zinc (Zn)	ug/L	1.0 mg/L	1.0 mg/L	110	36	52	120	140	1300	180	190	160	140	45	44	43	n/a	29
pH	pH	5.5 - 9.0		6.33	6.45	7.84	5.77	6.77	7.09	7.12	7.27	7.08	6.75	6.89	6.85	6.83	6.89	6.61
Total suspended solids (TSS)	mg/L	30 mg/L	30 mg/L	9	24	25	510	120	4	1	13	3	1	6	22	30	18	53
Radium 226	Bq/L	1.11 mg/L	1.11 Bq/L	0.001	0.001	0.002	0.044	0.02	0.003	0.01	0.005	0.002	0.006	0.01	0.01			
Iron	ug/L															11000	<100	
Turbidity	NTU															510	n/a	

SAMPLE: COA-SW12

SOURCE: SURFACE WATER FROM TIMMINS 4, AFTER PASSING THROUGH SEDIMENTATION POND C

				COA-SW12-1	COA-SW12
Parameters	**Units**	**CofA**	**MMER (review 10 years)**	May 19 2014	May 5 2013
Arsenic (As)	ug/L	1.0 mg/L	0.2 mg/L	2.8	<1.0
Copper (Cu)	ug/L	0.6 mg/L	0.1 mg/L	5.8	1.5
Nickel (Ni)	ug/L	1.0 mg/L	0.5 mg/L	4.0	<1.0
Lead (Pb)	ug/L	0.4 mg/L	0.1 mg/L	1.4	0.50
Zinc (Zn)	ug/L	1.0 mg/L	1.0 mg/L	22	7.1
pH	pH	5.5 - 9.0		6.45	6.06
Total suspended solids (TSS)	mg/L	30 mg/L	30 mg/L	24	84
Radium 226	Bq/L	1.11 mg/L	1.11 Bq/L	<0.002	<0.002
Iron	ug/L				
Turbidity	NTU				

Legend		
	XXX	Above the Certificate of Approval regulation
	XXX	Unusually high