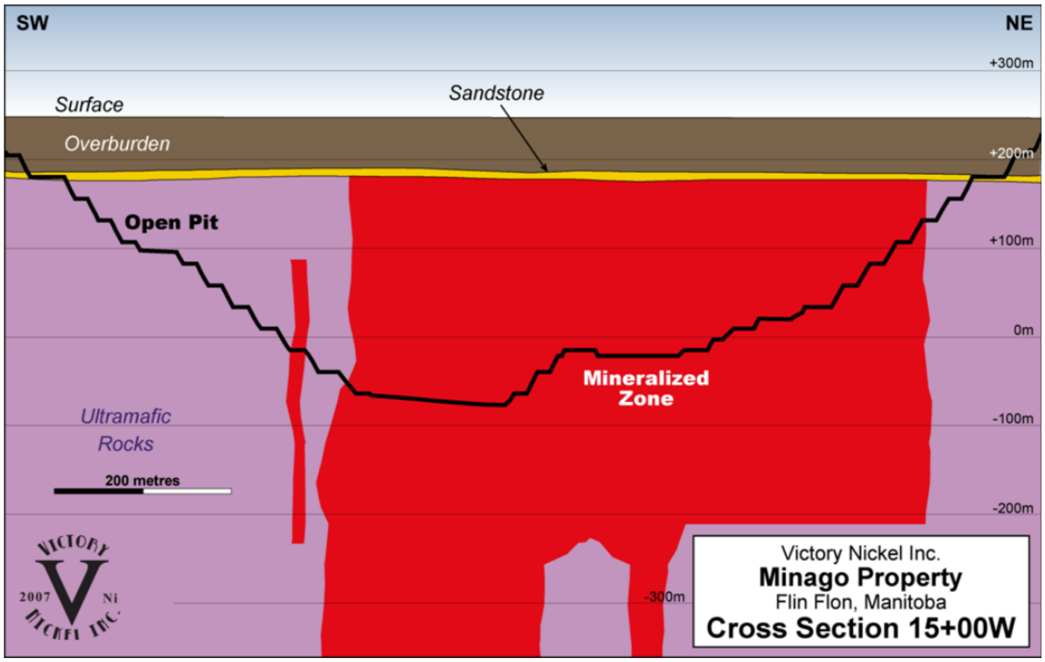

Chapter 2 – Project Description

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2. PROJECT DESCRIPTIONS

2.1 Project Overview

The Minago Property is located in Manitoba's Thompson Nickel belt, approximately 225 km south of Thompson, Manitoba, Canada (Figure 2.1-1).

The Property has a favorable location adjacent to the paved provincial Highway 6, which traverses north to Thompson. A 230 kV Manitoba Hydro power line runs parallel to the highway. The Property is only 60 km from the OmniTrax Canada railway line, which extends from Flin Flon and The Pas to Churchill. Grand Rapids is the closest township, located approximately 100 km south of the Property.

In 2006, Nuinsco Resources Ltd. (Nuinsco) retained Wardrop Engineering Inc. (Wardrop) to provide the Preliminary Economic Assessment (PEA) of the Property. The PEA was completed in accordance with the National Instrument 43-101 (NI 43-101) requirements to identify the resources within economic open pit and underground mine designs.

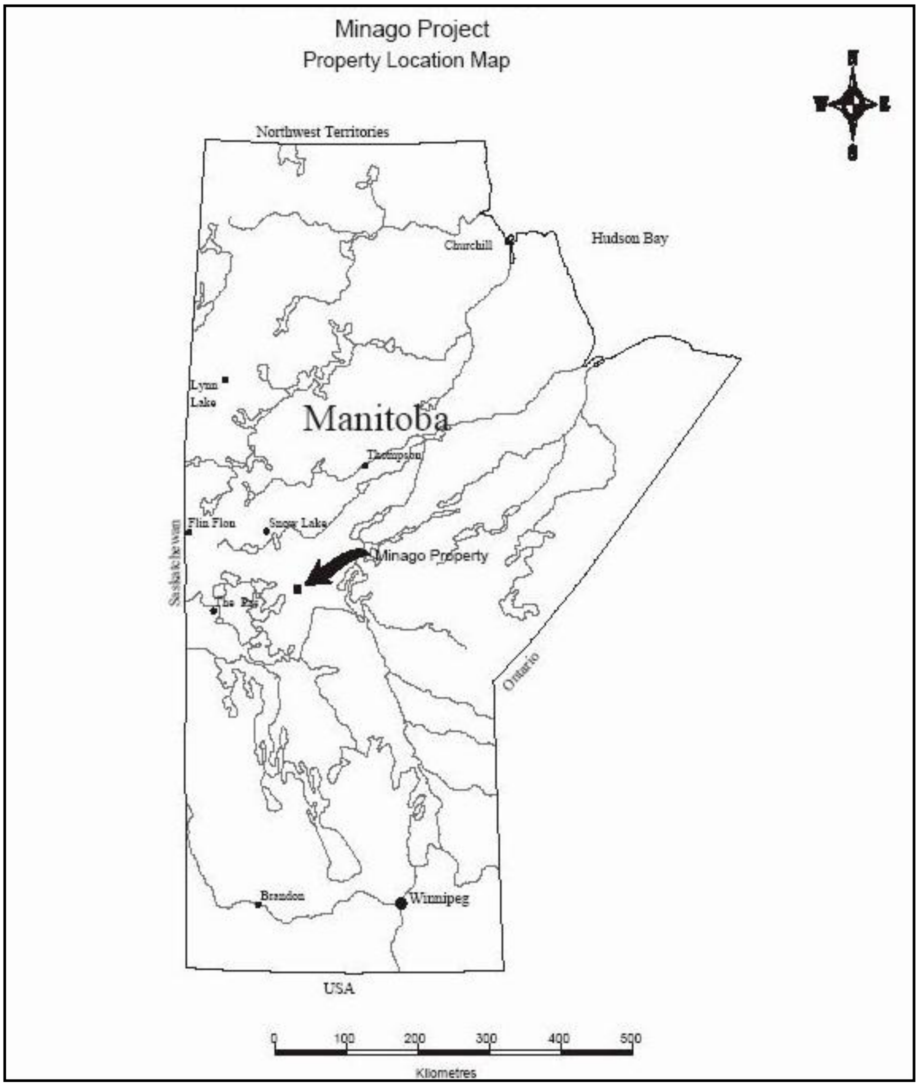
At the time the PEA was issued, Nuinsco owned 100% of the mining lease on the Property. In 2007, ownership of the Property was transferred to Victory Nickel Inc. (Victory Nickel), at that time, a wholly owned subsidiary of Nuinsco. On April 24, 2007, Victory Nickel engaged Wardrop to prepare the Minago Feasibility Study and a NI 43-101 compliant report. For this work, the resource estimation was provided by Wardrop in accordance with the Canadian Institute of Mining, Metallurgy, and Petroleum (CIM) Mineral Resource and Mineral Reserves definitions.

The feasibility study revealed that the Minago deposit has potential as a large tonnage, low-grade nickel sulphide deposit amenable for open pit, and possibility for underground bulk tonnage mining methods. Significant parts of the deposit below a depth of 400 m require additional drilling to upgrade the resource class from inferred to indicated (Wardrop, 2009b).

Wardrop estimates that the Minago deposit contains a measured resource of 9.1 Mt grading 0.47% NiS above a cutoff grade of 0.2% NiS. In addition, the deposit contains 35 Mt of indicated resource at 0.42% NiS above a 0.2% NiS cutoff grade. An inferred resource of 12 Mt at 0.44% NiS above a 0.2% NiS has also been estimated (Wardrop, 2009b). The potential of the Minago Property is further supported by metallurgical testing in which very high grade concentrate was produced.

Wardrop also identified a sandstone horizon averaging ten metres thick above the unconformity of the main nickel bearing serpentinite. These well rounded silica sand particles in the sandstone formation were identified as being suitable for use as hydraulic fracturing sand, or "frac sand". When used as proppants in oil or gas wells these sands will improve the porosity of the shale beds leading to improved recovery and enhanced production. Currently, in onshore US wells, approximately 50% of the gas wells and 30% of the oil wells are hydraulically fractionated (Wardrop, 2009b).

The deposit has potential as a large tonnage, low-grade nickel sulphide deposit (30,954,000) Mt at 0.43% nickel (Ni), 0.20% cut-off grade) and contains 14.8 Mt million tonnes of marketable frac sand. The potential of the Property is supported by a recent metallurgical test program, where a very high



Source: Wardrop, 2006

Figure 2.1-1 Property Location Map

grade nickel concentrate was produced. The excellent recoveries for the ore from the open pit mine are substantiated by historical and current metallurgical testing data.

Together with the limestone-dolomite, the sandstone layer must be removed to access the nickel mineralization within the proposed open pit mine. To capture the value of this sand, Victory Nickel instructed Wardrop to include an assessment of frac sand within the Minago Feasibility Study. As a result of this additional work, the economic viability of commercial frac sand production has been established (Wardrop, 2009b).

In parallel with the feasibility study work, VNI undertook environmental and Social Impact Assessment to commence permitting of the project. On April 30, 2010, VNI submitted an Environmental Act Proposal (EAP) to MB Conservation. In August 2011 an EAL 2981 was granted to VNI.

The mine life is estimated to be ten years, with frac sand being produced throughout the life of the mine. Accommodation facilities and other associated facilities will be provided for the majority of the workforce, who will manage, operate, and maintain the mine on a rotational basis. To the extent possible, the workforce will be comprised of members of the local First Nations community.

The proposed project will be comprised of an open pit mine, an Ore Concentrating Plant, a Frac Sand Plant, the proposed TWRMF and supporting infrastructure (Figure 2.1-2). The current configuration of the site is depicted in Figure 2.1-3. The Ore Concentrating Plant will process 3,600,000 t/a of ore through crushing, grinding, flotation, and gravity operations. This feed rate will produce approximately 49,500 t/a of 22.3% nickel concentrate on an average year before transportation losses and approximately 46,400 t/a after losses. The Frac Sand Processing Plant will be capable of producing between 1,500,000 t/a of various sand products including 20/40 and 40/70 frac sand, glass sand, and foundry sand products.

Following discovery of additional mineralization in the area where the current TWRMF is located VNI decided to relocate the TWRMF to the area on the west of the current facility. Since this new TWRMF was not part of the 2010 EIS and hence, the EAL 2981, VNI is required to apply for an amendment to the existing EAL.

The mine site is situated within a topographically low area of water-saturated peat and forest terrain. The area is almost entirely swampy muskeg with vegetation consisting of sparse black spruce and tamarack set in a topographic relief of less than 3 m. Although this low area extends for significant distances to the north and east, elevated limestone outcrops exist to the south and west at a distance of 7 to 20 km from the site.

The site is located within the Nelson River sub-basin, which drains northeast into the southern end of the Hudson Bay. The basin has two more catchments, the Minago River and the Hargrave River, which enclose the project site to the north. There are two more tributaries, the William River and the Oakley Creek present at the periphery of the project area. The catchments of these two tributaries are within the Lake Winnipeg basin and drain northward into the Nelson River sub-basin.

The supporting infrastructure for the Minago Project will include:

- a Tailings and Ultramafic Management Facility (TWRMF); rock dumps; overburden dumps with supporting facilities;
- a Potable Water Treatment Plant (PWTP);
- local flood collection ponds and flood retention area with associated pumping systems;
- polishing pond (PP)

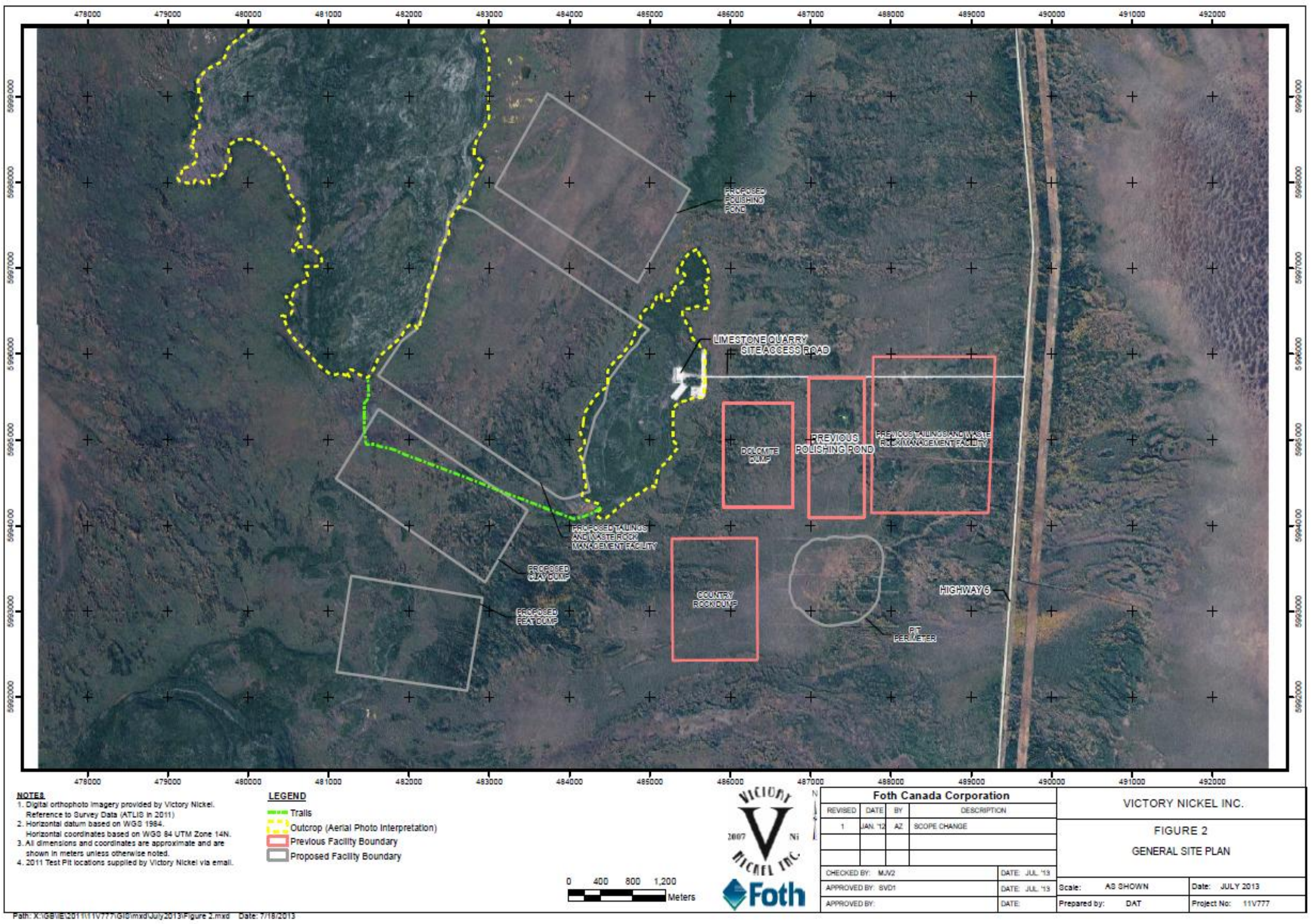
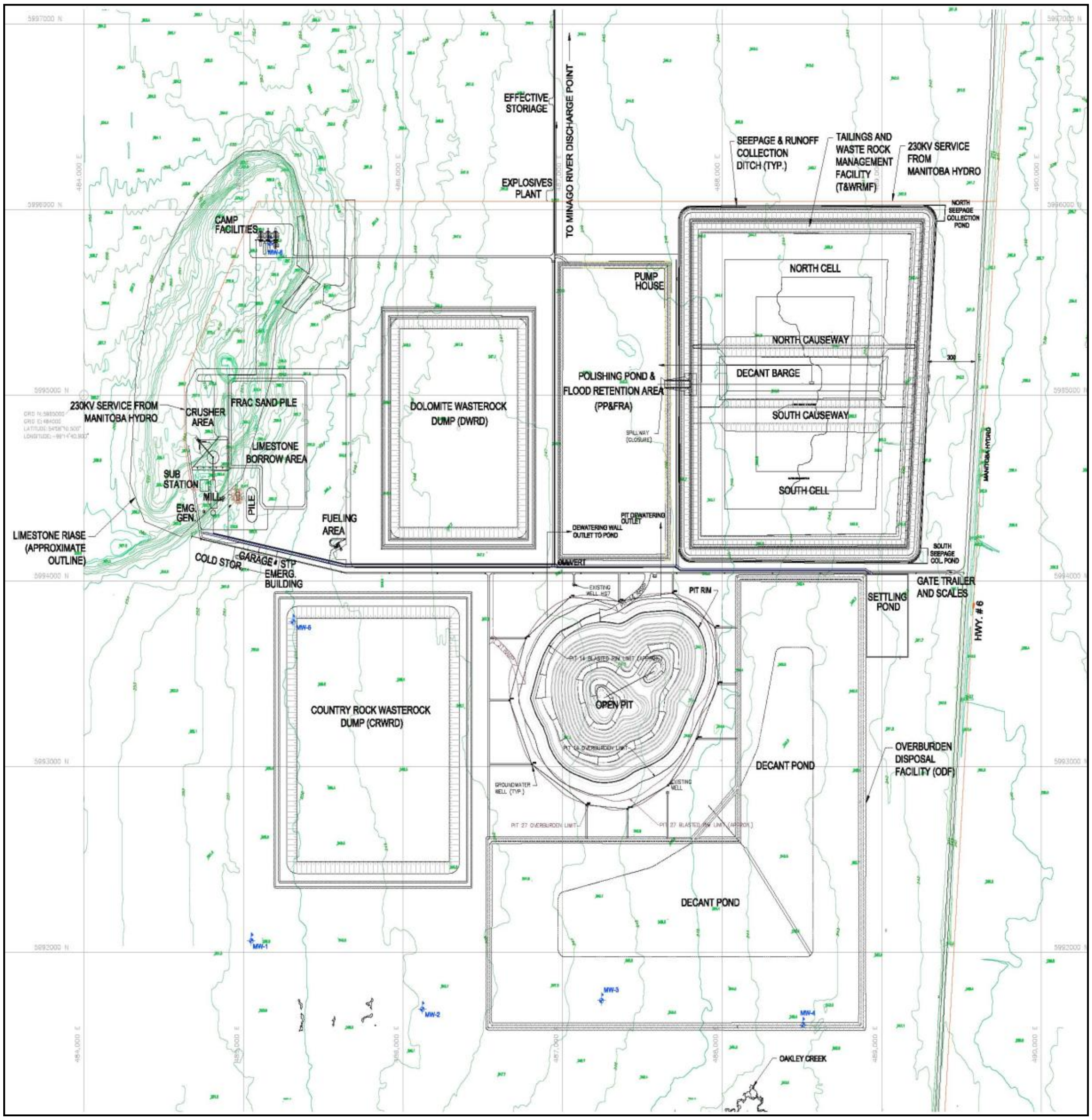


Figure 2.1-2 Current General Site Plan of Minago



Source: adapted from Wardrop, 2009b

Figure 2.1-3 Current General Site Plan of Minago

- de-watering systems with associated pipelines and pumping stations;
- roads and laydown areas;
- staff accommodations and facilities;
- open pit mining equipment including trucks, shovels, loaders, and drills; and
- truck repair and maintenance facilities.

The plant and infrastructure facilities have been located as close to the open pit mine as possible, based on a geotechnical investigation that identified the closest location with the best foundation conditions for the heavy equipment.

The plant and infrastructure facilities, shown in Figure 2.1-3, have been located as close to the open pit mine as possible on the limestone bluff to the west of the site. The escarpment will be cut back to a general elevation of 254 m.a.s.l. to ensure clearance above the water Table for the plant facilities. The crusher will be located on the limestone bluff at a position where the elevation grade is most favorable. A more detailed sketch showing the plant and the camp facilities is given in Figure 2.1-4.

The Tailings and Waste Rock Management Facility (TWRMF) has been located on the west side of the side of the property where the geotechnical investigations conducted in 2011 and 2012 identified the best foundation conditions.

The dumps for country rock, waste dolomite and the overburden were located around the pit to minimize the haul distances from the pit.

The road network was determined by the location of the dumps, facilities, and the ring road around the open pit mine, which will be used to access the de-watering wells. An access and maintenance road to service the discharge line to the Minago River was positioned in relation to the flood retention area and the associated pump houses.

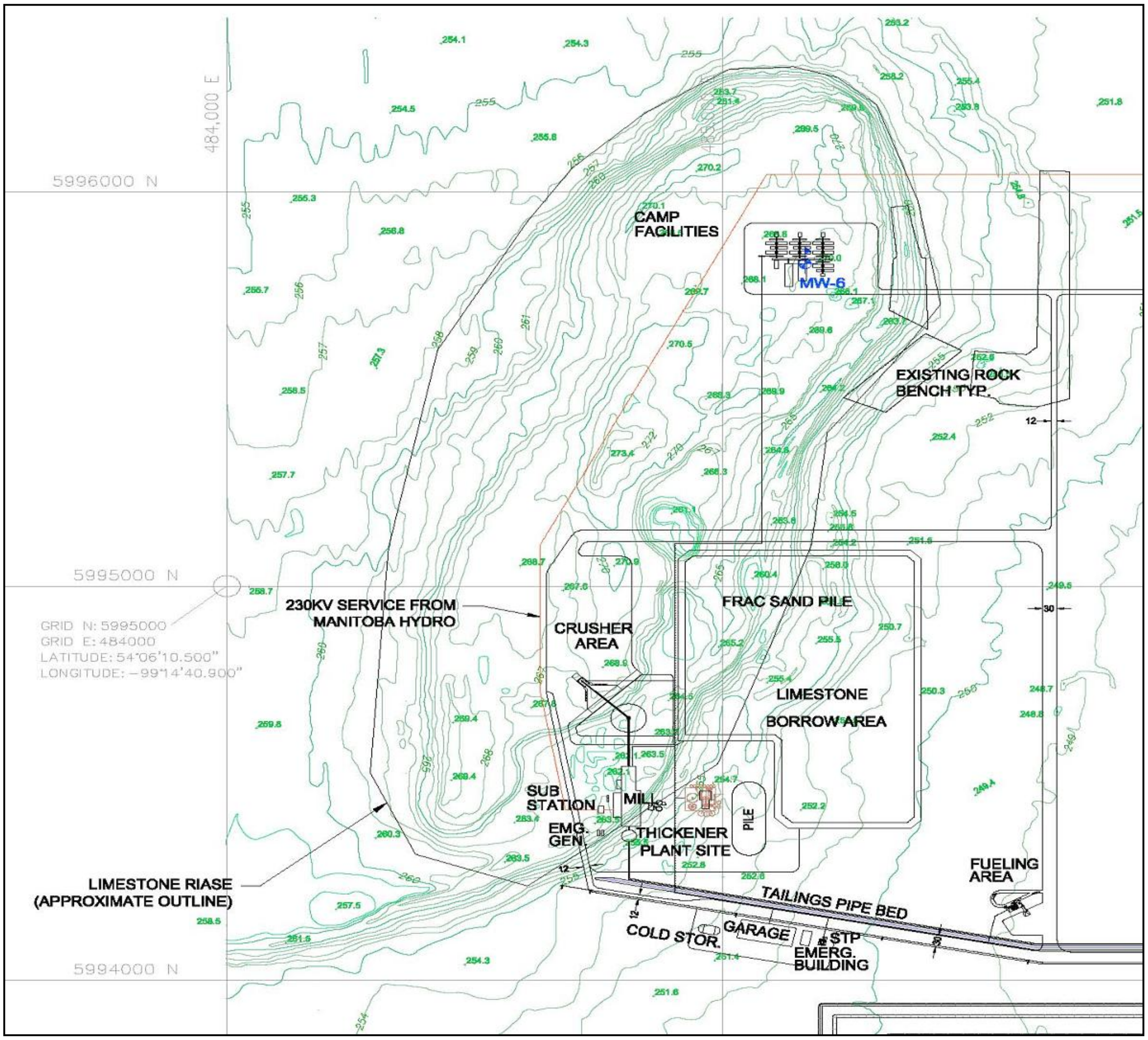
2.1.1 Project Purpose and Need

TWRMF

The proposed TWRMF is a key component of the Minago Project. Without the proposed TWRMF, there will be no nickel and frac sand production.

Nickel Project

China and India have become the world's largest consumers of Nickel. The demand for nickel in China will continue to grow as the World's economies continue to improve. This suggests strong continued growth in nickel consumption. The long- term picture for nickel production shows no relief in sight for the current market trend. The increasing demand for nickel will continue to outpace the forecasted increases in production. The timing for the development of a nickel mine producing high grade nickel concentrate is excellent.



Source: Wardrop, 2009b

Figure 2.1-4 Plant and Camp Facilities

The market for nickel concentrates is strong, bringing favorable purchase terms and providing long-term security to project economics. Victory Nickel Inc. (VNI) intends to take advantage of this excellent market opportunity and the exceptional ore resource of the Minago Project to create profits for its shareholders. The Minago Project will provide a much-needed boost to the Manitoba economy, an economy that has experienced a serious downturn due to the current economic recession. The project will provide a solid tax base, support for infrastructure development, and workforce development opportunities for local communities.

2.1.2 Project Timing

The mine life is estimated to be ten years, with concentrate production mirroring ore production. The frac sand, which is to be mined at the start of mining will be produced throughout the life of the mine.

The tailings and Waste Rock production schedule is given in Table 2.1-1.

Table 2.1-1 Tailings and Waste Rock Production Schedule (tonnes)

Unit (tonne)	Overburden	Dolomite	Country Rock	Mill (Ni) Production	Frac Sand Plant Production	Mill (Ni) Tailings to TWRMF	Frac Sand Tailings to TWRMF	Ultramafic (PAG) Waste Rock To TWRMF	Total Tailings to T&PAGWRM
Year - 2	6,600,000	29,653,000	0	0	0	0	0	0	0
Year - 1	2,685,000	41,066,000	3,389,000	0	285,000	0	68,000	2,026,000	68,000
Year 1		26,060,000	11,031,000	900,000	1,140,000	889,000	356,000	4,189,000	1,245,000
Year 2		13,928,000	12,465,000	3,600,000	1,140,000	3,555,000	356,000	5,896,000	3,911,000
Year 3		325,000	27,165,000	3,600,000	1,140,000	3,555,000	356,000	4,945,000	3,911,000
Year 4		0	27,200,000	3,600,000	1,140,000	3,555,000	356,000	4,100,000	3,911,000
Year 5		0	16,236,000	3,600,000	1,140,000	3,555,000	356,000	4,223,000	3,911,000
Year 6		0	11,043,000	3,600,000	1,140,000	3,555,000	356,000	5,218,000	3,911,000
Year 7		0	6,836,000	3,600,000	1,140,000	3,555,000	356,000	4,449,000	3,911,000
Year 8		0	786,000	3,600,000	1,140,000	3,555,000	356,000	613,0000	3,911,000
Year 9		0	0	3,600,000	1,140,000	3,555,000	356,000	0	3,911,000
Year 10		0	0	1,254,000	770,000	1,238,,000	240,000	0	1,478,000
Year 11		0	0	0	0	0	0	0	0
Total	9,285,000	111,032,000	116,147,000	30,954,000	11,315,000	30,567,000	3,512,000	35,659,000	34,079,000

Prepared by: JMH3
Checked by: JBH1

Construction can commence once all the permits are obtained from the MB Government. Victory Nickel anticipates to get the Environmental Act License approvals for mining and mill construction by August, 2010. Commencement of milling operations will commence in Year 2012 (Year -2) and into Year 2013 (Year -1). This is contingent upon receipt of the required licenses from the MB Government. Frac sand production will start in Year 2013 (Year -1) and Nickel production will start in 2014 (Year 1).

The Pre-load / Starter Dam are scheduled to be constructed during the first year of mine development (Year -2) when dolomitic limestone will be available from overburden removal. The Ultimate Dam is scheduled to be constructed during the second year of mine development (Year -1) with the dolomite waste rock and clay overburden from the open pit. Direct disposal of the dolomite waste rock and clay overburden at the site of the TWRMF perimeter dam will minimize double handing of material.

The delivery of ultramafic PAG rock is schedule for the middle of Year -1, frac sand tailings at the end of Year -1 and nickel tailings at the end of Year 1. TWRMF site preparation and mine development will start approximately one year prior to the disposal of PAG ultramafic waste rock and 2 years prior to the deposition of nickel tailings.

A simplified construction schedule is given in Figure 2.1-5.

Figure 2.1-5 Construction Schedule

2.1.3 Overview of Project Components, Design Criteria and General Layout

The overall layout for the Minago Project is presented in Figure 2.1-2. The project has and will continue to be designed according to the following general criteria:

- The project must meet or exceed the highest standards of industrial health and safety and demonstrate minimum environmental impact. Existing industry guidelines, codes of practice, standards and regulations will be consulted and the most stringent will be applied.
- The project will mine and process 10,000 t/d of run of mine ore, including variable amounts of external dilution. In addition, the facility will produce frac sand.
- The project will be designed to operate continuously, 365 days per year with appropriate design allowances in each department for planned maintenance shut downs.
- Tailings and ultramafic waste rock will be co-disposed of in the Tailings and Waste Rock Management Facility to control potential for Acid Rock Drainage (ARD) and Metal Leaching (ML).
- The mining method will be drill and blast, and use electrical and diesel powered equipment. The mining method must be very adaptable, safe, and conserve the resource by achieving high performance standards.
- The process plant will use flotation methods to produce one nickel concentrate to agreed quality specifications. The concentrates will be sold to external smelters for processing to metal. The project will not produce marketable metal as there will be no smelter.
- Employees will be drawn from local communities and provided with hotel style accommodation at the mine camp.
- A nucleus of skilled experienced workers will be recruited for initial development and construction. Through local recruiting and comprehensive training, the company has set the goal of maximizing the percentage of Manitoba residents, and the Communities of Interest (COI) in particular.

When completed, the Minago project production facilities will consist of a 10000 t/d Open pit, flotation concentrator, process water treatment plant, waste rock dumps, and a subaqueous tailings and waste rock management facility. These production facilities will be supported by the following infrastructure: a maintenance workshop, warehouse, electric power supply, fuel and propane tank farm, offices, sanitary and changing facilities (dry), camp, water supply system, sewage plant, domestic and industrial waste disposal and transportation corridors.

2.2 Certificate of Title and Mineral Dispositions

2.2.1 Mineral Rights

Victory Nickel owns mineral leases 2 and 3 granted under subsection 14(6) of the Mines and Minerals Act in respect of Crown minerals or a mineral lease granted under subsection 103(1) and the Company holds mineral rights to produce minerals that are found on, in or under land, whether or not title to the minerals in the land is severed from title to the land. The various minerals dispositions are detailed in this Chapter (Section 2.2.2).

2.2.2 Mineral Dispositions

The Property is comprised of one contiguous group of claims and one mineral lease, augmented by an isolated claim and a second adjacent mineral lease (Figures 2.2-1 and 2.2-2). The contiguous block consists of one mineral lease and 40 unpatented mineral claims with a combined surface area of 7,298.23 hectares (ha).

Mineral Lease 2 and Mineral Lease 3, which were issued on April 1, 1992, for a period of 21 years and may be renewed after that time at the discretion of the Minister of Manitoba Industry, Economic Development, and Mines.

Mineral claims KON 1 through KON 4 are in good standing until May 17, 2021 plus 60 days.

Mineral claims BARNEY 1 to BARNEY 6 inclusive are in good standing until September 24, 2022 plus 60 days.

The mineral claims MIN 1 through MIN 29 are in good standing.

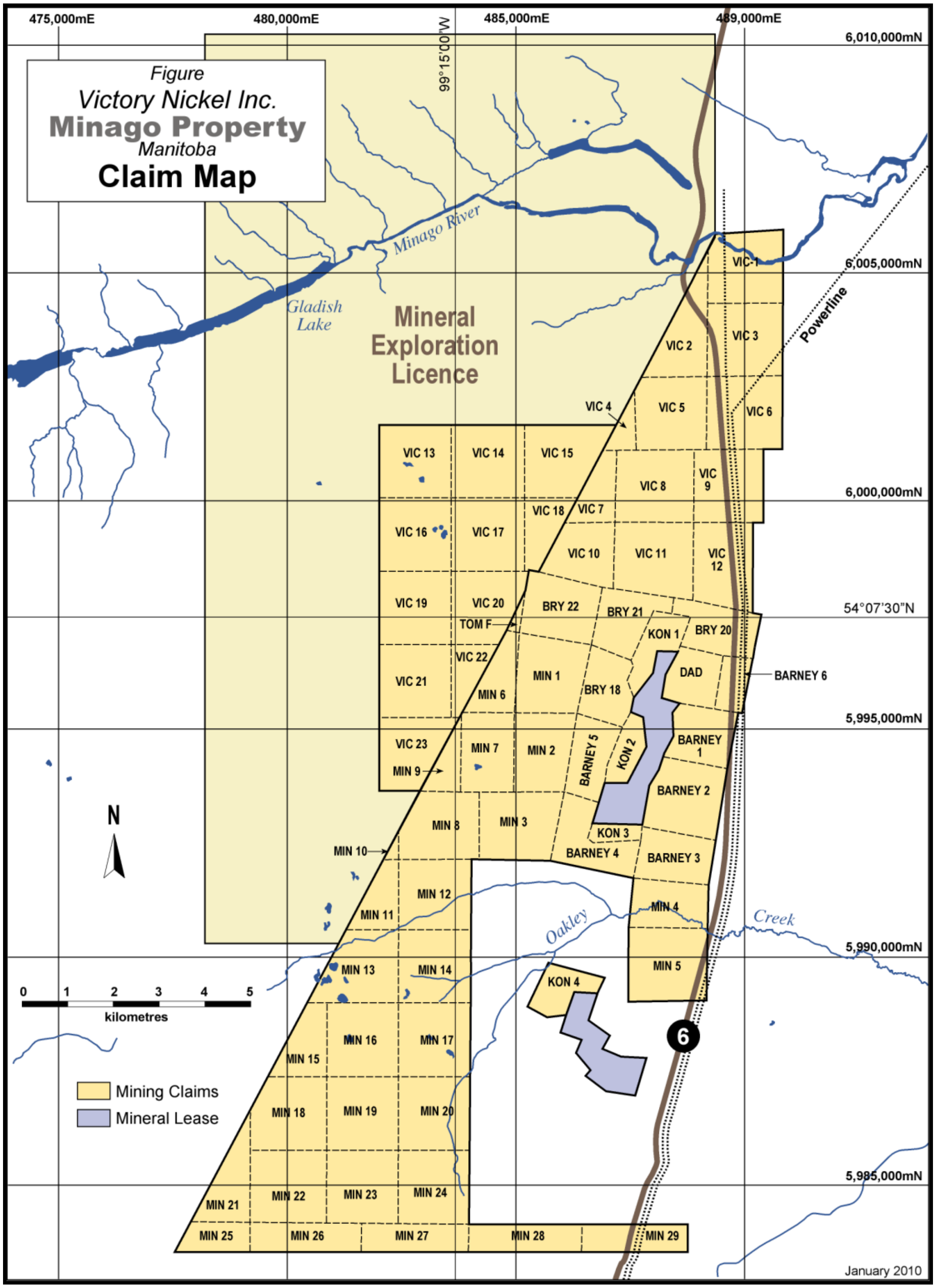
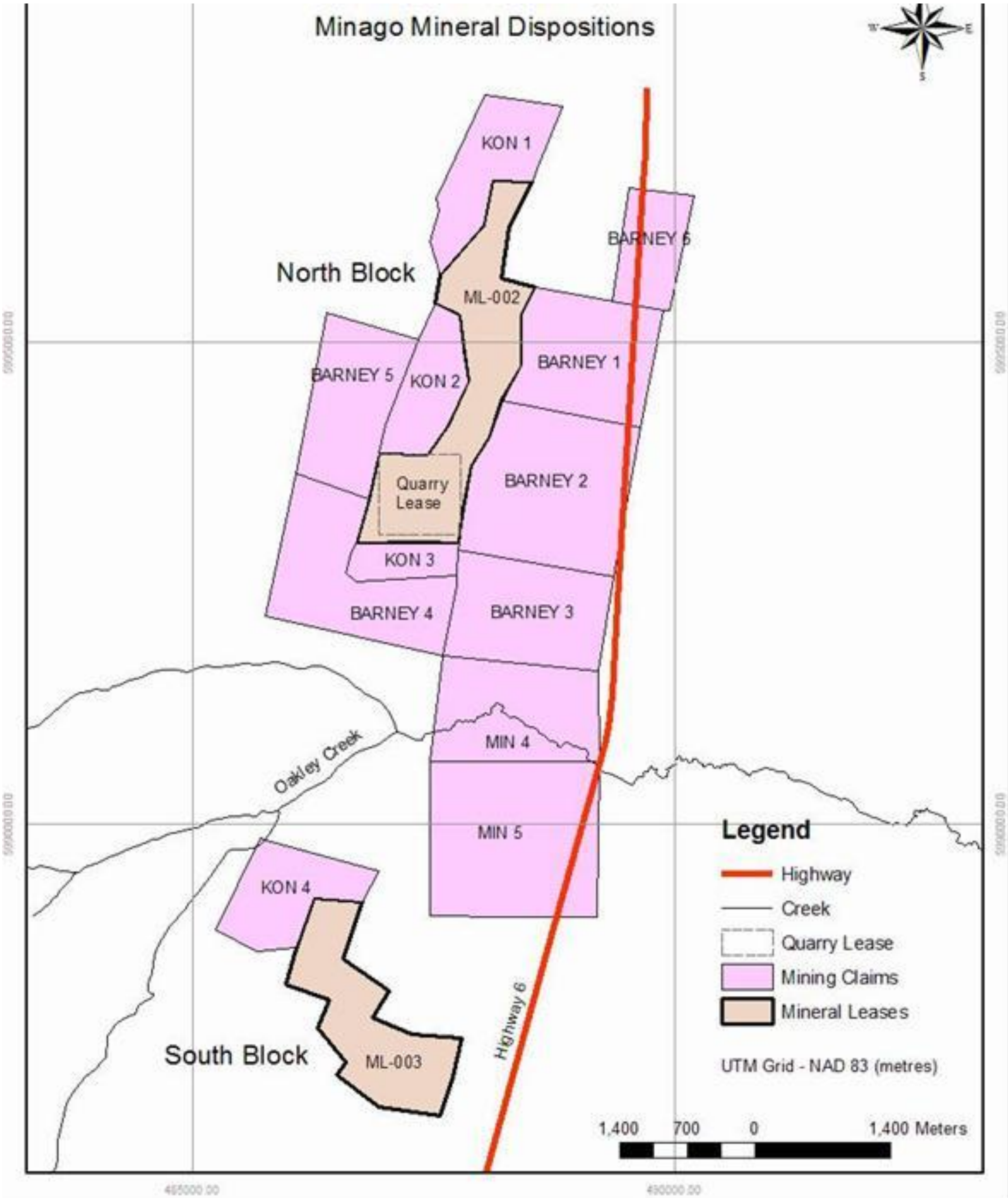


Figure 2.2-1 Minago Mineral Dispositions



Source: Wardrop, 2006

Figure 2.2-2 Minago's Historical Mineral Dispositions

Mineral claims VIC 1 through VIC 12 are in good standing until April 17, 2021 plus 60 days.

Mineral claims VIC 13 through VIC 23 are in good standing.

As a result of an option agreement entered into with Xstrata Nickel on claims BRY 18, BRY 20, BRY 21, BRY 22, TOM F, and DAD and subsequently fully exercised at year- end 2008, a NSR is payable to Xstrata on any exploited mineralization found on the claims.

Victory Nickel has obtained a quarry lease (QL-1853) with an area of 69.88 ha on a portion of the mineral lease ML-002. In addition, four quarry leases, surrounding and contiguous with QL-1853 have been applied for. These pending quarry leases over a total area of an additional 244 ha. Victory Nickel has also been issued the 10-year quarry lease QL-2067 that commenced in November 2009 (Figure 2.2-3).

Quarry lease QL-1853 has a term of 10 years and may be renewable for further terms of 10 years subject to the discretion of the Minister.

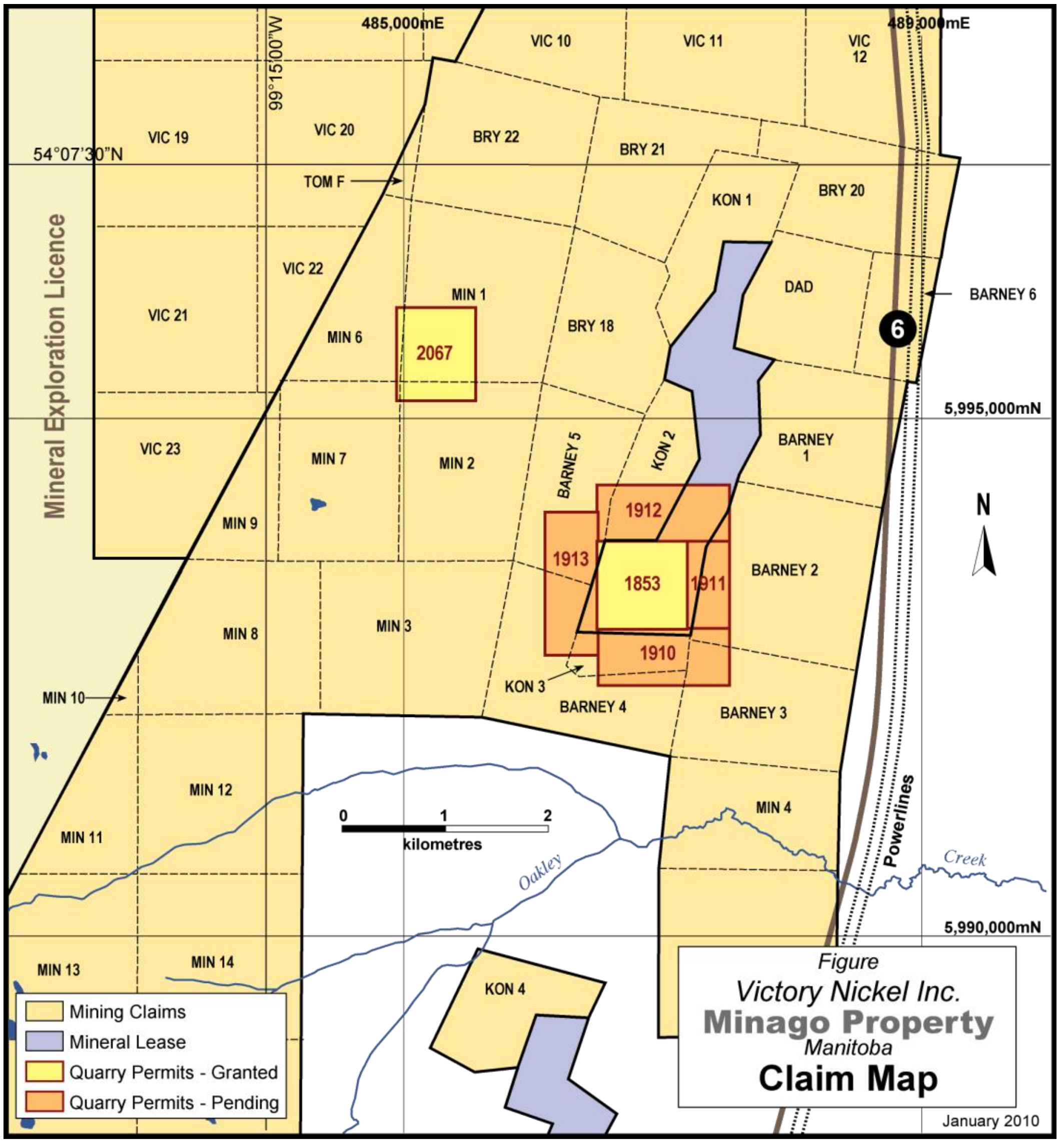


Figure 2.2-3 Minago Property Quarry Lease Status

2.2.3 Ownership

Victory Nickel has 100% ownership of the Minago Project and also the Mines and Minerals Act entitles mineral claims owners the rights as given below:

The holder (Victory Nickel) of a mineral claim has the exclusive right to explore for and develop the Crown minerals, other than the quarry minerals, found in place on, in, or under the lands covered by the claim (The Mines and Minerals Act, 73[1]).

The lessee (Victory Nickel) of a mineral lease has the exclusive right to the Crown minerals, other than quarry minerals, that are the property of the Crown and are found in place or under the land covered by the mineral lease. The lessee also has access rights to open and work a shaft or mine, and to erect buildings or structures upon the subject land (The Mines and Minerals Act, 108[a], [b], [i], [ii]).

With respect to the pending quarry lease, the lessee of a quarry lease has the exclusive right to the Crown quarry minerals specified in the lease (in this case limestone) that are found on or under the land covered by the lease and that are the property of the Crown (The Mines and Minerals Act ,140[1] [a]).

There are no instruments registered with the Mining Recorder at Manitoba Energy, Mines, Science and Technology Ministry on any of the mineral dispositions with respect to liens, judgments, debentures, royalties, back-in rights or other agreements.

2.2.3.1 Encumbrances

Encumbrances on the mineral dispositions include:

- For Norway House District: Registered Trap Line (RTL) # 150-07 covering all mineral dispositions.
- For Forestry Branch, Forest Management License: (FORM REPAP W 0012 and FORM REPAP 2 0012 covering all mineral dispositions.
- For Manitoba Hydro, Transmission Line and Easement Agreement: Right of Way 319.735 m wide, plan number 5830 N.L.T.O for portions of BARNEY 1, BARNEY 2, BARNEY 6, and MIN 5.
- For Manitoba Department of Highways: Right of way 91.44 m wide that is split 65.532 m west of the centre line and 25.908 east of the centre line, plan number 6149 N.L.T.O for portions of BARNEY 1, BARNEY 2, BARNEY 3, BARNEY 6, MIN 4, and MIN 5.
- For Manitoba Department of Highways: Quarry Withdrawal, plan number 6148 N.L.T.0.for southeast corner of ML-003.

There is no mining-related infrastructure on the Property although the Minago River Nickel Deposit, previously referred to as the Nose Deposit, is located on mineral lease ML 002.

There are no environmental liabilities attached to the Property.

2.2.4 Tenure Rights

The holder of a mineral claim has the exclusive right to explore for and develop the Crown minerals, other than the quarry minerals, found in place on, in, or under the lands covered by the claim (The Mines and Minerals Act, 73[1]).

The lessee of a mineral lease has the exclusive right to the Crown minerals, other than quarry minerals, that are the property of the Crown and are found in place or under the land covered by the mineral lease. The lessee also has access rights to open and work a shaft or mine, and to erect buildings or structures upon the subject land (The Mines and Minerals Act, 108[a], [b], [i], [ii]).

The lessee of a quarry lease has the exclusive right to the Crown quarry minerals specified in the lease (in this case limestone) that are found on or under the land covered by the lease and that are the property of the Crown [The Mines and Minerals Act, 140 (1) (a)].

2.2.5 Option Agreement with Xstrata Nickel

As a result of an option agreement entered into with Xstrata Nickel on claims BRY 18, BRY 20, BRY 21, BRY 22, TOM F, and DAD and subsequently fully exercised at year- end 2008, a NSR is payable to Xstrata on any exploited mineralization found on the claims.

2.3 Existing Land Use

The project is located in the Norway House Resource Management Area. In addition, there is a Registered Trap Line (RTL) # 150-07 covering all mineral dispositions.

Resource Management Areas have been established by the Manitoba government. The RMA, in which the project area is located, is currently an inactive area so there are no current land use plans developed for the project area.

2.4 Minago Project – Economic Assessment

2.4.1 Feasibility Study

In 2007, Victory Nickel retained Wardrop to undertake a Feasibility Study of the Minago Project following positive results of the Scoping Study completed in 2006. The Feasibility Study was completed in the first quarter of 2010. The results of the Feasibility Study are discussed below.

The deposit has potential as a large tonnage, low-grade nickel sulphide deposit (30,954,000 Mt at 0.43% nickel (Ni), 0.20% cut-off grade) and contains 14.8 Mt million tons of marketable frac sand. The potential of the Property is supported by a recent metallurgical test program, where a very high grade nickel concentrate was produced. The excellent recoveries for the ore from the open pit mine are substantiated by historical and current metallurgical testing data.

The economic aspects of a deposit would be constrained by some 80 m of overburden, limestone, and sand resulting in a high open pit strip ratio. However, in the case of the Minago Project, the 10 m sand layer just above the ultramafic ore bearing rock contains marketable frac sand, which offsets the cost of the stripping.

In addition to the Nickel Ore Concentrating Plant, the installation of a Frac Sand Processing Plant will generate further revenues for the project. The financial analysis assumes that critical revenue streams will be developed from both the nickel and frac sand resources. Table 2.4-1 shows the proposed production schedule by year, for the waste, the nickel ore and the sand.

Table 2.4-1 Production Schedule by Year and Product

Unit (tonne)	Overburden	Dolomite	Country Rock	Mill (Ni) Production	Frac Sand Plant Production	Mill (Ni) Tailings to TWRMF	Frac Sand Tailings to TWRMF	Ultramafic (PAG) Waste Rock To TWRMF	Total Tailings to T&PAGWRM
Year - 2	6,600,000	29,653,000	0	0	0	0	0	0	0
Year - 1	2,685,000	41,066,000	3,389,000	0	285,000	0	68,000	2,026,000	68,000
Year 1		26,060,000	11,031,000	900,000	1,140,000	889,000	356,000	4,189,000	1,245,000
Year 2		13,928,000	12,465,000	3,600,000	1,140,000	3,555,000	356,000	5,896,000	3,911,000
Year 3		325,000	27,165,000	3,600,000	1,140,000	3,555,000	356,000	4,945,000	3,911,000
Year 4		0	27,200,000	3,600,000	1,140,000	3,555,000	356,000	4,100,000	3,911,000
Year 5		0	16,236,000	3,600,000	1,140,000	3,555,000	356,000	4,223,000	3,911,000
Year 6		0	11,043,000	3,600,000	1,140,000	3,555,000	356,000	5,218,000	3,911,000
Year 7		0	6,836,000	3,600,000	1,140,000	3,555,000	356,000	4,449,000	3,911,000
Year 8		0	786,000	3,600,000	1,140,000	3,555,000	356,000	613,0000	3,911,000
Year 9		0	0	3,600,000	1,140,000	3,555,000	356,000	0	3,911,000
Year 10		0	0	1,254,000	770,000	1,238,.000	240,000	0	1,478,000
Year 11		0	0	0	0	0	0	0	0
Total	9,285,000	111,032,000	116,147,000	30,954,000	11,315,000	30,567,000	3,512,000	35,659,000	34,079,000

Prepared by: JMH3
Checked by: JBH1

During the development of the Feasibility Study, certain concepts were pursued in the interests of cost and efficiency. In place of the mechanical removal of the overburden, Wardrop has selected a dredging option to reduce costs significantly and create more favorable spoil areas. By co-depositing the potentially acid generating, metal leaching ultramafic rock and sealing these within the tailings, significant infrastructure and legacy costs are eliminated. Finally, by shortening the production life of the Frac Sand Plant to match that of the Ore Processing Plant, general and administrative and surface facility costs will be minimized.

The mine life is estimated to be ten full years, with concentrate production mirroring ore production. The frac sand which is to be mined at the start of mining is produced throughout the life of the mine.

The Project features an open pit bulk tonnage mining method, a 3.6 Mt/a Nickel Ore Processing Plant, and a 1.5 Mt/a Sand Processing Plant producing various sand products, including 20/40 and 40/70 frac sand, and other finer sized sands. The Project will be built over a three year period at a capital cost of $596.3 million. The Nickel Ore Processing Plant is scheduled to come online in the spring of 2014 and the Frac Sand Plant is scheduled to come online in the spring of 2013.

The work undertaken for the Feasibility Study and Environmental Baseline Studies formed the basis of the EIS. A copy of the Feasibility Study for the Minago Project can be obtained at www.sedar.com. A copy of the EIS can be obtained upon request. An EAL 2981 was issued to VNI in August 2011.

2.4.2 Proposed TWRMF

Following the discovery of additional mineralization, Victory Nickel resolved to relocate the Tailings and Waste Rock Management Facility (TWRMF). In parallel with the additional drilling of the north limb Victory Nickel extended their leases to include the shallow valley directly to the west. A series of trial pits were dug across the valley and a helicopter survey were conducted in early 2011 which suggested that the valley was ideal for the combined depository.

To confirm that the clay base to the valley identified with the trial pits was thick and consistent and to develop an appropriate design, Victory Nickel engaged Foth Canada Corporation (Foth). In late 2011/early 2012, Foth conducted a site investigation of the valley and commenced with the engineering design for the TWRMF. This work was halted in April 2012 then was restarted in April 2013 with a reduced scope limiting the design to a Conceptual Design rather than the full Feasibility Study Design.

The Manitoba Government issued the Environmental Act License No. 2981 which covers the revised location for the TWRMF on August 23, 2011.

This work follows the previous studies completed by Wardrop, Golder Associates (Golder), URS, and others. Where information has been abstracted from these reports the source has been identified and the approval of the Client, Victory Nickel obtained.

Since the proposed site is some 4 kilometer (km) from the current site, the geotechnical information from the previous work has not been incorporated into the design but has been used as a reference to check the appropriateness of the conceptual design and resulting conclusions.

he essential components of work for the Conceptual Design are summarized as:

- Completion of Factual Report for Phase 1 and Phase 2 Field Investigations (Foth, 2013).
- Preparation of a Design Criteria and Basis Memo to be incorporated in the report herein.
- Evaluation of deposition strategies and the development of a deposition plan.
- Stability and seepage analyses, and geotechnical design of TWRMF and PP containment dams.
- Evaluation of Water Management Strategies, and design of the PP and water cover.
- Preparation of the Conceptual Design Report.
-

The TWRMF is proposed to occupy a long, narrow water-saturated muskeg/peat wetland with some forested areas approximately four km northwest of the proposed pit. This lowland extends approximately 8 km from the southwest to the northeast and is bound on the east and west by sub-parallel dolomite bedrock ridges, approximately 2.5 km apart. The ridges rise nearly 20 meters above the wetland valley that slopes gently at approximately 0.2% but consistently to the north-northeast. The proposed TWRMF structures would be oriented between the ridges, and along the lowland.

2.5 Project Alternatives

Victory Nickel Inc. sees no feasible alternative to Minago Project. The project is the principle asset of VNI and although there are other mineral deposits in the Minago Area, VNI does not own any interest in them and therefore cannot effect the evaluation of the possible co-development with the Minago deposit. Similarly, currently it is not possible to consider the potential addition of other deposits that may be discovered through exploration. Given the current and future global market for Nickel, the proposed project is the best available option to achieve the business goals of the company.

VNI has assessed a number of alternatives in coming to the proposed design of the Minago Project. The alternatives considered include the various ways that the project could be implemented or carried out, including alternative locations in the project area, routes and methods of development, implementation, and mitigation.

Examining the main project alternatives involved answering the following three questions:

1. What alternatives are technically and economically feasible?
2. What are the environmental effects associated with the feasible alternatives?
3. What is the rationale for selecting the preferred alternative?

Throughout the Minago Project design process, various mining concepts were developed, analyzed, refined and eventually focused down to preferred alternatives. This section describes alternatives that were considered by VNI, and the rationale for selecting the preferred alternative.

The decisions made by VNI and its consultants for the purposes of project design and mine planning are based on feasibility level information. This information provides a reasonable basis for detailed design.

2.5.1 Mining Method

A conventional open pit with full seven and two partial years of ore production life is envisaged after dewatering the overburden and overlying limestone and sandstone. Twelve metre bench heights will be used. A contractor will be employed to remove the overburden and some limestone during the two pre-production years. Equipment will be purchased to utilize the favorable electric power costs in Manitoba. Electric hydraulic shovels will load ore and waste into 218 tonne haul trucks.

Underground operations have been considered but were deemed to be uneconomical due to poor ground control and low-grade aspects. Open pit mining is the only feasible means of extracting the Minago deposit. There will be two products mined from the open pit – frac sand and nickel ore. Frac sand will be mined after the overburden materials (peat and clay and dolomitic limestone) have been removed. The removal of the frac sand will expose the nickel ore. Open pit mining method is the most optimal extraction method to extract both frac sand and nickel ore.

2.5.2 Pit Location

The pit is located where the ore is and therefore, there is no viable alternative.

2.5.3 Ore and Waste Haulage

VNI will use 218 tonne trucks to move ore to the mill and waste rock to the waste rock dumps. The 218 tonne trucks are the most economical mode of transportation bearing in mind the waste-to-ore ratio of 6.7 to 1 for mining the nickel sulphide ore and the frac sand. Transportation of ore and waste rock using high capacity equipment is the most viable approach and therefore, there is no viable alternative.

2.5.4 Ore Processing

Conventional flotation will be employed by VNI to process the ore, as there is no viable alternative. The process flow sheet will consist of crushing plant, grinding circuit and a concentrator.

2.5.5 Waste Rock Disposal

The locations of the waste rock dumps and overburden stockpile are selected to optimize hauling costs and are located in the vicinity of the open pit. The waste rock dumps for Country Rock and Dolomite and overburden stockpile locations were selected based on geotechnical investigation results and for the following reasons:

- they are located near the pit to optimize haul distances;
- the overburden is largely clay;
- there will be large waste rock volumes; and
- the waste will be Non-Acid Generating (NAG).

The existing facilities have adequate storage capacities for the waste rock that will be generated from pit during development and operational phases and as such, no alternative to the existing infrastructure were examined. During the operations phase, waste rock will be disposed into the dumps. The Overburden, Dolomite and Country Waste Dumps with store approximately 11 Mt of overburden, 90 Mt of limestone waste and 122 Mt of granitic (country rock) waste, respectively. Approximately 35.67 Mt of ultramafic waste rock will be co-disposed with tailings in a Tailings and Ultramafic Waste Rock Management Facility (TWRMF). Co-disposal will minimize metal leaching and increase the stability of the tailings management area.

2.5.6 Tailings Disposal

Sub-aerial disposal of liquid tails (slurry) was selected for the property. An alternative method involving the on-land disposal of dry tailings in paste form was assessed. Advantages of paste tailings disposal are:

- A tailings dam does not have to be constructed, removing a significant capital cost item.
- Water does not have to be managed to prevent the oxidation of potentially acid generating materials.

The disadvantages of this option are:

- Dust can be generated from the tailings.
- Pumping is more difficult and expensive than for liquid tailings.
- Operating costs are higher due to the pumping and, potentially, the need to add minimal cement to the tails to retain its form as paste.

The most significant reason for selecting sub-aqueous disposal of liquid tailings is that VNI prefers to adopt proven technology rather than embark on a pioneer project. While numerous operations have elected to select paste tailings disposal in favour of sub-aqueous disposal, these are primarily gold operations with benign tailings.

2.5.7 Tailings Facility Location

There are numerous interdependencies among facilities that dictated the order in which they would be located. VNI located the tailings facility based on results of site surveys, test pits and reviews of past work. Wardrop Engineering Inc. conducted an assessment of potential tailings facility (TF) locations in 2007 and 2008. The Tailings and Ultramafic Waste Rock Management Facility (TWRMF) is located reasonably close to the mill. However, the TWRMF in the 2010 EAP/EIS is located in an area where a new mineralization has been discovered through condemnation drilling conducted in 2010 and 2011.

The proposed TWRMF location is the preferred location for the following reasons:

- The TWRMF will be cost effective to construct as it in between two dolomite ridges
- The TWRMF will have only two dams (North and South). The two ridges will be used to contain the tailings.
- Co-disposal of tailings and ultramafic waste rock will minimize metal leaching and will increase the stability of the facility.

VNI's closure objective is to design and manage the TWRMF to enable the site to be left without requirements for long-term water treatment.

2.5.8 Camp Location (Operational and Construction Camps)

The following two alternatives were considered for the camp location:

- Off site (South of the property near the existing William River Camp); and
- On site.

VNI selected the onsite option as the preferred site for the camp. VNI assumes that the differences in the two locations, from an economic and technical perspective were significant so as other factors, such as health and safety aspects, were considered.

Locating a camp on site would be closer to the working area and will minimize travel time and eliminates the carbon footprint. The chosen site has the advantage that personnel can walk to or from the industrial complex to the camp and additional transportation will not be necessary.

The main disadvantage of locating a camp at the existing site in the vicinity of William River is that it is too far from the Minago site and VNI would have to provide transportation to the project site. This would increase the carbon footprint and may be a problem during winter storm events.

2.5.9 Power Supply

The Minago project will require a continuous power supply for the industrial complex, the camp and supporting facilities. The type of the energy sources used in the operation will have an immediate impact on the capital requirement and the on-going cost of the project. The three energy sources considered for the project and their limitations are as follows:

- Connection to the Main Grid - the connection to the existing Manitoba Hydro power grid will require a high voltage line located approximately 300 metres from the site access. Based on the proximity of the power grid, this option is considered viable.
- Natural gas power generation - previous studies of other mines have indicated that the natural gas and diesel based power generation systems have comparable reliability. However, the diesel generators seem to be 5% to 10% more efficient than natural gas. Diesel fuel is quite expensive and will result in significant operating costs and therefore, the genset option is not considered viable. Natural gas turbines are economical for processes that require high heat or where natural gas supplies, such as pipelines and wells, are nearby. Since there are no gas sources in the area of the project and the diesel-based system provides higher efficiency, the natural gas power generation is not considered viable.

- Hydropower generation - generally hydropower provides the environmentally cleanest operation with the lowest operating cost structure. There are disadvantages; however, such as very high initial capital cost investment, long payback period and complex regulatory requirements with a possible four to five year approval period. In addition, there are no water bodies in the immediate area that can be used for hydropower development. This option is not considered viable.

2.5.10 Site Access Road Location

The Minago Nickel Property (Property) is located 485 km north-northwest of Winnipeg, Manitoba, Canada and 225 km south of Thompson, Manitoba on NTS map sheet 63J/3. The property is approximately 100 km north of Grand Rapids off Provincial Highway 6 in Manitoba. Provincial Highway (PTH) 6 is a paved two-lane highway that serves as a major transportation route to northern Manitoba.

The Minago Project is located just off PTH6 and to access the proposed industrial area will require a maximum of 4 kilometres of road development. The road network to be constructed at the Minago Project will be located in the VNI Mineral Lease Parcel. VNI commissioned environmental baseline studies to determine current baseline conditions. The assessment included air photo and map reviews, and paper route projections. Helicopter reconnaissance and selective ground truthing was conducted. The key design and assessment requirements that were considered included:

- land tenure;
- the avoidance of environmentally sensitive areas such as streams, and wildlife critical habitat areas;
- alignment gradient and length; and
- the presence of bedrock and blasting requirements.

Based on these assessments, VNI optimized the design of the main access road to minimize environmental impacts and construction costs.

Grand Rapids, the closest community to the Property, is located where the Saskatchewan River flows into Lake Winnipeg. In 1996, Grand Rapids had 404 residents (1996 census). The economy of Grand Rapids is based on commercial fishing, hydroelectric generation, tourism, forestry, trapping.

Grand Rapids is served by an RCMP detachment, a nursing station, daily bus and truck transportation to Winnipeg and a 1.02 km grass/turf airstrip in addition to a number of small supply and service businesses.

Provincial Highway 6 crosses a portion of the Property and a network of diamond drill roads enables pickup truck travel on the Property in the winter and all terrain vehicle (Argo) travel in the summer.

The OmniTrax Canada railway line connecting the southern prairie region of western Canada to Churchill, Manitoba (a seasonal seaport) crosses Provincial Highway 6 approximately 60 km north of the Property.

2.6 Project Alternatives

Victory Nickel Inc. sees no feasible alternative to Minago Project. The project is the principle asset of VNI and although there are other mineral deposits in the Minago Area, VNI does not own any interest in them and therefore cannot effect the evaluation of the possible co-development with the Minago deposit. Similarly, currently it is not possible to consider the potential addition of other deposits that may be discovered through exploration. Given the current and future global market for Nickel, the proposed project is the best available option to achieve the business goals of the company.

VNI has assessed a number of alternatives in coming to the proposed design of the Minago Project. The alternatives considered include the various ways that the project could be implemented or carried out, including alternative locations in the project area, routes and methods of development, implementation, and mitigation.

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Throughout the Minago Project design process, various mining concepts were developed, analyzed, refined and eventually focused down to preferred alternatives. This section describes alternatives that were considered by VNI, and the rationale for selecting the preferred alternative.

The decisions made by VNI and its consultants for the purposes of project design and mine planning are based on feasibility level information. This information provides a reasonable basis for detailed design.

2.6.1 Mining Method

A conventional open pit with seven years of full production and two years of partial ore production life is envisaged after dewatering the overburden and overlying limestone and sandstone. Twelve metre bench heights will be used. A contractor will be employed to remove the overburden and some limestone during the two pre-production years. Equipment will be purchased to utilize the favorable electric power costs in Manitoba. Electric hydraulic shovels will load ore and waste into 218 tonne haul trucks.

Underground operations have been considered but were deemed to be uneconomical due to poor ground control and low-grade aspects. Open pit mining is the only feasible means of extracting the Minago deposit. There will be two products mined from the open pit – frac sand and nickel ore. Frac sand will be mined after the overburden materials (peat and clay and dolomitic limestone) have been removed. The removal of the Frac sand will expose the nickel ore. Open pit mining method is the most optimal extraction method to extract both Frac sand and nickel ore.

2.6.2 Pit Location

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2.6.3 Ore and Waste Haulage

VNI will use 218 tonne trucks to move ore to the mill and waste rock to the waste rock dumps. The 218 tonne trucks are the most economical mode of transportation bearing in mind the waste-to-ore ratio of 6.7 to 1 for mining the nickel sulphide ore and the frac sand. Transportation of ore and waste rock using high capacity equipment is the most viable approach and therefore, there is no viable alternative.

2.6.4 Ore Processing

Conventional flotation will be employed by VNI to process the ore, as there is no viable alternative. The process flow sheet will consist of crushing plant, grinding circuit and a concentrator.

2.6.5 Waste Rock Disposal

The locations of the waste rock dumps and overburden stockpile are selected to optimize hauling costs and are located in the vicinity of the open pit. The waste rock dumps (Dumps #1, 2 and 3) and overburden stockpile locations were selected based on geotechnical investigation results and for the following reasons:

- they are located near the pit to optimize haul distances;
- the overburden is largely clay;
- there will be large waste rock volumes;
- the waste will be Non-Acid Generating (NAG).

The existing facilities have adequate storage capacities for the waste rock that will be generated from pit during development and operational phases and as such, no alternative to the existing infrastructure were examined. During the operations phase, waste rock will be disposed into the dumps. The Overburden, Dolomite and Country Waste Dumps with store approximately 11 Mt of overburden, 111.1 Mt of limestone waste and 122 Mt of granitic (country rock) waste, respectively. Approximately 35.67 Mt of ultramafic waste rock will be co-disposed with tailings in a Tailings and Ultramafic Waste Rock Management Facility (TWRMF). Co-disposal will minimize metal leaching and increase the stability of the tailings management area.

2.6.6 Tailings Disposal

Sub-aerial disposal of liquid tails (slurry) was selected for the property. An alternative method involving the on-land disposal of dry tailings in paste form was assessed. Advantages of paste tailings disposal are:

- A tailings dam does not have to be constructed, removing a significant capital cost item.
- Water does not have to be managed to prevent the oxidation of potentially acid generating materials.

The disadvantages of this option are:

- Dust can be generated from the tailings.
- Pumping is more difficult and expensive than for liquid tailings.
- Operating costs are higher due to the pumping and, potentially, the need to add minimal cement to the tails to retain its form as paste.

The most significant reason for selecting sub-aerial disposal of liquid tailings is that VNI prefers to adopt proven technology rather than embark on a pioneer project. While numerous operations have elected to select paste tailings disposal in favour of sub-aerial disposal, these are primarily gold operations with benign tailings.

2.6.7 Tailings and Waster Rock Management Facility Location

There are numerous interdependencies among facilities that dictated the order in which they would be located. VNI located the tailings facility based on results of site surveys, test pits and reviews of past work. Wardrop Engineering Inc. conducted an assessment of potential tailings facility (TF) locations in 2007 and 2008. In 2012, Foth Canada (Foth Canada, 2013) undertook geotechnical investigation in the area for the proposed TWRMF. The Tailings and Ultramafic Waste Rock Management Facility (TWRMF) is located reasonably close to the mill.

The TWRMF location is the preferred location for the following reasons:

- The dam will be cost effective to construct as it is near the open mine, which is earmarked to be the source of the construction materials.
- Co-disposal of tailings and ultramafic waste rock will minimize the potential for ARD and metal leaching and will increase the stability of the facility.
- The proposed TWRMF is located near the processing plant to reduce pumping costs
- The new location of the TWRMF was selected in order to accommodate COI concerns

VNI's closure objective is to design and manage the TWRMF to enable the site to be left without requirements for long-term water treatment.

2.6.8 Camp Location (Operational and Construction Camps)

The following two alternatives were considered for the camp location:

- Off site (South of the property near the existing William River Camp); and
- On site.

VNI selected the onsite option as the preferred site for the camp. VNI assumes that the differences in the two locations, from an economic and technical perspective were significant so as other factors, such as health and safety aspects, were considered.
Locating a camp on site would be closer to the working area and will minimize travel time and eliminates the carbon footprint. The chosen site has the advantage that personnel can walk to or from the industrial complex to the camp and additional transportation will not be necessary.

The main disadvantage of locating a camp at the existing site in the vicinity of William River is that it is too far from the Minago site and VNI would have to provide transportation to the project site. This would increase the carbon footprint and may be a problem during winter storm events.

2.6.9 Power Supply

The Minago project will require a continuous power supply for the industrial complex, the camp and supporting facilities. The type of the energy sources used in the operation will have an immediate impact on the capital requirement and the on-going cost of the project. The three energy sources considered for the project and their limitations are as follows:

- Connection to the Main Grid - the connection to the existing Manitoba Hydro power grid will require a high voltage line located approximately 300 metres from the site access. Based on the proximity of the power grid, this option is considered viable.
- Natural gas power generation - previous studies of other mines have indicated that the natural gas and diesel based power generation systems have comparable reliability. However, the diesel generators seem to be 5% to 10% more efficient than natural gas. Diesel fuel is quite expensive and will result in significant operating costs and therefore, the genset option is not considered viable. Natural gas turbines are economical for processes that require high heat or where natural gas supplies, such as pipelines and wells, are nearby. Since there are no gas sources in the area of the project and the diesel-based system provides higher efficiency, the natural gas power generation is not considered viable.
- Hydropower generation - generally hydropower provides the environmentally cleanest operation with the lowest operating cost structure. There are disadvantages; however, such as very high initial capital cost investment, long payback period and complex

regulatory requirements with a possible four to five year approval period. In addition, there are no water bodies in the immediate area that can be used for hydropower development. This option is not considered viable.

Therefore, power required for the operations will come from Manitoba Hydro.

2.6.10 Site Access Road Location

The Minago Nickel Property (Property) is located 485 km north-northwest of Winnipeg, Manitoba, Canada and 225 km south of Thompson, Manitoba on NTS map sheet 63J/3. The property is approximately 100 km north of Grand Rapids off Provincial Highway 6 in Manitoba. Provincial Highway (PTH) 6 is a paved two-lane highway that serves as a major transportation route to northern Manitoba (Figure 2.6-1).

The Minago Project is located just off PTH6 and to access the proposed industrial area will require a maximum of 4 kilometres of road development. The road network to be constructed at the Minago Project will be located in the VNI Mineral Lease Parcel. VNI commissioned environmental baseline studies to determine current baseline conditions. The assessment included air photo and map reviews, and paper route projections. Helicopter reconnaissance and selective ground truthing was conducted. The key design and assessment requirements that were considered included:

- land tenure;
- the avoidance of environmentally sensitive areas such as streams, and wildlife critical habitat areas;
- alignment gradient and length; and
- the presence of bedrock and blasting requirements.

Based on these assessments, VNI optimized the design of the main access road to minimize environmental impacts and construction costs.

Grand Rapids, the closest community to the Property, is located where the Saskatchewan River flows into Lake Winnipeg. In 1996, Grand Rapids had 404 residents (1996 census). The economy of Grand Rapids is based on commercial fishing, hydroelectric generation, tourism, forestry, trapping.

Grand Rapids is served by an RCMP detachment, a nursing station, daily bus and truck transportation to Winnipeg and a 1.02 km grass/turf airstrip in addition to a number of small supply and service businesses.

Provincial Highway 6 crosses a portion of the Property and a network of diamond drill roads enables pickup truck travel on the Property in the winter and all terrain vehicle (Argo) travel in the summer.

The OmniTrax Canada railway line connecting the southern prairie region of western Canada to Churchill, Manitoba (a seasonal seaport) crosses Provincial Highway 6 approximately 60 km north of the Property.

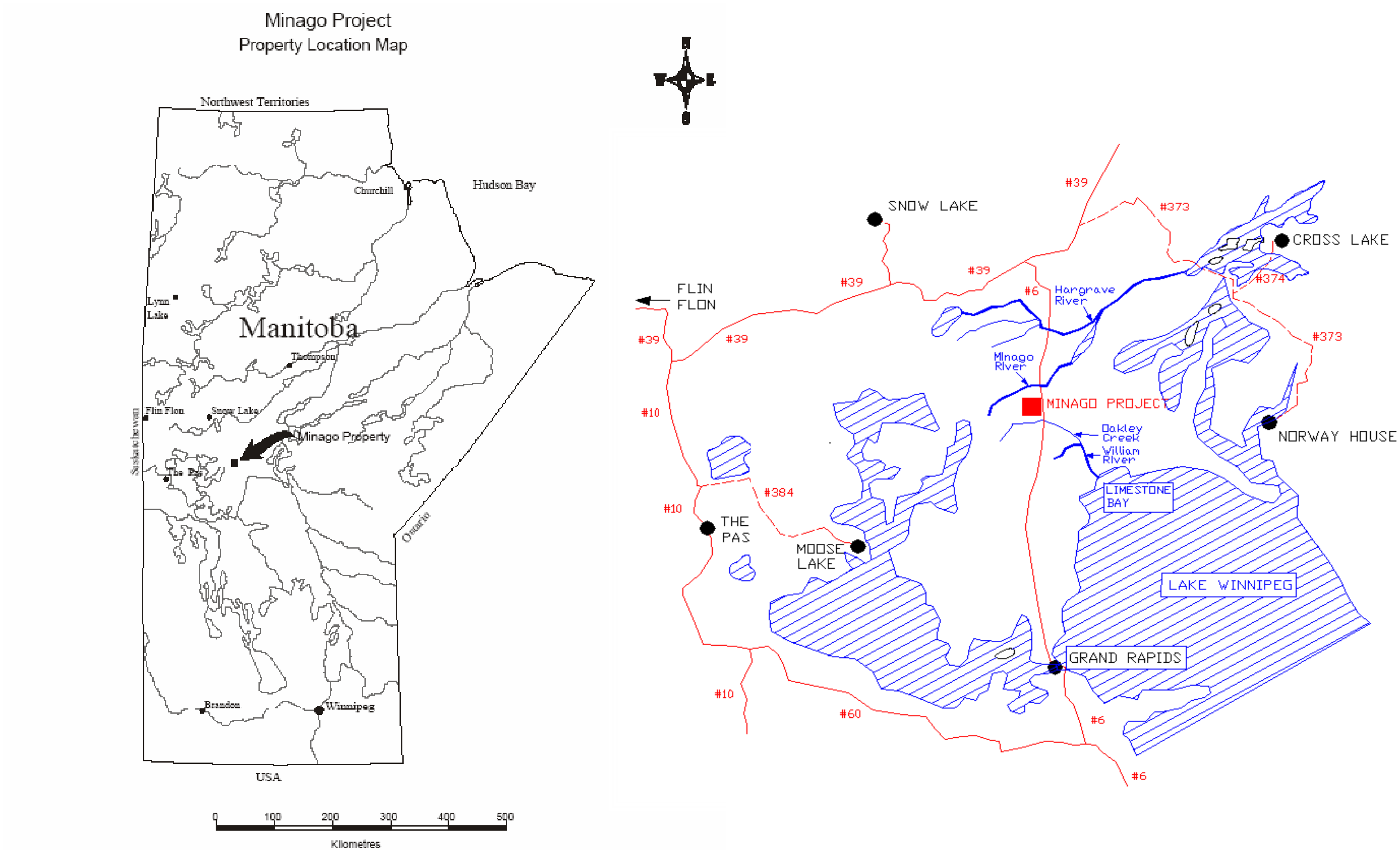


Figure 2.6-1 Site Access Road Location

2.7 Site Characterization

2.7.1 Site Geology

The surface cover typically comprises 1.0 to 2.1 m of muskeg and peat that is underlain by 1.5 to 10.7 m of impermeable compacted glacial lacustrine clays. The clays are dark brown to grey and carbonate rich overlain with muskeg formed by an accumulation of sphagnum moss, leaves, and decayed matter.

The underlying clay and sporadic till was deposited from former glacial Lake Agassiz. Lake Agassiz once stretched across portions of Saskatchewan, Manitoba and western Ontario, impounded by retreating and transgressing Laurentian ice sheets. The extent of clays deposited in Lake Agassiz is shown in green in (Figure 2.7-1). The deposit contains silt and some sand and gravel with glacial till found locally below the clay.

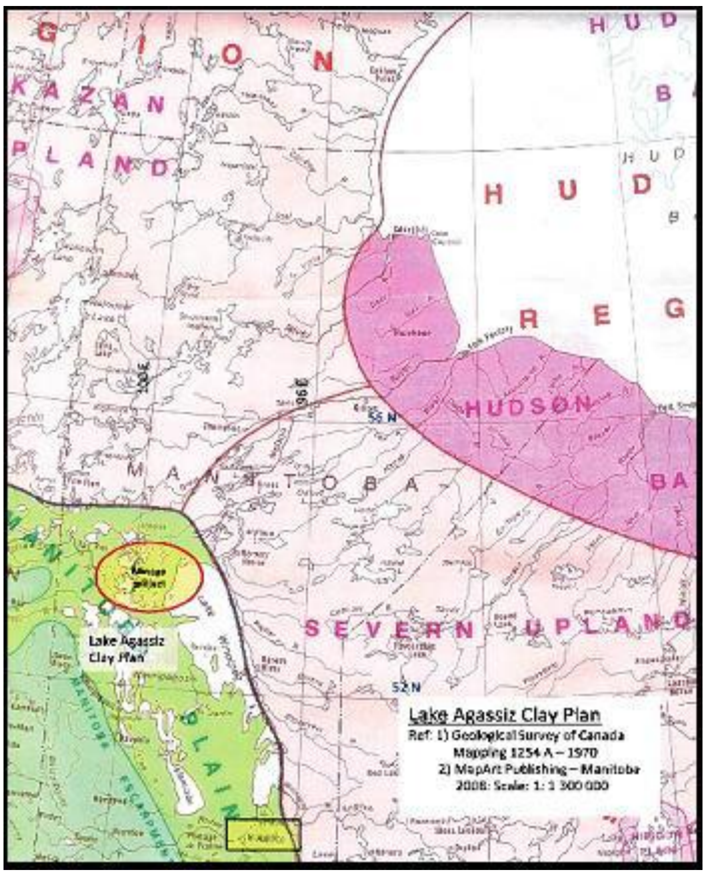


Figure 2.7-1 Clays Deposited in Lake Agassiz

2.7.1.1 Regional Geology

The regional geology comprises the eastern edge of the Phanerozoic sediments of the Western Canada Sedimentary Basin. The basin overlies Precambrian crystalline basement rocks, including the Thompson Nickel Belt. The basin tapers from a maximum thickness of about 6,000 m in Alberta to zero at the north and east, where it is bound by the Canadian Shield. The Property is located near the northeast corner of the basin, where it comprises approximately 53 m of Ordovician dolomitic limestone underlain by approximately 7.5 m of Ordovician sandstone.

The Precambrian basement rocks of the Thompson Nickel Belt form a northeast southwest trending 10 to 35 km wide belt of variably reworked Archean age basement gneisses and Early Proterozoic age cover rocks along the northwest margin of the Superior Province. Lithotectonically, the Thompson Nickel Belt is part of the Churchill Superior boundary zone. The Archean age rocks to the southeast of the Thompson Nickel Belt include low to medium grade metamorphosed granite greenstone, and gneiss terrane and the high grade metamorphosed Pikwitonei Granulite Belt. The Pikwitonei Granulite Belt is interpreted to represent exposed portions of deeper level equivalents of the low to medium grade metamorphosed granite greenstone and gneiss terranes. The Superior Province Archean age rocks are cut by mafic to ultramafic dikes of the Molson swarm dated at 1883 mega annum (Ma).

Dikes of the Molson swarm occur in the Thompson Nickel Belt, but not to the northwest in the Kisseynew domain. The early Proterozoic rocks to the northwest of the Thompson Nickel Belt comprise the Kisseynew domain that is interpreted to represent the metamorphosed remnants of a back arc or inter arc basin. The variably reworked Archean age basement gneisses constitute the dominant portion (volumetrically) of the Thompson Nickel Belt. The Early Proterozoic rocks that occur along the western margin of the Thompson Nickel Belt are a geologically distinguishable stratigraphic sequence of rocks known as the Opswagan Group.

2.8 Geochemical Rock Characterization

This section summarizes the geochemical rock characterization program for the Minago Project. The program was led by URS and is consistent with widely accepted industrial standards. It occurred between April 2007 and November 2008 (URS, 2009i).

The objectives of the geochemical assessment were to (URS, 2009i):

- Assess major with respect to their Acid Rock Drainage (ARD) and Metal Leaching (ML) potential as waste rock and tailings material;
- Provide information for development of a waste management plan and application for mine development; and
- Determine whether subaqueous tailings storage will be sufficient to prevent ARD/ML from the tailings material.

The reaction of naturally-occurring metal sulphides (primarily iron sulphide) with oxygen and water can produce sulphuric acid or Acid Rock Drainage (ARD) over time. ARD is leachate drainage with a pH less than 4.5. The acidic drainage can dissolve metals in the sulphides and cause metal leaching (ML) by releasing metals to groundwater and/or surface water.

The geochemical program was conducted in two phases to characterize lithologic units that will be encountered, excavated and/or exposed during open pit mining, milling, and concentrating ore on-site by conventional flotation methods. The first phase consisted of static testing to determine the ARD/ML potential of all lithologic units (overburden, Ordovician dolomitic limestone, Ordovician sandstone, altered Precambrian basement, and Precambrian basement) and to design the second phase geochemical assessment program for the Minago site. The second phase involved the assessment of the multiple lithologies encountered within the Precambrian basement, including undifferentiated altered Precambrian basement, granitic rock material, Ultramafic rock that includes ore bearing materials, mafic metavolcanic rock materials, metasedimentary rock materials, and Molson Dike Swarm dikes and sills. The second phase geochemical assessment program consisted of static and kinetic testing and the determination of readily-soluble elements to identify elements that are of potential concern. The reaction rates of acid generating and acid consuming components were also determined (URS, 2009i).

Static testing involves subjecting test specimens to Acid-Base Accounting (ABA) tests (including fizz test, paste pH, inorganic carbonate content, total sulphur, sulphate sulphur, sulphide sulphur, and bulk Acid Neutralization Potential) and total metal content analysis.

In kinetic tests, humidity cell tests are used to simulate the oxidation reactions that would occur upon exposure of sulphidic materials to the environment. Kinetic tests are designed to verify the ARD and ML potential by enhancing and accelerating the rate of acid generation in sulphide-containing material so that results can be obtained in a timely manner to allow prediction of potential future impacts. Humidity cell tests tend to be better than static tests at evaluating the rate of acid production, the availability of acid neutralization, and resultant water quality over natural water pH ranges. Therefore, they are useful for determining whether materials with uncertain acid-generating status are likely to generate acid when exposed to oxidizing conditions.

2.8.1 Geochemical Assessment of Waste Rock

The geochemical characterization of waste rock and other mining wastes are given in the 2010 EIS document (Victory Nickel Inc., 2010), therefore only a summary of the results will be given in this section.

The standard Sobek method significantly over-estimated the ANP of material sampled from the Minago Project when compared to ANP measured using carbonate ANP and modified Sobek method, the results of which tended to be in relative agreement (URS, 2009i).

Overburden, Ordovician dolomitic limestone, and Ordovician sandstone material overlying the altered Precambrian basement and Precambrian basement lithologies are considered not potentially acid generating (NAG) and have minor metal leaching potential based on the results of this geochemical characterization program (URS, 2009i).

A preliminary screening of the elemental concentrations of overburden, Ordovician dolomitic limestone and Ordovician sandstone detected elevated chromium, nickel, sulphur, antimony, thorium and uranium. In overburden and Ordovician dolomitic limestone, concentrations of these elements were slightly elevated and likely represent local and/or regional background. In Ordovician sandstone, elevated chromium, nickel, and sulphur concentrations suggest a potential for metal leaching. The NPRs of composite samples containing Ordovician dolomitic limestone suggest that these materials could provide sufficient neutralization capacity to offset the AGP of Precambrian basement lithologies (URS, 2009i).

Generalized altered Precambrian basement and Precambrian basement samples contained low to high sulphide sulphur concentrations, coupled with low to moderate carbonate concentrations. The fresh material was considered to be PAG, while the altered material was equivocal: five of the eight altered Precambrian basement samples were NAG while three were PAG. Composite samples containing these lithologies and Ordovician sandstone or overburden were considered to be NAG. Screening of undifferentiated Precambrian basement material indicated elevated levels of barium, cobalt, chromium, copper, iron, nickel, and sulphur (URS, 2009i).

Granite is considered to be NAG, based on a low but variable sulphide sulphur content ranging from 0.02 to 0.39 % by weight (AGP values ranging from 0.63 to 12.2 kg $CaCO_3$/tonne) and low to moderate ANP values of 9.7 to 87.2 kg $CaCO_3$/tonne. Higher sulphide sulphur value and low ANP values occurred in one sample, which was considered to be PAG. The NPR value ranged from 0.8 to 105.5. Screening the elemental concentrations in granite indicated elevated levels of silver, arsenic, cadmium, cobalt, chromium, copper, iron, nickel, phosphorus, selenium, sulphur, antimony, and possibly bismuth and mercury (URS, 2009i).

Serpentinite was considered to be NAG based on low but variable sulphide sulphur values ranging from 0.02 to 0.80 % by weight (AGP values ranged from 0.6 to 23.1 kg $CaCO_3$/tonne) and ANP was moderate to high at values of 33.4 to 272.4 kg $CaCO_3$/tonne. The NPR values ranged from 3.0 to 268.3. Screening the elemental concentrations in these rock types indicated elevated levels of arsenic, copper, molybdenum, nickel, lead, selenium, sulphur, antimony (URS, 2009i).

Amphibolite, mafic dike, and altered Precambrian basement rock types contain negligible to low sulphide sulphur concentrations (<0.3 % by weight) and low to high carbonate concentrations. These rock types were considered to be NAG. The NPR values ranged from 5.1 to 10.2. Screening the elemental concentrations indicated elevated levels of silver, arsenic, cadmium, cobalt, chromium, copper, nickel, selenium, sulphur, antimony, and possibly bismuth and mercury (URS, 2009i).

Mafic metavolcanic rock was considered to be PAG based on low sulphide sulphur content (0.5 % by weight or an AGP of 14.4 kg $CaCO_3$/tonne) and an equally low ANP of 21.0 kg $CaCO_3$/tonne.

The NPR value was 1.5. Screening the elemental concentrations in this rock type indicated elevated levels of silver, cadmium, selenium, sulphur, antimony, and possibly bismuth (URS, 2009i).

Metasedimentary rock was considered to be PAG based on a variable sulphide sulphur content of 0.2 to 5.1 % by weight (AGP of 5.3 to 160.0 kg $CaCO_3$/tonne) and a low to moderate ANP of 6.8 to 89.3 kg $CaCO_3$/tonne. The NPR value ranged from 0.1 to 7.7. Screening the elemental concentrations indicated elevated levels of silver, cadmium, cobalt, chromium, copper, nickel, selenium, sulphur, antimony, and possibly mercury (URS, 2009i).

The sample population of rock types used to draw these conclusions is small relative to the estimated volume of waste rock expected to be generated by mining activities at the Minago Project, and additional static testing may be required on discrete samples of all lithologies to develop a statistically valid dataset to confirm the conclusions of this geochemical assessment (URS, 2009i).

2.8.1.1 Waste Rock Kinetic Test Program

The carbonate molar ($Ca+Mg/SO_4$) ratios in conjunction with the sulphate, calcium, and magnesium loading rates indicated that carbonate dissolution in the humidity cells was not solely attributable to sulphide oxidation and acid generation.

Humidity cell NPR values categorized the humidity cells as near PAG (NPR = 3.7) or NAG (NPR ranged between 7.8 and 40.5). The calculated times to depletion of carbonate minerals was greater than for sulphide minerals in all the humidity cell tests, and so all the cell samples were considered NAG.

Humidity cells containing Ordovician dolomitic limestone yielded lower sulphide loading rates from a higher initial sulphide sulphur content, suggesting that limestone may have provided micro-scale neutralization of sulphide oxidation.

The leaching rates from the humidity cells for all metals of concern (nickel, aluminum, molybdenum, selenium, chromium, cobalt, copper, iron, and trace elements such as strontium) were low, indicating that metal leaching from waste rock, pit walls and other waste materials may be low.

Loading rates from kinetic humidity cell tests of samples of altered Precambrian basement and Precambrian basement material, encountered in and adjacent to the pit shell, indicated the time to completely oxidize the acid generating potential (i.e., sulphide material) was 12 to 58 years, while the time calculated to consume the acid neutralization potential (i.e., carbonate material) was a period of 49 to 954 years. These humidity cell test results also suggest that limestone mixed with altered Precambrian basement and Precambrian basement could be effective in providing excess acid neutralization capacity to compensate secondary sulphide oxidation products on a micro-scale or meso-scale in-situ (URS, 2009i).

URS (2009i) recommended an operational program for static testing on blast hole cuttings based on a geologic block model. Based on kinetic test carbonate molar ratios, URS recommended a preliminary neutralization potential ratio of 1.7 for segregating PAG from NAG waste rock materials (URS, 2009i).

URS (2009i) recommended the following common method for differentiating PAG from NAG material, used at many operating mines, for the Minago Project:

- Collect samples from blasthole cuttings in PAG waste material – ultramafic and granitic;
- Perform static testing (using ABA and/or other appropriate surrogate methods) and fizz tests of blasthole cuttings at an on-site laboratory;
- Input the static test results into a geologic block model and krig the results;
- Communicate the in-pit PAG/NAG limits to pit operators; and
- Dispose of the material in the appropriate disposal areas, based on the PAG/NAG delineation.

This process has been used successfully at several open pit mines in British Columbia, including the Huckleberry Mine, QR Mine, and Kemess South Mine (URS, 2009i).

2.8.2 Geochemical Assessment of Tailings

The tailings assessment was intended to determine the ARD/ML potential of tailings material. The results were used to determine whether subaqueous tailings storage will be sufficient to prevent ARD/ML from the tailings material. The Minago Project tailings geochemical assessment had two parts: a static testing program and a kinetic testing program. Based on discussions with representatives of VNI and Wardrop, the basis of kinetic testing of tailings was that tailings would be contained in a flooded tailings impoundment.

The objectives of the static program were to determine 1) whether representative tailings samples will be PAG or acid-neutralizing, and 2) the total ML potential within those samples. Based on static test results for the tailings samples and the very low sulphur content, it was not considered necessary to calculate primary sulphide oxidation, acid generation, carbonate dissolution, or acid neutralization rates (URS, 2009i). Therefore, the objectives of the tailings kinetic testing program were to assess 1) the geochemical stability of tailings under saturated conditions and 2) potential leachate water quality and chemical loading rates from the tailings.

2.8.2.1 Analytical Methods

In August 2007, after conferring with Victory Nickel and Wardrop about the Minago Project metallurgical testing program, URS requested SGS-CEMI to produce a master tailings composite sample from their 2006 lock cycle metallurgical testing. This sample was called the “2006 Master Lock Cycle Composite” sample.

In 2007, Wardrop completed a second round of bulk metallurgical testing, which was considered to be more representative of the nickel grades within the Minago deposit. The lock cycle test cleaner scavenger and rougher rejects were considered more representative of the potential tailings geochemistry at Minago. The following two samples were produced for static testing by SGS-CEMI (URS, 2009i):

- The “2007 0.3% Ni Lock Cycle Tails” sample contained 0.3 % by weight nickel grade material; and
- The “2007 Master Lock Cycle Composite” sample contained a composite of the master lock cycle material.

2.8.2.1.1 Static Test Program

Static testing for the Minago Project involved subjecting test specimens to Acid-Base Accounting (ABA) tests and total metal content analysis by inductively-coupled atomic emissions spectrometry (ICP-AES). The static tests were conducted by SGS - Canadian Environmental and Metallurgical Inc. (SGS-CEMI), located in Burnaby, British Columbia. The static testing included the following parameters:

- Fizz Test;
- Paste pH;
- Weight % CO_2, which was converted to Total Inorganic Carbonate (TIC) content expressed as $CaCO_3$ equivalents;
- Total Sulphur content, expressed as weight %;
- Sulphate Sulphur content, expressed as weight %;
- Insoluble sulphur content, expressed as % by weight;
- Sulphide sulphur content, expressed as % by weight and determined from the difference between total sulphur and sulphate sulphur plus insoluble sulphur (where sulphate and insoluble sulphur were analyzed); and
- ANP by both modified Sobek and standard Sobek methods.

From the analytical results the following ABA parameters were calculated:

- AGP was calculated from sulphide sulphur content;
- Net-ANP was calculated from the difference between modified Sobek ANP and AGP; and

- NPR was calculated as the ratio of the modified Sobek ANP to AGP.

2.8.2.1.2 Total Metals

The three tailings lock cycle composite samples were submitted to SGS-CEMI for analysis of total metals by ICP-AES following digestion by aqua regia.

2.8.2.1.3 Particle Size Analysis

The 2007 0.3% Ni Lock Cycle Tails sample was submitted for particle size analysis to classify the material based on the Unified Soil Classification System.

2.8.2.1.4 Leachate Extraction Tests

The three tailings lock cycle composite samples were submitted to SGS-CEMI for shake flask extraction tests to determine readily leachable constituents. The shake flask extraction tests were the first step in determining the likelihood of metal leaching from potential tailings material.

2.8.2.1.5 Mineralogical Analysis

A sub-sample of the 2007 0.3% Ni Lock Cycle Tails sample was submitted to the Department of Earth and Ocean Sciences at the University of British Columbia for mineralogic analysis with X-ray diffraction using the Rietveld method. Sub-samples of both the 2006 Master Lock Cycle Composite and 2007 Master Lock Cycle Composite samples were submitted to SGS-CEMI for mineralogical analysis using QEMSCAN and Scanning Electron Microscope equipped with Energy Dispersive Spectrometer (URS, 2009i).

2.8.2.1.6 Kinetic Test Program

Kinetic testing of tailings was carried out under saturated conditions as the tailings are planned to be contained in a flooded tailings impoundment. The objectives of the conducted kinetic testing program were to:

- Assess the geochemical stability of tailings under saturated conditions; and if possible;
- Assess the relative rates of acid generation and acid neutralization of tailings;
- Assess the relative timing of complete sulphide oxidation (acid generation) and complete weathering/dissolution of carbonate minerals (acid neutralization) and if acid neutralization is exhausted prior to acid generation, the potential onset of Acid Rock Drainage and Metal Leaching (ARD / ML);
- Predict leachate water quality and loadings from tailings; and
- Predict final effluent discharge water quality and, if necessary, the potential requirement for effluent treatment.

Due to sample availability, only the 2007 0.3% Ni Lock Cycle Tails sample was submitted to SGS-CEMI for laboratory kinetic subaqueous column tests, including (adapted from URS, 2009i):

- Biweekly cycling with 100 ml of de-ionized water added on even weeks and 160 ml of de-ionized water added on odd weeks for 54 weeks;
- Weekly measurement of pH, oxidation reduction potential, specific conductivity and sulphate;
- Biweekly measurement of acidity, alkalinity, and dissolved oxygen on odd weeks; and
- Weekly analysis of total metals by ICP-AES.

2.8.2.2 Results

2.8.2.2.1 Static Test Results for Tailings

Results of the static test program on tailings are summarized below and in Table 2.8-1. Detailed results are provided in Appendix 2.8 and elsewhere (URS, 2009i).

2006 Master Lock Cycle Composite

The 2006 Master Lock Cycle Composite sample had a total sulphur content of 0.12 % by weight, of which 0.03 % by weight was sulphate sulphur and 0.02 % by weight was insoluble sulphur (Table 2.8-1). By difference, the sulphide sulphur content was 0.07 % by weight, equating to an AGP of 2.2 kg $CaCO_3$/tonne. The TIC content was 0.41 % by weight, equating to a carbonate ANP of 34.2 kg $CaCO_3$/tonne. The Sobek ANP was 433.4 kg $CaCO_3$/tonne, and the modified Sobek ANP was 72.4 kg $CaCO_3$/tonne. The carbonate ANP and modified Sobek ANP values were in reasonable agreement with one another. However, the standard Sobek method significantly overestimated the sample's ANP. URS (2009i) attributed the higher ANP value by the standard Sobek method to dissolution of low soluble carbonate minerals and aluminosilicate minerals. The NPR based on the modified Sobek ANP was 34.1, and the sample material is considered to be NAG.

Table 2.8-1 Static Test Results for Minago Tailings

Sample ID	paste pH	Fizz Test	Total Inorganic Carbon (TIC) (wt%)	Carbonate Acid Neutralization Potential (kg $CaCO_3$/tonne)	Total Sulphur (wt%)	Sulphate Sulphur (wt%)	Sulphide Sulphur (wt%)*	Insoluble Sulphur (wt%)*	AGP** (kg $CaCO_3$/tonne)	Standard Sobek: ANP (kg $CaCO_3$/tonne)	Standard Sobek: Net-ANP (kg $CaCO_3$/tonne)	Standard Sobek: NPR (ANP/AGP)	Modified Sobek: ANP (kg $CaCO_3$/tonne)	Modified Sobek: Net-ANP (kg $CaCO_3$/tonne)	Modified Sobek: NPR (ANP/AGP)
Tails Composite - 2007 [1]	8.38		0.38	31.7	0.12	0.02	0.04	0.06	1.3	455.9	454.7	364.7	74.7	73.5	59.8
Tails Composite - 2007 [2]	8.41	None	0.46	38.3	0.12	0.05	0.07	<0.01	2.2	397.2	395.0	181.6	76.5	74.3	35.0
Tails Composite - 2006 [3]	8.70	Slight	0.41	34.2	0.12	0.03	0.07	0.02	2.2	433.4	431.2	198.1	74.6	72.4	34.1
Detection Limits	0.1		0.03	---	0.02	0.01	---	---	---	0.1	0.1	---	0.1	0.1	---

Notes:

* Based on difference between total sulphur and sulphate-sulphur.

** Based on sulphide-sulphur.

AGP = acid generation potential in kilograms $CaCO_3$ equivalent per tonne of material.

ANP = acid neutralization potential in kilograms $CaCO_3$ equivalent per tonne of material.

NPR = ANP / AGP

[1] = 2007 Master lock cycle composite tailings sample (1st cleaner and rougher tailings).

[2] = 2007 0.3 % Ni lock cycle composite tailings sample (1st cleaner and rougher tailings).

[3] = 2006 Master lock cycle composite tailings sample (1st cleaner and rougher tailings).

Source: URS, 2009i

2007 0.3% Nickel Lock Cycle Composite

The static test results for the 2007 0.3% Ni Lock Cycle Tails sample had a total sulphur content of 0.12 % by weight, of which 0.05 % by weight was sulphate sulphur and <0.01 % by weight was insoluble sulphur (Table 2.8-1). By difference, the sulphide sulphur content was 0.07 % by weight, equating to an AGP of 2.2 kg $CaCO_3$/tonne. The TIC content was 0.46 % by weight, equating to a carbonate ANP of 38.3 kg $CaCO_3$/tonne. ANP by the standard Sobek method was 397.2 kg $CaCO_3$/tonne, and the modified Sobek ANP was 76.5 kg $CaCO_3$/tonne. Again, the standard Sobek method significantly overestimated the sample's ANP. The NPR based on the modified Sobek ANP was 35.0, and the sample material is considered to be NAG.

2007 Master Lock Cycle Composite

The 2007 Master Lock Cycle Composite sample had a total sulphur content of 0.12 % by weight, of which 0.02 % by weight was sulphate sulphur and 0.06 % by weight was insoluble sulphur (Table 2.8-1). By difference, the sulphide sulphur content was 0.04 % by weight equating to an AGP of 1.3 kg $CaCO_3$/tonne. The TIC content was 0.38 % by weight, equating to a carbonate ANP of 31.7 kg $CaCO_3$/tonne. ANP by the standard Sobek method was 455.9 kg $CaCO_3$/tonne, and the modified Sobek ANP was 74.7 kg $CaCO_3$/tonne. Again, the standard Sobek method significantly overestimated the sample's ANP. The NPR based on the modified Sobek ANP was 59.8, and the sample material is considered to be NAG per tonne and the modified Sobek ANP was 59.8 kg $CaCO_3$ per tonne. The Neutralization Potential Ratio based on the modified Sobek ANP was 59.8.

Comparison of Tailings Static Test Results

The static test results from all three samples show a reasonable correlation of both the sulphur species content in the tailings and Acid Generation Potential (AGP), and the TIC and Acid Neutralization Potential ANP. Static test results are also in reasonable agreement with the 2006 tailings lock cycle composite tested by SGS Lakefield in 2010 EAP/EIS . The tailings sample tested by SGS Lakefield had 0.7 weight % total sulphur and <0.04 weight % sulphate sulphur and a modified Sobek ANP of 88.8 kg $CaCO_3$ per tonne.

Based on the static test results, the metallurgical lock cycle testing on two (2) bulk samples from the Minago deposit recovered the majority of sulphide minerals as evidenced by the very low sulphide sulphur content in the cleaner scavenger and rougher tailings tested. Based on the low sulphide sulphur content and high carbonate content, the tested tailings samples are considered to be non-acid generating (NAG).

2.8.2.2.2 Total Metals

The total metal concentrations in the tested tailings are shown in Table 2.8-2. Elemental concentrations were compared to normal elemental concentrations in typical ultramafic rock types

Table 2.8-2 Total Elements Minago Tailings

Sample #	Rock Type	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	La	Mg	Mn
		ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	ppm	%	ppm	%	ppm
2007 Tails Composite [1]	Tailings	0.1	1.14	1.3	**191**	1	0.4	0.74	0.1	57.8	347	**69.7**	5.27	<0.1	0.57	47	**>10.00**	511
2007 Tails Composite [2]	Tailings	<0.2	0.85	**<5**	**192**	0.6	<5	0.92	2	93	259	**8**	5.44	<1	0.5	59	**>15.00**	524
2006 Tails Composite [3]	Tailings	<0.2	0.89	**7**	**166**	<0.5	<5	0.92	2	48	319	**46**	4.51	<1	0.35	40	**>15.00**	435
Ultrabasic [4]		0.06	2.00	1	0.4	na	na	2.50	na	150	1600	10	9.43	na	40	na	2.04	1620
3X Ultrabasic		0.180	6.00	**3**	**1.2**			7.50		450	4800	**30**	28.3		120		**6.12**	4860

Sample #	Rock Type	Mo	Na	Ni	P	Pb	S	Sb	Sc	Sr	Th	Ti	Tl	U	V	W	Zn	Zr
		ppm	%	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
2007 Tails Composite [1]	Tailings	1.2	0.05	>1000.0	0.025	1.6	**0.14**	<0.1	5.4	**53**	**4.7**	0.024	0.1	**3.9**	20	4.3	72	2.7
2007 Tails Composite [2]	Tailings	<2	0.03	2456	65	**8**	**0.15**	**6**	4	**29**	**<5**	0.02	<10	**26**	16	<10	60	6
2006 Tails Composite [3]	Tailings	<2	0.05	2292	111	**6**	**0.13**	**9**	5	**11**	**8**	0.03	<10	**20**	30	<10	22	6
Ultrabasic [4]		0.3	0.42	2000	220	1	0.03	0.10	15	1	0.004	0.03	1	0.001	40	0.7	50	45
3X Ultrabasic		0.9	1.26	6000	660	**3**	**0.09**	**0.30**	45	**3**	**0.012**	0.09	**3**	**0.003**	120	2.1	150	135

Notes:

[1] 2007 Master lock cycle composite tailings sample (1st cleaner and rougher tailings).
[2] 2007 0.3 % Ni lock cycle composite tailings sample (1st cleaner and rougher tailings).
[3] 2006 Master lock cycle composite tailings sample (1st cleaner and rougher tailings).
[4] Source: Turekian and Wedepohl (1961)

Source: URS (2009i)

for screening purposes (Turekian and Wedepohl, 1961). For screening purposes, levels greater than three times the normal concentration was considered to be elevated. The results indicate elevated concentrations of arsenic, barium, copper, lead, antimony, strontium, thallium, and uranium. In general, there was reasonable agreement in concentrations of the same element in all three tailings samples. The full laboratory analytical results are provided in Appendix 2.8.

2.8.2.2.3 Particle Size Analysis

Results of the grain size analysis of the 2007 0.3% nickel lock cycle composite sample are given in Appendix 2.8. The tailings particle size fell within three general ranges:

- 14%: +60 mesh or 0.25 mm diameter;
- 25%: -140 mesh (0.106 mm) to +270 mesh (0.053 mm); and
- 35%: -325 mesh (0.044 mm).

Based on the USCS soil classification system the tailings are considered to be primarily composed fine sand, silt and clay sized particles.

2.8.2.2.4 Leachate Extraction Results

The results of shake flask extraction tests are shown in Table 2.8-3. The full laboratory analytical results are included in Appendix 2.8. Selenium ranged between 0.9 and 2.08 µg/L; boron ranged between 1,750 and 3,350 µg/L; and nitrite ranged between 0.021 and 0.184 µg/L. The nitrite may have originated from the process chemicals used during the lock cycle testing. Only selenium and nitrite concentrations slightly exceeded Manitoba guideline limits.

Further test work could identify the possible sources of nitrite and assess whether mill process water effluent could contain similar nitrite levels.

2.8.2.2.5 Mineralogical Analysis

The minerals identified using X-ray diffraction in the 2007 0.3% Ni Lock Cycle Tails sample were (in decreasing abundance): antigorite, lizardite, phlogopite, talc, magnetite, dolomite, quartz, vermiculite, and calcite. These minerals reflect mineralogy of altered granite and serpentinite of the Minago deposit. The slower-reacting carbonate mineral dolomite was found to be more abundant than calcite in the tailings sample. The full analytical report is provided in URS (2009i).

The mineralogy identified in both Master Lock Cycle Composite samples using SEM-EDS was consistent with the Rietveld X-ray diffraction analysis. The following non-sulphide minerals were identified (in decreasing abundance): serpentinite, talc, amphibole, phlogopite, carbonate, olivine, chlorite, and quartz. Sulphide minerals identified by Scanning Electron Microscope equipped with Energy Dispersive Spectrometer included millerite, pentlandite, chalcopyrite, pyrite and violarite.

Table 2.8-3 Shake Flask Extraction Test Results for Minago Tailings

Sample ID			1st Cleaner + Rougher Tails Composite	1st Cleaner + Rougher Tails Composite	1st Cleaner + Rougher Tails Composite	REGULATIONS			
Parameter	**Method**	**Units**	**2006 - Master**	**2007 - 0.3% Ni**	**2007 - Master**	**Manitoba**	**Tier**	**CCME**	**MMER [1]**
Volume Nanopure water		mL	1800	-	1800				
Sample Weight		g	600	-	600				
pH	meter		8.08	8.3	8.02	6.5-8.5	III	6.5-9	6.5-9
Redox	meter	mV	411	435	374				
Conductivity	meter	uS/cm	590	803	522				
Acidity (to pH 4.5)	titration	mg CaCO3/L	na	na	na				
Total Acidity (to pH 8.3)	titration	mg CaCO3/L	2.5	na	3.2				
Alkalinity	titration	mg CaCO3/L	67.2	94.5	58.4				
Fluoride		mg/L	0.9	0.63	50				
Chloride		mg/L	47.5	114	0.7				
Bromide		mg/L	0.12	1.60	4.1				
Ammonia		mg/L	0.08	0.06	0.04	here: 1.5-8.4	II	19 (as NH_3)	
Nitrite		mg/L	0.184	0.021	<0.5	0.06 (NO2-N)	III	0.06 (NO2-N)	
Nitrate		mg/L	0.07	0.07	<2	10 (as NO3-N)	III		
Sulphate	Turbidity	mg/L	148	176	132	500	III	--	
Dissolved Metals									
Hardness CaCO3		mg/L	165	165	145				
Aluminum Al	ICP-MS	µg/L	2	2.3	8.8	100	III	100	
Antimony Sb	ICP-MS	µg/L	2.21	1.90	0.62	--			
Arsenic As	ICP-MS	µg/L	0.52	0.40	1.30	150[A]	II	5	1000
Barium Ba	ICP-MS	µg/L	37.8	32.0	53.5	--			
Beryllium Be	ICP-MS	µg/L	<0.010	<0.010	0.02	--			
Bismuth Bi	ICP-MS	µg/L	<0.005	<0.005	<0.005	--			
Boron B	ICP-MS	µg/L	1750	3350	2830	5000	III		
Cadmium Cd	ICP-MS	µg/L	0.021	<0.005	0.010	here: 2.9-3.2[B]	II	0.017	
Calcium Ca	ICP-MS	µg/L	40200	16500	17600	--			
Chromium Cr	ICP-MS	µg/L	1.4	0.1	4.8	here: 100.5-111.7[C]	II	8.9 [3]	
Cobalt Co	ICP-MS	µg/L	0.124	0.1	0.287	--			
Copper Cu	ICP-MS	µg/L	1.44	0.3	0.32	here: 12.3-13.7[D]	II	3[2]	600
Iron Fe	ICP-MS	µg/L	3	<1	2	300	III	300	
Lead Pb	ICP-MS	µg/L	0.12	0.018	0.014	here: 3.8-4.3[E]	II	here: 4[2]	400
Lithium Li	ICP-MS	µg/L	26.2	33.5	49.2	--			
Magnesium Mg	ICP-MS	µg/L	15700	22400	24500	--			
Manganese Mn	ICP-MS	µg/L	1.25	1.4	1.96	--			
Mercury Hg	CVAA	µg/L	<0.01	<0.01	<0.01	0.1	III	0.026	
Molybdenum Mo	ICP-MS	µg/L	9.87	10.4	12.3	73	III	73	
Nickel Ni	ICP-MS	µg/L	22.1	8.8	42.5	here: 71.2-79.4[F]	II	here: 110[2]	1000
Potassium K	ICP-MS	µg/L	16400	20100	17300	--			
Selenium Se	ICP-MS	µg/L	1.71	0.9	2.08	1	III	1	
Silicon Si	ICP-MS	µg/L	2090	1650	2690	--			
Silver Ag	ICP-MS	µg/L	0.006	<0.005	0.01	0.1	III	0.1	
Sodium Na	ICP-MS	µg/L	48200	105000	40600	--			
Strontium Sr	ICP-MS	µg/L	307	243	306	--			
Sulphur (S)	ICP-MS	µg/L	57000	46000	58000	--			
Thallium Tl	ICP-MS	µg/L	0.287	0.122	0.327	0.8	III	0.8	
Tin Sn	ICP-MS	µg/L	0.07	0.01	0.02	--			
Titanium Ti	ICP-MS	µg/L	<0.5	<0.5	<0.5	--			
Uranium U	ICP-MS	µg/L	0.049	0.073	0.045	--			
Vanadium V	ICP-MS	µg/L	<0.2	<0.2	<0.2	--			
Zinc Zn	ICP-MS	µg/L	0.8	0.8	0.5	here: 161.9-180.6[G]	II	30	1000
Zirconium Zr	ICP-MS	µg/L	<0.1	<0.1	<0.1	--	III		
Ra-226		Bq/L	na	0.02	0.04	0.6	III		0.37

Notes:

1 monthly mean 2002 Metal Mining Effluent Regulations (MMER) requirements also include cyanide, TSS and acute toxicity.

2 guideline concentration in CCME Water Quality Guidelines for the protection of freshwater aquatic life (Dec. 2007) depends on hardness.

3 chromium III

Manitoba Water Quality Standards, Objectives, and Guidelines (Williamson, 2002):

A Arsenic limits: 0.15 mg/L for averaging duration 4 days (4-Day, 3-Year or 7Q10 Design Flow); 0.34 mg/L for averaging duration 1 hr (1-Day, 3-Year or 1Q10 Design Flow)

B Cadmium limits: [e{0.7852[ln(Hardness)]-2.715}]×[1.101672-{ln(Hardness)(0.041838)}] for 4 days averaging duration.
[e{1.128[ln(Hardness)]-3.6867}]×[1.136672-{ln(Hardness)(0.041838)}] for 1 hour averaging duration.

C Chromium limits: Chromium III: [e{0.8190[ln(Hardness)]+0.6848}]×[0.860] for 4 days averaging duration.
Chromium III: [e{0.8190[ln(Hardness)]+3.7256}]×[0.316] for 1 hour averaging duration.
Chromium VI: 0.011 mg/L for averaging duration 4 days (4-Day, 3-Year or 7Q10 Design Flow);
0.016 mg/L for averaging duration 1 hr (1-Day, 3-Year or 1Q10 Design Flow)

D Copper limits: [e{0.8545[ln(Hardness)]-1.702}]×[0.960] for 4 Days hour averaging duration.
[e{0.9422[ln(Hardness)]-1.700}]×[0.960] for 1 hour averaging duration.

E Lead limits: [e{1.273[ln(Hardness)]-4,705}]×[1.46203 -{ln(Hardness)(0.145712)}] for 4 Days averaging duration.
[e{1.273[ln(Hardness)]-1.460}]×[1.46203 -{ln(Hardness)(0.145712)}] for 1 hour averaging duration.

F Nickel limits: [e{0.8460[ln(Hardness)]+0.0584}]×[0.997] for 4 Days averaging duration.
[e{0.8460[ln(Hardness)]+2.255}]×[0.998] for 1 hour averaging duration.

G Zinc limits: [e{0.8473[ln(Hardness)]+0.884}]×[0.976] for 4 Days averaging duration.
[e{0.8473[ln(Hardness)]+0.884}]×[0.978] for 1 hour averaging duration.

Source: adapted from URS, 2009i

All were less than 1% in abundance. An important note regarding all sulphide minerals identified are their extremely small size, ranging up to 400 µm but typically ranging from 5 to 25 µm.

2.8.2.2.6 Kinetic (Subaqueous Column) Test Results for Tailings

Weekly loading rates, expressed in mg/kg/week, were calculated for the 54 week long kinetic subaqueous column test SAC-1. The volume of extracted leachate was multiplied by the measured concentration and divided by the sample mass. The calculated loading rates, therefore, tended to fluctuate week-to-week since the column was cycled biweekly with 160 ml of water on odd weeks and 100 ml of water on even weeks. Analyses were made on samples of both column surface water and pore water. Where constituents were not detected above laboratory detection limits, the detection limit was taken to be the measured value. While loading rates were calculated for most constituents or parameters, only those considered most relevant are discussed below. These include pH, sulphate, aluminum, nickel, chromium, selenium, calcium, and magnesium (Table 2.8-4). Loading rates for all constituents and parameters can be found in Appendix 2.8.

The pH surface and pore water was similar, near-neutral, and relatively constant, and pH ranged between 6.45 and 8.39 (Table 2.8-4). Overall, there was a very slight increase in pH to week 54 that was likely the result of non-sulphide dissolution of carbonate and/or aluminosilicate minerals in the tailings (URS, 2009i). The pH values in surface water were similar to those in the column pore water (Table 2.8-4).

The sulphate loading rates in pore water were initially half as high as those in surface water, but by week 5 the pore water loading rate exceeded that in surface water and remained higher throughout the test. Surface water loading rates were initially near 4 mg/kg/wk (Appendix 2.8) and likely represented limited carbonate dissolution. After week 11, surface water sulphate loading rates fell off and gradually decreased to approximately 1.5 mg/kg/wk during the last weeks of the test. The pore water sulphate loading rates were initially approximately 2 mg/kg/wk increasing to a maximum peak of 15 mg/kg/wk at week 13 (Appendix 2.8). After week 13, sulphate loading rates gradually decreased to less than 4 mg/kg/wk at week 54. The disconnect between surface and pore water loading rates indicated that these waters were not in equilibrium (URS, 2009i).

Aluminum loading rates were very similar in surface and pore water. Typical loading rates ranged between 0.000046 and 0.00014 mg/kg/wk, and peaks were detected at weeks 16, 22, 27, 31, 45, and 49 (Appendix 2.8). These peaks are interpreted as localized changes in mineral equilibrium due to aluminosilicate weathering and dissolution (URS, 2009i).

Nickel loading rates for surface water were on average approximately five times greater than in pore water (Appendix 2.8); surface water loading rates ranged between 0.00018 and 0.00084 mg/kg/wk, and pore water loading rates ranged between 0.00002 and 0.00023 mg/kg/wk. The increased oxygen content in the surface water samples, and subsequent increased sulphide mineral oxidation, is likely responsible for the difference in nickel loading rates between the surface and pore waters (URS, 2009i).

Table 2.8-4 Laboratory Kinetic Test Results and Loading Rates for Minago Tailings

Subaqueous Column - Surface Water
Sample = 1st Cleaner + Rougher Tails

	pH	Loading Rates (mg/kg/wk) [1]												
		Sulphate mg/kg/wk	Aluminum mg/kg/wk	Antimony mg/kg/wk	Arsenic mg/kg/wk	Cadmium, mg/kg/wk	Chromium mg/kg/wk	Copper mg/kg/wk	Iron mg/kg/wk	Lead mg/kg/wk	Molybdenum mg/kg/wk	Nickel mg/kg/wk	Selenium mg/kg/wk	Zinc mg/kg/wk
Minimum	6.45	0.76	2.00E-05	6.08E-06	2.00E-06	1.60E-07	3.20E-06	1.80E-05	3.20E-05	9.28E-07	6.00E-05	1.80E-04	4.00E-06	4.16E-05
Average	7.55	1.99	2.12E-04	9.29E-06	1.30E-05	7.49E-07	1.21E-05	8.01E-05	1.57E-04	1.62E-05	1.18E-04	4.02E-04	8.72E-06	1.30E-04
Maximum	8.15	4.80	1.44E-03	1.18E-05	6.40E-05	7.68E-06	2.00E-05	2.24E-04	6.20E-04	1.63E-04	1.96E-04	8.42E-04	2.18E-05	7.68E-04

Subaqueous Column - Pore Water
Sample = 1st Cleaner + Rougher Tails

	pH	Loading Rates (mg/kg/wk) [1]												
		Sulphate mg/kg/wk	Aluminum mg/kg/wk	Antimony mg/kg/wk	Arsenic mg/kg/wk	Cadmium, mg/kg/wk	Chromium mg/kg/wk	Copper mg/kg/wk	Iron mg/kg/wk	Lead mg/kg/wk	Molybdenum mg/kg/wk	Nickel mg/kg/wk	Selenium mg/kg/wk	Zinc mg/kg/wk
Minimum	6.97	2.56	2.00E-05	1.00E-05	6.00E-06	1.92E-07	3.20E-06	2.00E-05	1.40E-04	4.16E-07	4.20E-04	2.00E-05	1.28E-06	3.52E-05
Average	7.79	6.95	2.21E-04	3.22E-05	2.39E-05	7.41E-07	1.23E-05	9.39E-05	5.27E-04	9.62E-06	7.44E-04	8.93E-05	3.51E-06	1.15E-04
Maximum	8.39	15.20	1.15E-03	1.63E-04	1.20E-04	4.61E-06	2.00E-05	4.35E-04	1.96E-03	1.06E-04	1.13E-03	2.30E-04	9.28E-06	3.84E-04

1 Loading rates are calculated as the average loading rates during weeks 11-54, when the subaqueous column was in steady state.

Source: adapted from URS, 2009i

Chromium concentrations in surface and pore water were at or below laboratory detection limits throughout the test (Appendix 2.8), and the highest calculated loading rate was 0.00002 mg/kg/wk.

Selenium loading rates decreased during the test (Appendix 2.8) and ranged between 0.000004 and 0.000022 mg/kg/wk in surface water and between 0.0000013 and 0.0000093 mg/kg/wk in pore water.

Calcium and magnesium loading rate profiles were similar to the sulphate loading rate profiles; these rates increased between weeks 1 and 12 in pore water while remaining fairly constant in surface water, and then they declined consistently through the rest of the test (Appendix 2.8). Surface water calcium loading rates peaked at 1.04 mg/kg/wk and dropped to 0.37 mg/kg/wk at test's end. Pore water calcium loading rates peaked at 2.7 mg/kg/wk and dropped to 0.5 mg/kg/wk at test's end. Surface water magnesium loading rates peaked at 0.46 mg/kg/wk and dropped to 0.16 mg/kg/wk at test's end. Pore water magnesium loading rates peaked at 1.20 mg/kg/wk and dropped to 0.4 mg/kg/wk at test's end.

Molar ((Ca + Mg) / SO_4) Ratios and Carbonate Depletion Rates

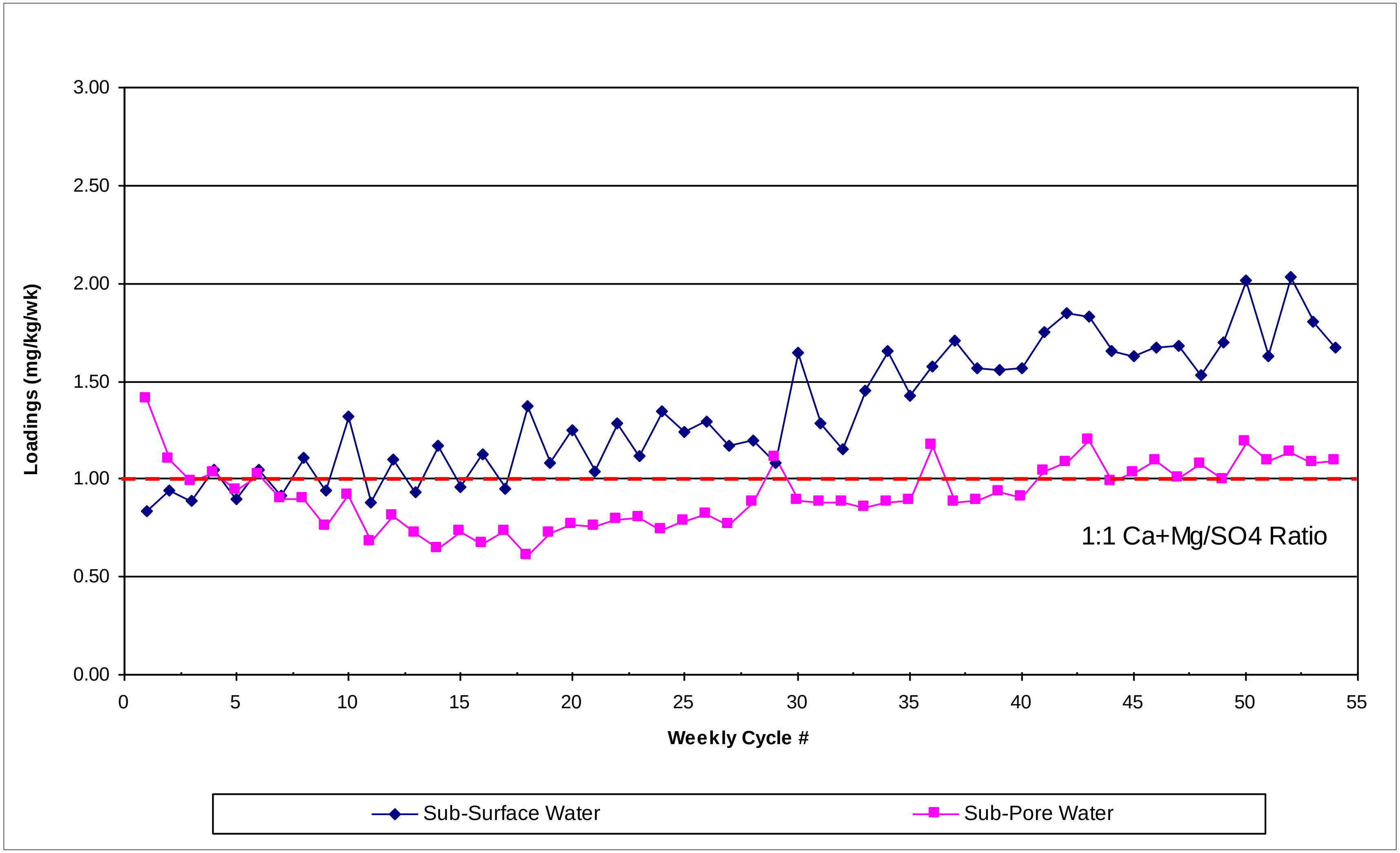
Carbonate molar ratios (the molar ratio of calcium and magnesium to sulphate in the leachates; (Ca+Mg)/SO_4) for the subaqueous column test SAC-1 are shown in Figure 2.8-1. This unit less ratio provides an estimate of the proportion of carbonate material that is released (dissolved) in response to both sulphide oxidation and to processes other than acid neutralization.

The molar ratios for the column surface water varied around a value of 1.0 for the first 17 weeks of the test (Figure 2.8-1), indicating that for every molecule of sulphide mineral oxidized to sulphate, one molecule of carbonate was dissolved. After week 17, the ratio increased from approximately 1.0 to 2.0, which appeared to have resulted from increased carbonate dissolution. This shift to higher molar ratios may have occurred as carbonate material maintained chemical equilibrium with the surface water solution because both sulphate and carbonate loading rates were decreasing during this period of the test (Appendix 2.8) (URS, 2009i).

The molar ratios for the column pore water decreased from a peak value of 1.4 to 0.6 over the first 18 weeks of the column, gradually increased to 0.9 by week 40, and then remained at approximately 1 for the rest of the test (Figure 2.8-1). The beginning of the test was a period when both sulphate and carbonate loading rates were increasing in the pore water, and the decrease in the molar ratio appears to be the result of both pore water coming into chemical equilibrium with the minerals and sulphide mineral oxidation. During the last 13 weeks carbonate dissolution and sulphide oxidation appear to be in a 1:1 relationship (URS, 2009i).

Acid Generation Potential Depletion Rates and Timing

The weekly sulphate loading rates determined from the tailings subaqueous column were used to determine the average rate of AGP (sulphide mineral) depletion. Based on these results, weeks



Source: adapted from URS (2009i)

Figure 2.8-1 Carbonate Molar Ratios for Minago Tailings

11 to 54 were considered steady-state or equilibrium conditions and this value was used in rate calculations. It should be noted that subaqueous columns are not intended to provide primary reaction rates of sulphide oxidation, as mineral dissolution and secondary mineral precipitation reactions that mask primary reaction rates can occur in the tailings. Thus, these sulphate loading rates are expected to be lower than primary reaction rates obtained from a humidity cell and must be used with caution. However, these rates may be closer to actual field rates and can be a useful indicator of the relative difference in AGP and ANP rates and the time to their depletion. The sulphide sulphur concentrations from pre-kinetic static tests of the humidity cell sample materials were used as the initial AGP values.

Based on the calculated loading rates from tailings material, the calculated rate of AGP depletion from tailings surface water was 0.021 mmol/kg/wk (Table 2.8-5), and the estimated time to depletion of AGP from the sample was approximately 19 years. The sulphide depletion rate in tailings pore water was 0.072 mmol/kg/wk (Table 2.8-5), and the estimated time to AGP depletion was approximately five years. Details are given in Appendix 2.8.

Acid Neutralization Potential Depletion Rates and Timing

The weekly calcium and magnesium loading rates determined from the tailings subaqueous column were used to determine the average rate of carbonate (ANP) depletion. Based on the humidity cell results, weeks 11 to 54 were considered steady-state or equilibrium conditions and this value was used in rate calculations. The TIC values from pre-kinetic static tests of the humidity cell sample materials were used as the initial carbonate concentrations. Details of the calculations are provided in the 2010 EIS (Appendix 2.8).

Based on the calculated loading rates from tailings material, the calculated rate of carbonate ANP depletion from tailings surface water was 0.027 mmol/kg/wk (Table 2.8-5), and the estimated time to carbonate ANP depletion was 274 years. The calculated rate of carbonate depletion from tailings pore water was 0.060 mmol/kg/wk (Table 2.8-5), and the estimated time to carbonate depletion was 121 years. Note that the AGP and ANP depletion rates are similar in magnitude, which is further evidence that the carbonate mineral depletion occurred in direct response to sulphide mineral oxidation and acid production (URS, 2009i).

Table 2.8-5 Subaqueous Tailings Column Depletion Rates

COLUMN	Column Mass (kg)	Initial Sulphide-S					Sulphur remaining (mmol)	Avg. Sulphur depletion rate (mmol/kg/wk)	Weeks to Sulphur depletion	Years to Sulphur depletion
		(%)	(mg/kg)	(g/kg)	(mol)	(mmol)				
SAC-1 SURFACE WATER	5	0.07	700	0.7	0.11	109.17	102.88	0.021	992.4	19.08
SAC-1 PORE WATER	5	0.07	700	0.7	0.11	109.17	90.36	0.072	249.8	4.80

COLUMN	Sample Mass (kg)	Initial Total Carbonate[1]					Remaining Carbonate (mmol)[2]	Avg. Carbonate Depletion rate (mmol/kg/wk)[3]	Weeks to Carbonate Depletion	Years to Carbonate Depletion
		as TIC (%)	(kg $CaCO_3$/t)	(%)	(mmol/kg)	(mmol)				
SAC-1 SURFACE	5	0.46	38.3	3.8	383.014	1915.07	1907.52	0.027	14261	274
SAC-1 PORE	5	0.46	38.3	3.8	383.014	1915.07	1899.14	0.060	6302	121

NOTES:
1 Based on total inorganic carbonate measurements (TIC); assumes all carbonate ANP as calcite.
2 Based on difference between the initial total carbonate and the amount of calcium (Ca) and magnesium (Mg) which has leached from the samples.
3 Based on steady state combined depletion rates of Ca and Mg between weeks 11 and 54.

Cell ID	Sample ID	ABA Results				Total Metals (ppm)	Average Sulphide Depletion Rate [1,2]	Time to Sulphide Depletion [1]	Average Carbonate Depletion Rate [1,3]	Time to Carbonate Depletion [1]	Average Carbonate Molar Ratio [1]	Expected to be acid generating?
		ANP [4,5]	AGP [5]	NNP [5]	NPR	Ni	(mmol/kg/wk)	(years)		(mmol/kg/wk)	(years)	
SAC-1 SURFACE	2007 0.3% Ni Lock CycleTails	76.5	2.2	74.3	35.0	2456	0.021	19.1	1.29	0.027	274	**NO**
SAC-1 PORE	2007 0.3% Ni Lock CycleTails	76.5	2.2	74.3	35.0	2456	0.072	4.8	0.83	0.060	121	**NO**

NOTES:
1 Subaqueous column calculations are based on steady state conditions betwee weeks 11 and 54.
2 Sulphide depletion rates are based on the initial sulphide sulphur content.
3 Carbonate depletion rates are based on the initial total inorganic carbon (TIC) content.
4 NP derived from the modified Sobek method.
5 units are kg $CaCO_3$ per tonne.

Source: adapted from URS (2009i)

2.8.2.2.7 Conclusions

Static Test Program

Analysis of the 2006 and 2007 Master Lock Composite samples indicated that metallurgical lock cycle testing removed the majority of sulphide minerals. Based on the low sulphide sulphur content and high carbonate content, the tailings samples were considered to be NAG.

Metal concentrations screening found elevated arsenic, barium, copper, nickel, lead, antimony, strontium, thallium, and uranium relative to similar rock types (per Turekian and Wedepohl, 1961).

Kinetic Test Program

The (Ca+Mg)/SO_4 molar ratios, in conjunction with the sulphate, calcium, and magnesium loading rates, indicated that carbonate dissolution is primarily attributable to sulphide oxidation and acid generation.

The tailings are predicted to be NAG in a subaqueous environment, based on the low sulphide sulphur content, and because the time to depletion of carbonate minerals was greater than for sulphide minerals.

The metal loading rates are low, suggesting low leaching potential from tailings material.

2.9 Mining Processes

2.9.1 Overview

The open pit was designed using a two-stage approach. In the first stage, an optimum pit shell using the Lerchs-Grossman pit optimization method was identified. In the second stage, the selected pit shell was refined to a more detailed pit design that included catch berms and haul roads. Subsequently, mine development and production schedules were developed, equipment selections were performed and the capital and operating costs were estimated.

The Minago deposit has potential as a large tonnage, low-grade nickel sulphide deposit suitable for open pit bulk tonnage mining. Wardrop determined that the mining operation is amenable to conventional open pit mining methods.

The mine will provide mill feed of sulphide ore at a rate of 10,000 tonnes/day (t/d) for a total of 30,954,000 Mt of ore grading at 0.43%, over a period of approximately 8 years (Wardrop, 2009b). Local sandstone, that forms part of the overburden, is of suitable quality to produce frac sand, which is used in the oil and gas industry. The open pit will provide sand feed to a frac sand processing facility at a rate of about 4,100 t/d of sand, for a total of 14.9 Mt of frac sand over a period of about 10 years. The sand will be mined over a period of 3 years at the start of the mining operations, and then stockpiled. The throughput of the sand plant will be maximized to match the ore processing schedule (Wardrop, 2009b).

The estimated overall stripping ratios (waste-to-ore ratio tonne/tonne, t/t) to mine both the nickel sulphide ore and frac sand are given in Table 2.9-1.

Table 2.9-1 Open Pit Design 14 Stripping Ratios

Case	SR (t/t) (No Overburden)	SR (t/t) (With Overburden)
Frac Sand Only	7.48	8.23
Nickel Ore Only	11.27	11.71
Nickel Ore and Frac Sand	6.72	7.00

Source: Wardrop, 2009b

An overall mining sequence was developed in three phases: one initial pit phase and two pushback phases. Mine development will commence with the removal of trees and roots, and then the muskeg and clay overlying the dolomitic limestone will be mechanically removed from the open pit area. The mechanical removal method has been selected for the removal of the muskeg and clay overburden, using excavators for removal, and trucks for transportation and dumping.

A general arrangement drawing for the Mine Complex is shown in Figure 2.1-2. The particular features of the layout, which are pertinent to the operation of the open pit mine, are as follows:

- close proximity of the Overburden Disposal Facility to the open pit to minimize transportation distances;
- close proximity of the Dolomite and Country Rock Waste Rock Dumps to the open pit to minimize the haul distances for the waste rock; and
- close proximity of the Tailings and Ultramafic Waste Rock Management Facility (TWRMF) to the open pit to minimize the haul distances involved in moving and placing the dolomite etc. for the dam construction and disposal of ultramafic waste rock.

Details pertaining to the open design aspects including geotechnical considerations including open pit stability (domains and design sectors and pit geometry) and mine optimization; project development including mineable phases; production rate and schedule; mine access infrastructure; mining method including drilling, blasting, waste and ore loading and general hauling conditions; push back width; mining equipment selection; and pit dewatering are presented in the 2010 EIS document (Victory Nickel Inc.,2010). Therefore, these aspects are not be discussed herein.

2.10 Milling Processes

2.10.1 Summary

The nickel ore processing plant is designed to process nickel ore at a nominal rate of 10,000 t/d. The process will consist of the following conventional operations (Wardrop, 2009b):

- primary crushing;
- ore stockpile and reclaim;
- grinding circuit and size classification;
- rougher/scavenger/cleaner flotation using reagents;
- concentrate dewatering using filter presses, bagging and load out; and
- tailings thickening.

Major design criteria for the Nickel Ore Processing Plant are outlined in Table 2.10-1 and Figure 2.10-1 gives a simplified process flow sheet. Brief descriptions of the individual process components are given in the 2010 EIS document (Victory Nickel Inc., 2010).

Figure 2.10-1 illustrates the Nickel Ore Plant Layout. The SAG and ball mill products will discharge into a common pump box. Since the hydrocyclone cluster underflow launder feeds the ball mill feed chute, the hydrocyclone cluster was located on the north side of the ball mill.

The flotation cells will be located in one area, serviced by a single overhead crane. Each bank of flotation cells was laid out linearly to maximize efficient operation of the cells and eliminate shortcircuiting. Pumps and pump boxes will be positioned around the exterior of the flotation area for ease of maintenance and access.

The flotation cell banks will be positioned to decrease the length of pipelines and to decrease the amount of pumps and pump boxes. For example, the fourth cleaner bank of cells will be located above the fifth cleaner cells, so concentrate and tailings can flow by gravity and eliminate the need for pumps and pump boxes. The scavenger cells will also be slightly elevated to allow the concentrate and tailings to gravity flow to the desired locations.

The reagent area will be located on the west side of the building to minimize pump head and pipe lengths.

A central control room located between the grinding and flotation areas will allow control room operators to oversee the operations in both areas.

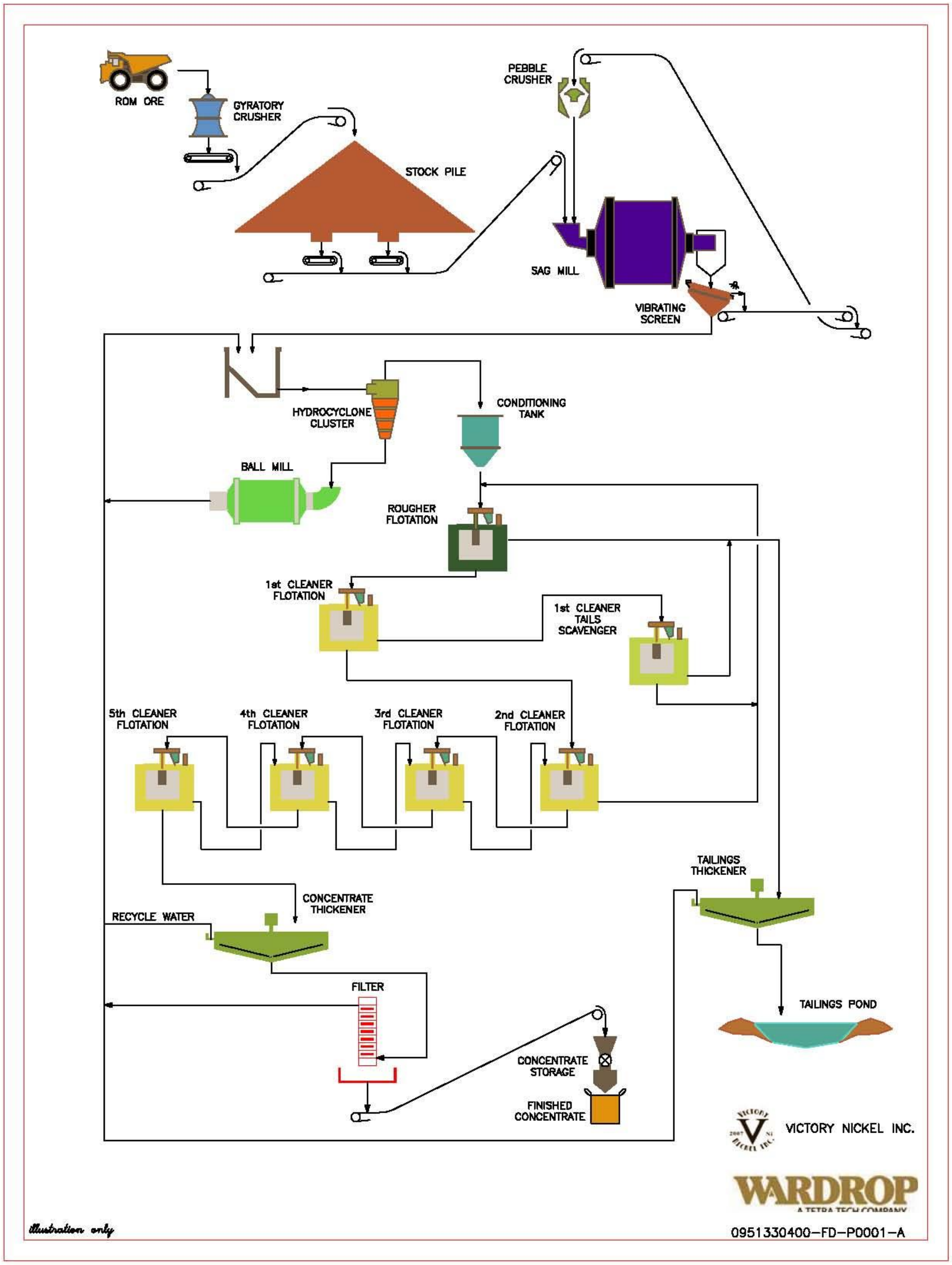
An assay and metallurgical laboratory will also be incorporated into the mill building to perform laboratory tests.

Table 2.10-1 Major Design Criteria

Criteria	Qty	Unit
Operating Days per Year	365	d
Overall Plant Availability	95	%
Primary Crushing Rate	502	t/h
Primary Crusher Availability	83	%
Ore Specific Gravity	2.65	
Processing Rate (at 100% availability)	416.7	t/h
SAG Mill Feed Size, 80% Passing	130,000	µm
SAG Mill Product Size, 80% Passing	1,072	µm
SAG Mill Circulating Load	16	%
Ball Mill Circulating Load	250	%
Primary Grind Size, 80% Passing	68	µm
Primary Bond Work Index (BWI)	14.9	kWh/t
Abrasion Index	0.065	
Concentrate Thickener Underflow	70	% Solids
Final Concentrate Moisture Content	8.6	%

Source: Wardrop, 2009b

Details pertaining to the processing plant aspects and components including the crushing operations, ore stockpile, grinding and classification; floatation, dewatering and drying; water and air supply are presented in the 2010 EIS document (Victory Nickel Inc., 2010). Therefore, these aspects are not discussed herein.



Source, Wardrop, 2009b

Figure 2.10-1 Simplified Flow sheet of the Nickel Ore Processing Plant

2.10.2 Reagents

2.10.2.1 Typical Reagent Consumption

Flocculants will be used in each thickener to assist in settling and generating a precipitate from solution. Reagents including potassium amyl xanthate (PAX) and sodium hexametaphosphate (SHMP or Calgon) will be added to the ore in the grinding stage to enhance the flotation performance downstream. Methyl isobutyl carbinol (MIBC) and depramin C (CMC) will be added to the cleaner flotation to increase concentrate quality.

The projected reagent addition rates are given in Table 2.10-2 and the storage and preparation of reagents is outlined below. The Material Safety Data Sheets (MSDS) for these chemicals, including toxicological information, are provided in Appendix 2.10 of the 2010 EIS document.

All reagent mixing and storage tanks will be equipped with low and high level indicators and instrumentation to ensure that spills do not occur during preparation and normal operation. In the event of a spill, sump pump locations are located throughout the reagent area for proper containment. Shower and eye wash safety stations will also be installed in case of skin or eye contact during a spill. Appropriate ventilation, fire and safety protection and MSDS stations will be provided at the facility.

Each reagent line and addition point will be labeled in accordance with Workplace Hazardous Materials Information Systems (WHMIS) standards and all operation personnel will receive WHMIS training and additional training for the safe handling and use of all reagents.

2.10.2.2 Preparation and Storage of Reagents

Figures 2.10-2 through 2.10-5 show reagents flow sheets and Figures 2.10-6 and 2.10-7 show concentrate flocculent and tailings flocculent flow sheets. Handling methods of the various process reagents are discussed below.

Potassium Amyl Xanthate (PAX)

Potassium Amyl Xanthate (PAX) will be shipped to the Minago site in bulk 1,000 kg super sacs. The bulk PAX will be diluted to a 10% solution in a 49.2 m^3 (13,000 gal) mixing tank (Wardrop, 2009b). Each batch process will consume five bulk super sacs and will be performed once per day. Once properly mixed, the PAX solution will be stored in a 60.6 m^3 (16,000 gal) storage tank (Wardrop, 2009b). The PAX solution will be pumped from the holding tank to a distribution trough. The distribution trough will allow for proper calibration and will feed separate metering pumps for each addition point (Wardrop, 2009b).

Table 2.10-2 Reagents and Flocculants in the Mining and Milling Process

					Dosage (g/tonne)	Dosage (kg/day)
CMC	Carboxmethyl Cellulose	wood product (used to make creamy soups)	Depressant	Depressant for Talc(MgO) coats talc particles to make them hydrophilic	700	7000
PAX	Potassium Amyl Xanthate		Collector	Collector for minerals coats mineral particles to render them hydrophobic so that are attracted to air bubbles and reject water	425	4250
SHMP	Sodium hexametaphophate	Calgon (water softener)	Dispersant	Dispersant for Talc keeps talc particles from adhering to mineral particles	500	5000
MIBC	Methyl isobutyl carbinol	similar to dish soap	Frother	Frothing agent to create stable froth bubbles in flotation cells to float metal particles	70	700
Flocculent (Tails)	Anionic polyacrylamide	used in water treatment	Coagulant	used in thickeners and clarifiers to collect particles so that they will agglomerate and sink	23	227
Flocculent (Conc.)	Anionic polyacrylamide	used in water treatment	Coagulant	used in thickeners and clarifiers to collect particles so that they will agglomerate and sink	5	0.63

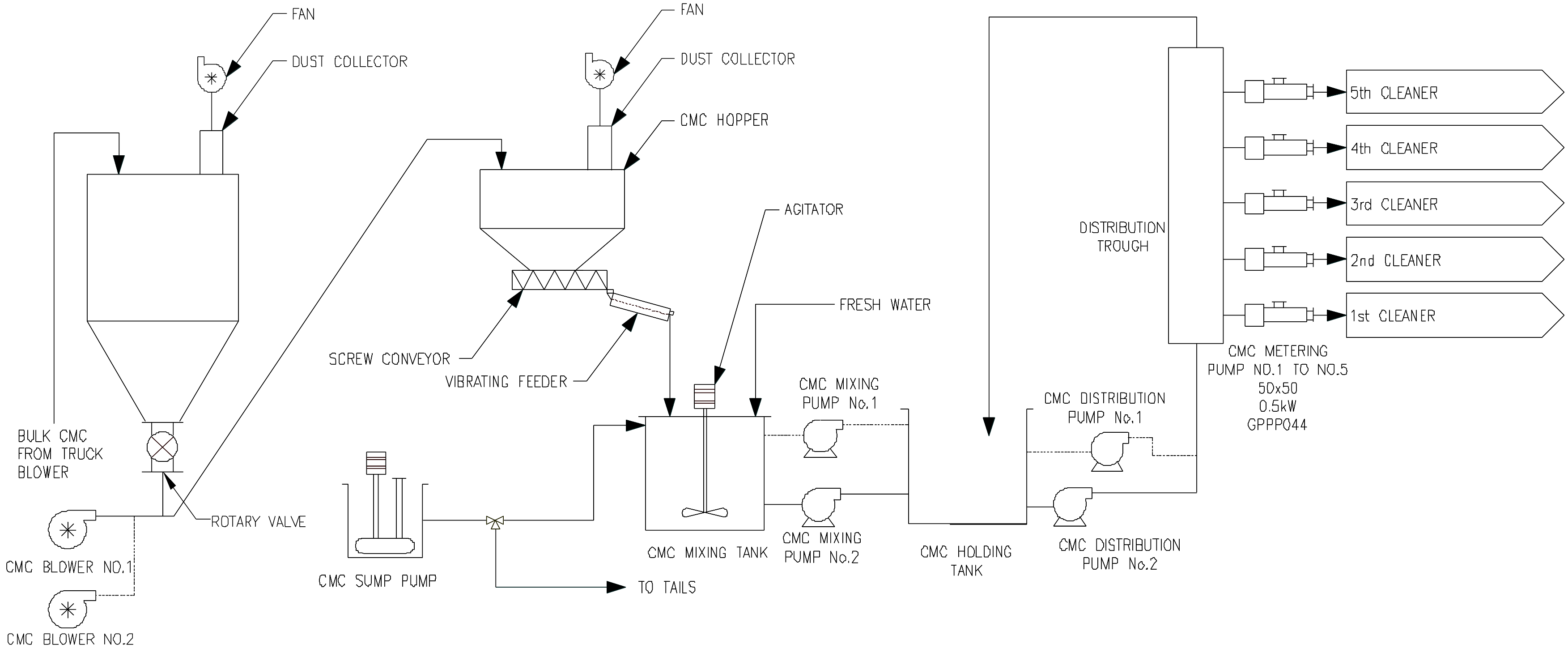


Figure 2.10-2 CMC Reagent Flow Sheet

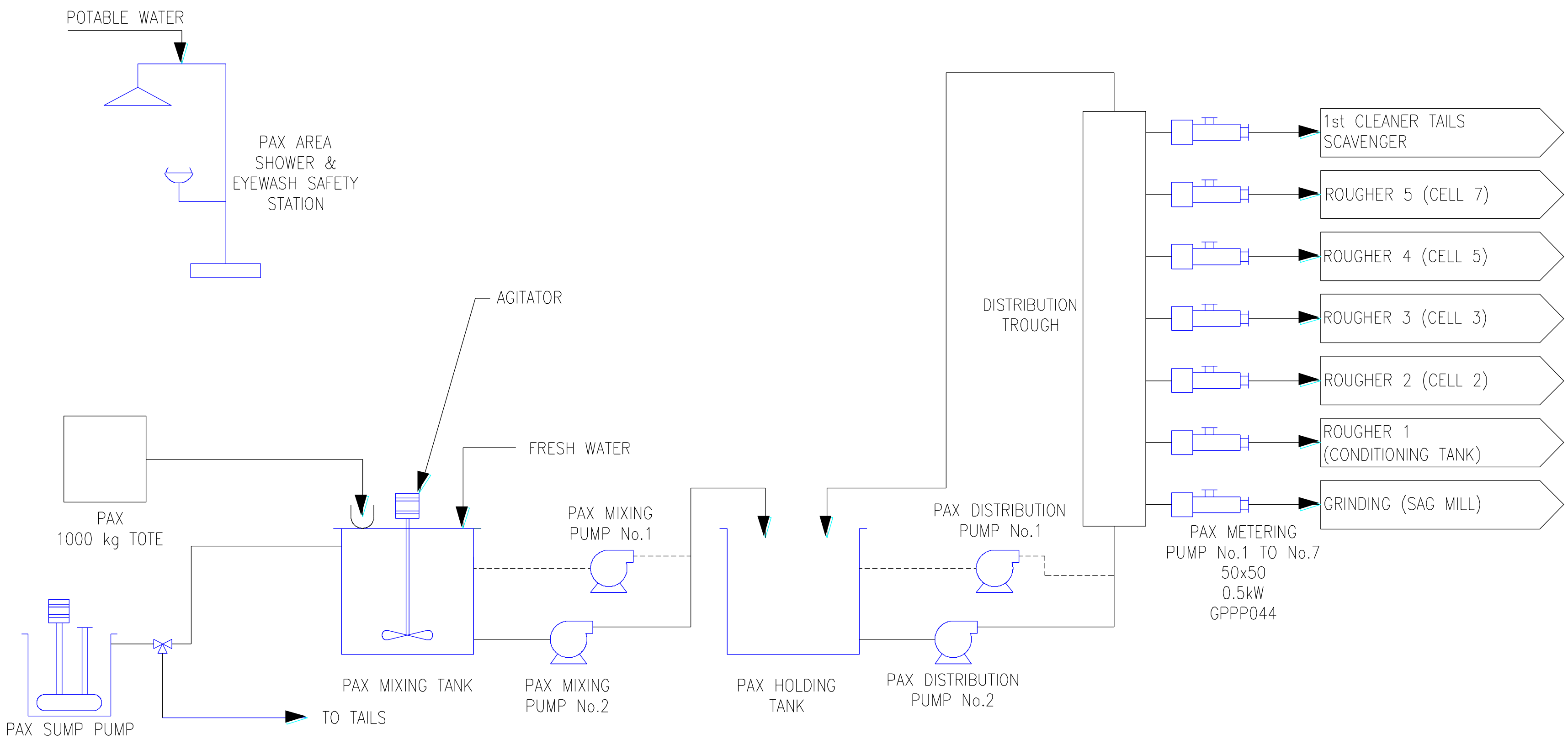


Figure 2.10-3 PAX Reagent Flow Sheet

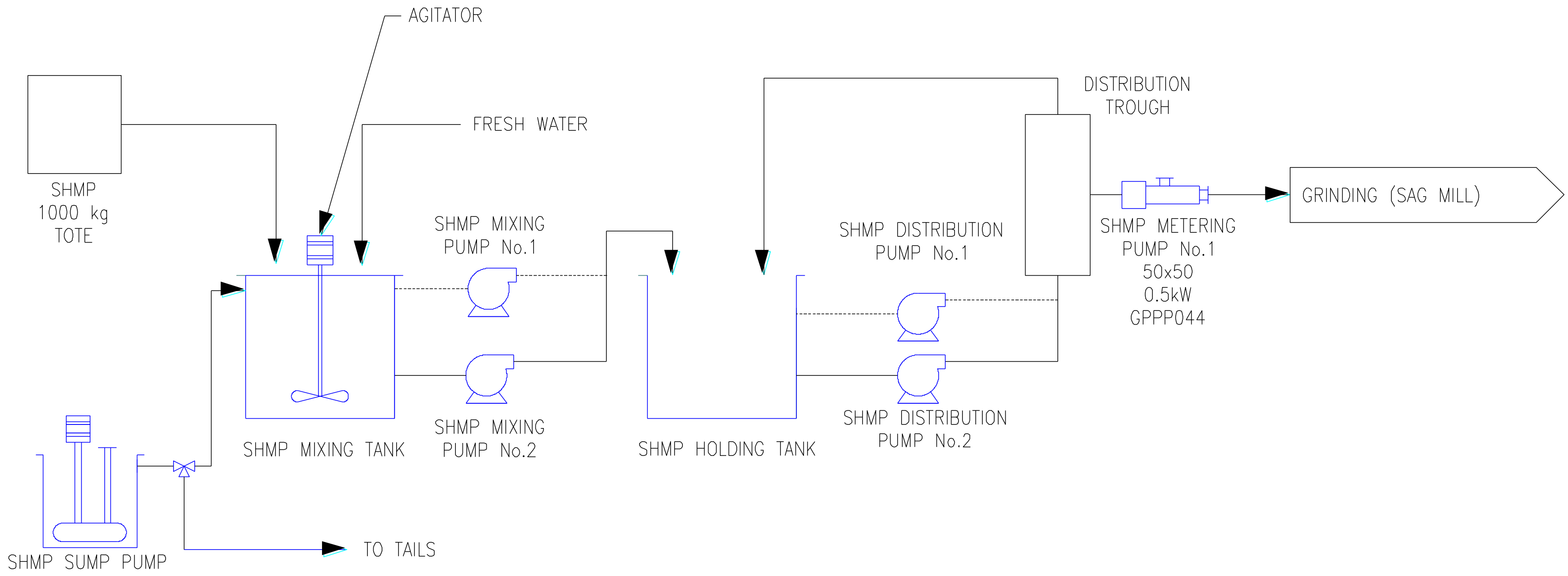


Figure 2.10-4 SHMP Reagent Flow Sheet

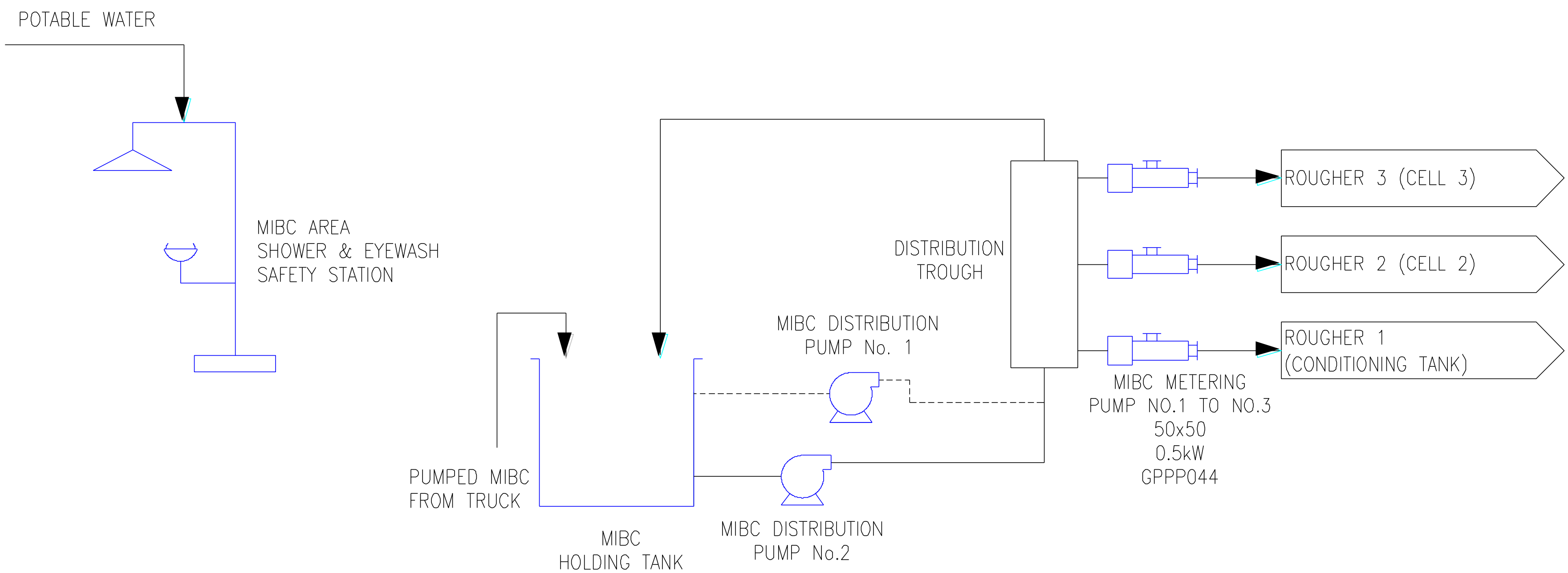


Figure 2.10-5 MIBC Reagent Flow Sheet

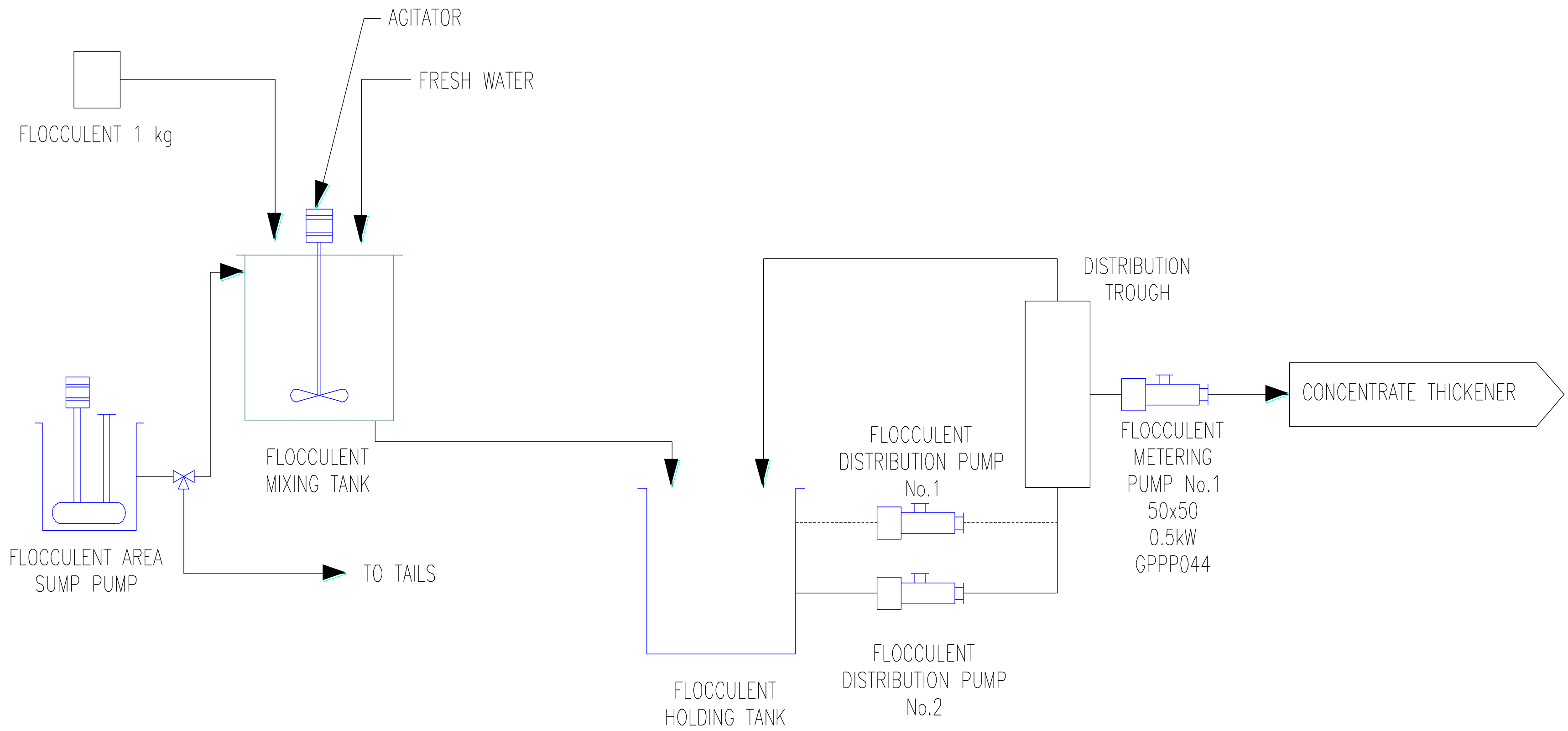


Figure 2.10-6 Concentrate Flocculent Flow Sheet

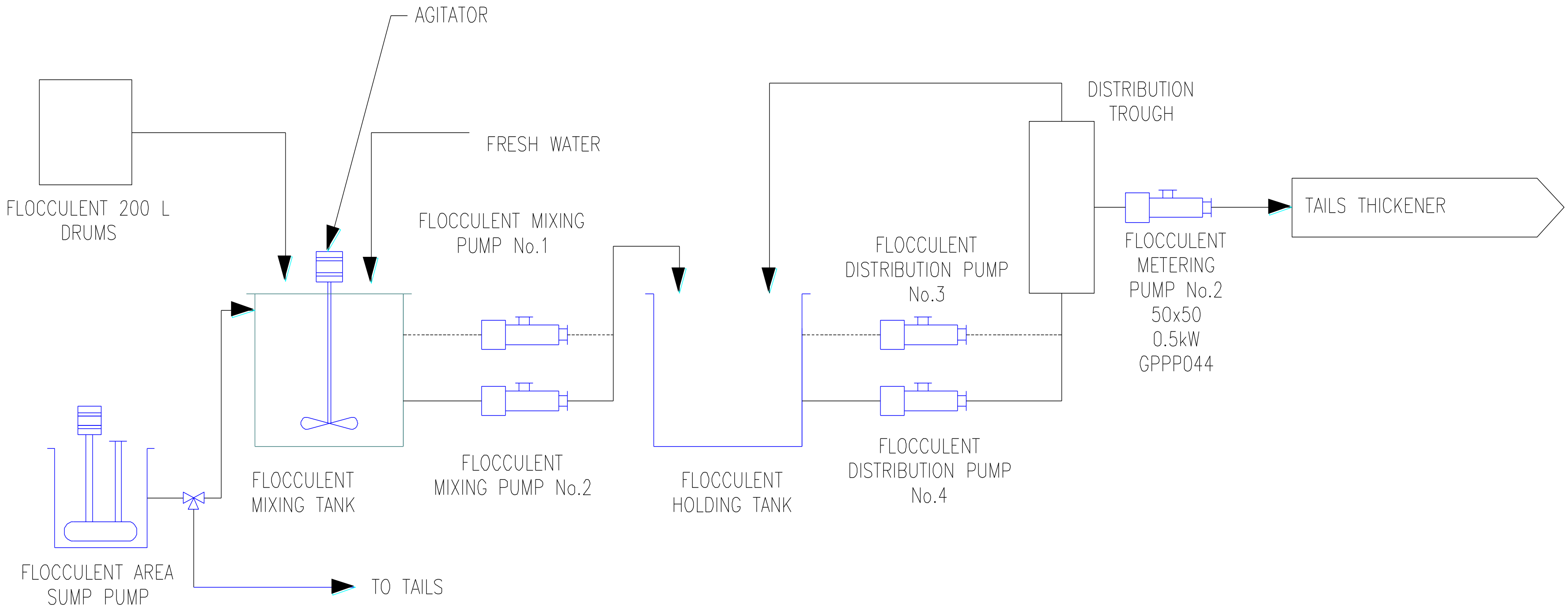


Figure 2.10-7 Tailings Flocculent Flow Sheet

Sodium Hexametaphosphate (SHMP)

Sodium Hexametaphosphate (SHMP) will be shipped in 1,000 kg bulk super sacs. The SHMP will be diluted to a 10% solution in a 56.8 m^3 (15,000 gal) mixing tank. Each batch process will consume six bulk super sacs and will need to be performed once per day. The SHMP will be stored in a 68 m^3 (18,000 gal) storage tank. The 10% SHMP solution will be pumped from the storage tank to a distribution trough by a horizontal centrifugal pump. The flow from the distribution trough will be metered through a progressive cavity pump to the addition point in the SAG mill (Wardrop, 2009b).

Methyl Isobutyl Carbinol (MIBC)

Methyl Isobutyl Carbinol (MIBC) will be shipped at 100% concentration in bulk 20 m^3 (5,280 gal) tankers, stored in a 26.5 m^3 (7,000 gal) storage tank and pumped in undiluted form to a distribution trough (Wardrop, 2009b). The distribution trough will feed separate diaphragm metering pumps, which will distribute the MIBC to each addition location (Wardrop, 2009b).

Carboxymethyl Cellulose (CMC)

Carboxymethyl Cellulose (CMC) will be delivered by 20 t bulk tanker trucks and stored in a 56.6 m^3 (2,000 ft^3) dedicated silo. Bulk CMC will be retrieved from the silo by a roots type blower to a 10 m^3 (350 ft^3) transition hopper located in the reagent preparation area. CMC will be metered from the transition hopper by a screw conveyor and vibrating feeder to an agitated 45.4 m^3 (12,000 gal) mixing tank. The 2% CMC solution will be prepared continuously and pumped to a 208 m^3 (55,000 gal) storage tank. The mixing tank will have a retention time of approximately three hours. The storage tank capacity was based on 14 hours of reagent consumption. This will allow for servicing the mixing tank agitator and pumps without affecting the CMC addition to the process. CMC from the storage tank will be pumped to a distribution trough. The flow will then be metered through separate progressive cavity pumps to each addition location (Wardrop, 2009b).

Flocculants

The concentrate flocculent **Hychem 308** or equivalent, will be shipped in 25 kg bags. The concentrate flocculent will be diluted to a 0.1% solution in a 1.1 m^3 (300 gal) mixing tank (Wardrop, 2009b). This flocculent is a non-toxic inert hydrocarbon polymer, similar to treatment used in drinking water. The polymer attracts the charged solids in the slurry, causing them to clump together - thus gaining enough mass to drop out of solution via gravity.

Each batch process will consume 1 kg of concentrate flocculent and will be performed every second day. After mixing, the 0.1% solution will be pumped to a storage tank with a capacity of 1.5 m^3 (400 gal). Stored concentrate flocculent will be pumped to a distribution trough. A progressive cavity pump will pump the required amount of flocculent from the distribution trough to the concentrate thickener.

The tailings flocculent, **Mag 10**, will be shipped in 200 L drums containing 91% active flocculent. The tails flocculent will be diluted to a 0.5% solution in a 38 m^3 (10,000 gal) mixing tank. Each batch process will consume one drum per day and will be prepared once per day. After mixing, the Mag 10 flocculent will be stored in a 45.4 m^3 (12,000 gal) storage tank. The Mag 10 solution will be pumped from the storage tank to a distribution trough by a low shear progressive cavity pump. A progressive cavity metering pump will meter the flow from the distribution trough to the tails thickener at a precise flow.

Details on the instrumentation and process control for the processing plant (mill) are presented in the 2010 EIS document (Victory Nickel Inc., 2010). Therefore, these aspects are not discussed herein.

2.10.3 Frac Sand Processing Plant

2.10.3.1 Introduction

The Minago Frac Sand Feasibility Study was conducted in parallel to Victory Nickel's Minago Feasibility Study. The Minago Frac Sand Feasibility Study is a result of the Preliminary Economic Assessment (PEA) (Wardrop, 2006), which identified a sandstone horizon (averaging nine metres thick) above the unconformity of the main nickel bearing serpentinite. This sandstone layer will be removed to access the nickel mineralization within the proposed open pit mine. The sandstone unit is amenable for use as a Fracturing Sand (Frac Sand) used in the oil and gas industry as it is typically comprised of small, round, uniformly sized silica sand.

Frac sands are used as part of a process to improve the productivity of petroleum reservoirs. This treatment, known as hydrofracing, is the forcing of a concoction of frac sands, viscous gel and other chemicals down a well to prop open fractures in the subsurface rocks thus creating passageways for fluid from the reservoir to the well. Frac sands function as a proppant: sized particles that hold fractures open after a hydraulic fracturing treatment.

The Minago sandstone will be mined, and then hauled to a temporary stockpile location separate from the waste dumps, where it will be processed. The Minago sandstone is not expected to require drilling and blasting to be removed, but will require additional backhoe cleanup due to the expected undulating contact at the top of the basement rocks. A backhoe will windrow the sand so that a front-end loader can easily load the material while minimizing the loss of sand due to the loaders large bucket size. The sand will be released each time mine development passes through the bedrock contact. These times are outlined in Table 2.10-3 (Wardrop, 2009b).

Table 2.10-3 Final Pit Contained Sand Resource

Phase	Sand (tonnes)
Starter Pit	5,288,864
Phase 1	2,091,628
Phase 2	7,466,065
Total	**14,846,557**

Source: Wardrop, 2009b

A separate NI-43-101, document for the Standard Disclosure of Mineral Projects was filed with Sedar to qualify the Sand Resources (Wardrop, 2009b).

Outotec Physical Separation Division (Outotec) in Jacksonville, FL, designed a Frac Sand Plant for Minago, which includes both wet and dry process plants; each containing dedicated processes for friable and non-friable ore types. The plant will be operable year round and accommodates seasonal market demand fluctuations with a capacity of 1.6 times the average production. The in-

situ sand will be processed at a feed rate of 1.5M t/y, producing different grades of frac sand at a rate of 1,142,805 tonnes of marketable sand annually (Outotec, 2008).

2.10.3.2 Laboratory and Flow sheet Development Test Work

To determine the quality of the sand and to evaluate the feasibility of the project, Wardrop arranged a series of test programs conducted by various independent laboratories. Representative Minago sand samples were tested for different standard quality parameters in accordance with the American Petroleum Institute (API) “Recommended Practice 56 - Recommended Practices for Testing Sand Used in Hydraulic Fracturing Operations, 1995”.

The API parameters include (Outotec, 2008):

- Grain size: 90 wt.% of the sand must fall within a specified size range for a particular product. The generally defined frac sand products are 12/20, 20/40, 40/70 and 70/140 (defined in terms of ASTM sieve sizes);
- Sphericity and roundness: The shape of the grains. Spherical, round grains are desired;
- Crush resistance: The amount of fines generated after a product is subjected to a specified pressure;
- Acid solubility: The percentage of the material dissolved in a HCL/HF acid solution;

- Turbidity: The amount of silt and clay-sized particulate matter in the sand; and
- Clusters or agglomerated grains: The presence of clusters or agglomerated grains reduces strength of the overall sand. The API specification is < 1% clusters.

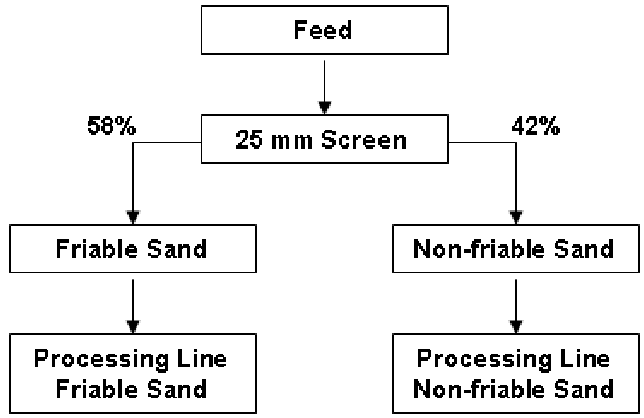
The following three different test programs were conducted between May 2007 and November 2008 (Wardrop, 2009b):

- Program 1: Between May and July 2007, Loring Laboratories Ltd. (Loring) of Calgary, AB performed mineralogical analyses, and EBA Consulting Engineers and Scientists (Material and Pavements Practice) (EBA) of Calgary, AB, performed material analyses.
- Program 2: Between May and September 2007, the Saskatchewan Research Council of Saskatoon, SK (SRC) performed mineralogical analyses, and the University of Saskatchewan performed a material analysis.
- Program 3: between December 2007 and January 2008, and between September and November 2008, Outotec Physical Separation Division (Outotec) in Jacksonville, FL performed mineralogical analyses and a material analysis.

During Program 1, each of four representative drill hole samples was split into two; the first half of each sample was provided to Loring for testing, the second half of each sample was retained. The sample from a fifth hole was split into four samples, which then formed the basis of Program 2 (Wardrop, 2009b). The results from both Programs 1 and 2 indicated low crush resistance parameters.

Outotec initiated test Program 3; wherein the remaining halved cores from the four original samples, plus representative samples from two additional holes, were delivered to Outotec and combined into a blended sample (Wardrop, 2009b). Outotec separated the sandstone into hard (non-friable) sand and consolidated (friable) sand. Using this approach, Outotec was able to improve the crush resistance parameter of the friable sand to meet API standards, thereby increasing the marketable volume. The non-friable sand was then crushed to produce a fine frac sand product suitable for shale gas applications (Wardrop, 2009b).

Subsequently, Outotec developed flowsheets for a Frac Sand Plant to meet API specifications for fracturing sand. Friable and non-friable portions will be processed separately, in two parallel circuits. A screen will be used to classify the friable ore from the non-friable (Figure 2.10-8) and only the non-friable portion of the material will be crushed.



Source: Outotec, 2008

Figure 2.10-8 Outotec Flow sheet, Separating Friable from Non-friable Sand

The parallel process is needed to ensure the non-friable products do not cause cluster related quality problems within the high value friable sand products. This approach ensures that the friable products will meet all of API's standards: sphericity and roundness, turbidity, crush resistance, low impurity level., leading to a higher volume of production of the different marketable products.

2.10.3.2.1 Friable Ore

The friable portion of Minago's sandstone deposit will be used to produce 20/40 and 40/70 frac sand meeting the API RP 56 specifications (API, 1995). The process operations required to successfully beneficiate the friable material are (Outotec, 2008):

- Attrition scrubbing,
- Desliming,
- Pre-classification,
- Drying,
- Screening, and
- Magnetic separation.

Attrition scrubbing (to break down agglomerates), desliming, and pre-classification are important sequential wet processes that will be performed first. Softer grains and coatings must be removed along with the Minus 140 Mesh particles. The presence of the Minus 140 Mesh materials would negatively impact the quality of the final sand products (Outotec, 2008).

Once the scrubbing and desliming have been completed, the sand will then be pre-classified using density separators. The pre-classified sand will be dried before it can be successfully upgraded to API quality frac sand. A fluid bed dryer will be used to remove all moisture from the sand (Outotec, 2008).

Once dried, the sand will be screened to the desired API size fractions of 20/40, 30/50, 40/70, and 70/140. The screened material will then be sent to dedicated magnetic separators for the removal of undesirable magnetic minerals and contaminants that can cause failings in API crush tests. Thereafter, API frac sand products will be ready for storage and sale (Outotec, 2008).

2.10.3.2.2 Non-Friable Ore

The following process steps were identified to successfully beneficiate the hard, non-friable sand (Outotec, 2008):

- Crushing, jaw and impactor;
- Pre-classification;
- Drying; and
- Screening.

The non-friable sand will require crushing to break down the large rocks and agglomerated particles for sufficient liberation. This step will enable upgrading in further processing stages to produce marketable products. Crushing tests were conducted to identify the suitable type and size of crushing required. At Minago, a combination of jaw and impactor crushing will be used. Jaw crushing will be used in advance of the impact crusher to allow for the processing of larger particles since impact crushers of the size needed for the feed rate are limited to approximately 100 mm top size particles (Outotec, 2008).

Following crushing, the non-friable ore will be slurried and then pre-classified using density separators to remove both the very coarse (+ 50 mesh) and very fine (–140 mesh) particles. The pre-classified nominal –50 mesh/+140 mesh sand will be filtered using belt filters and then transferred to the dry process for further upgrading (Outotec, 2008).

The pre-classified, non-friable material will be dried in a fluid bed dryer to remove all remaining moisture. This dry sand will then be screened to produce +50, 20/40, and 50/140 sand products. These products will not meet the API requirements for fracturing sand but can be used as flux sands or in applications where non-API fracturing sand is suitable (Outotec, 2008).

2.10.3.3 Frac Sand Plant Design

The Frac Sand Plant design was completed by Outotec, Physical Separation Division, Jacksonville, Fl, USA. Outotec developed an initial plant design to determine the cost of the proposed plant within an accuracy of -10% to +20%. Key process design considerations included deposit characterization and feed material assumptions, plant area capacities, operating hours for plant sections, and product quantities and grades. The initial design was followed by a Phase II revision, which included improvements to reduce the total costs and improve general plant and process operations.

The Outotec Phase II design takes into account the seasonality fluctuating demands of the frac sand market, the inclement winter weather of Manitoba, Canada, and the need to operate the full plant year-round (Outotec, 2008). The wet and dry plants will operate together in series, and are designed to operate at wet plant feed rate of 265 t/h. The overall plant has been designed to achieve a throughput that is 1.6 times average production rate, allowing plant capacity to meet periods of expected peak demand.

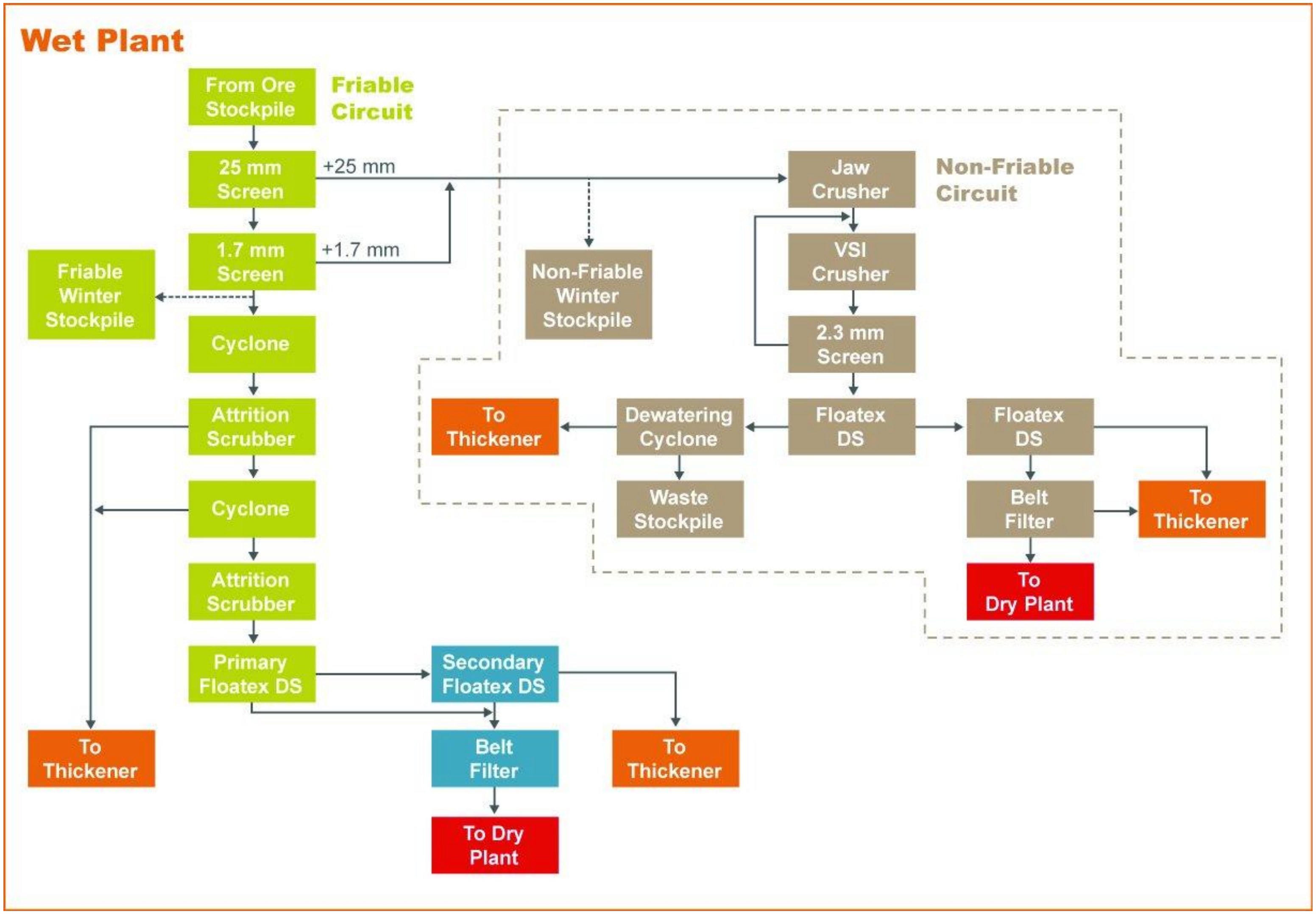
It is estimated that a 16-month schedule for plant completion (detailed design, procurement, construction, and commissioning) is the best-case scenario (Outotec, 2008).

The following key assumptions were made in the design of the Frac Sand Plant (Outotec, 2008):

- Plant capacity of 1,142,805 t/y comprised of 612,863 t/y API frac sand, and 529,941 t/y non-API sand, which includes 62,500 t/y of flux sand;
- Plant feed rate of 265 t/h or 1,500,000 t/y,
- Yearly operating hours – 4,822, 12 months yearly operating window for wet and dry processes;
- Friable and non-friable ores to be processed in separate, dedicated circuits;
- Two wet winter stockpiles (250,000 tonnes each) will be established to allow stockpiling of screened friable and non-friable material, during non-freezing months, for use as feed in the winter months. This is required because the screening stage will not be able to distinguish between a single large rock and a frozen lump of ore during the winter operation. The stockpiles will be built during the periods of low sales demand;
- Plants will be fed using front-end loaders via hopper and feeder systems;
- Marketable products will be held in storage silos (two-day capacity based on average production rates) and be transported via truck to the rail load-out or the marketplace; and
- Waste products will be stored in stockpiles (if solid) or send to the tailings impoundment (if slurry) via the thickener. Solid waste material will be removed by loader and truck.

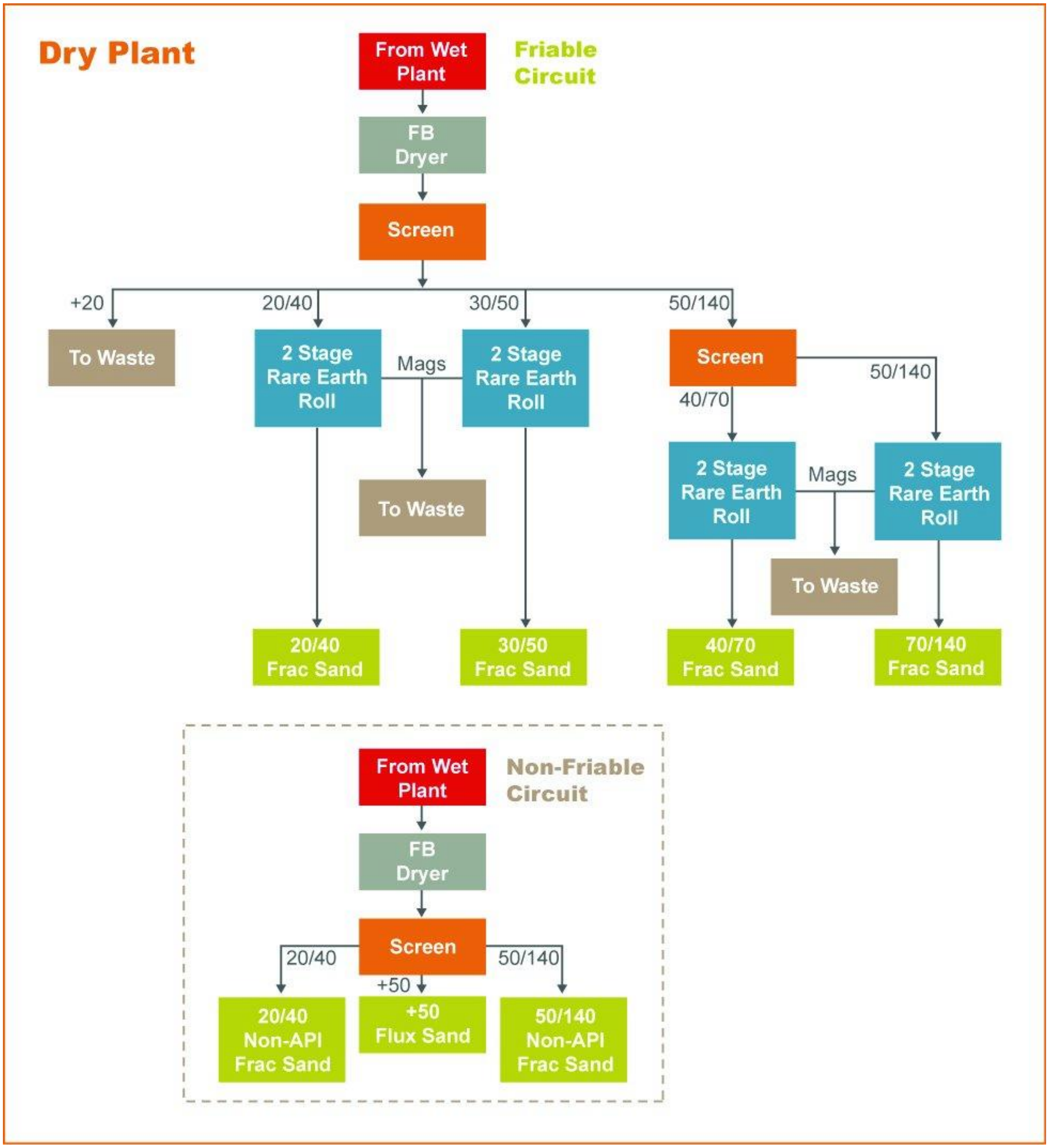
Simplified block diagrams for the wet and dry Frac Sand Plants are given in Figures 2.10-9 and 2.10-10, whereas detailed material (mass and water) balance diagrams for the wet and dry Frac

Sand Plant are provided in Appendix 2.10. Detailed Process Design Basis and the Operational Philosophy are provided elsewhere (Outotec, 2008).



Source: Outotec, 2008

Figure 2.10-9 Flow Sheet for Minago's Wet Frac Sand Plant



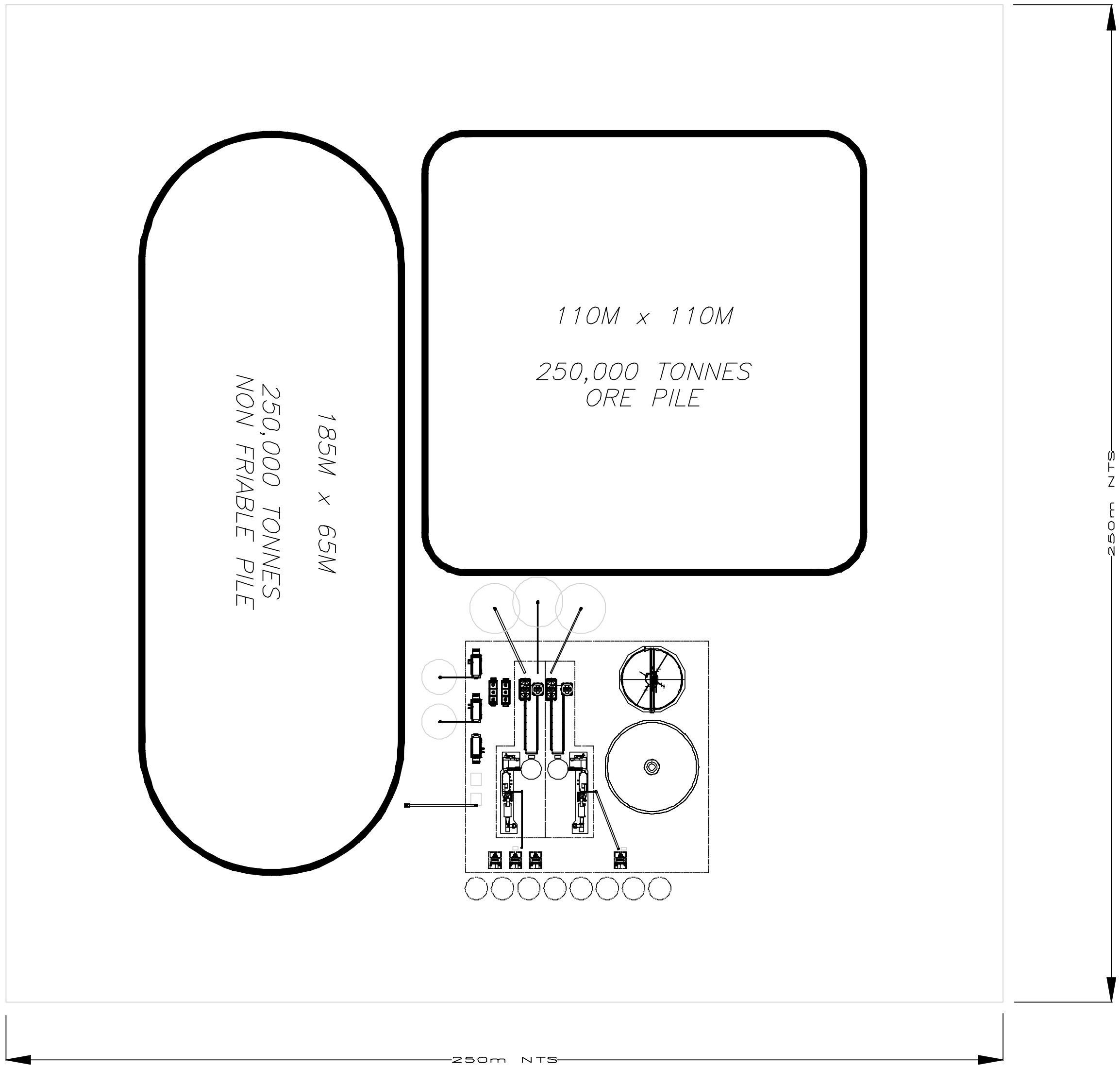
Source: Outotec, 2008

Figure 2.10-10 Flow Sheet for Minago's Dry Frac Sand Plant

2.10.3.3.1 Site Layout

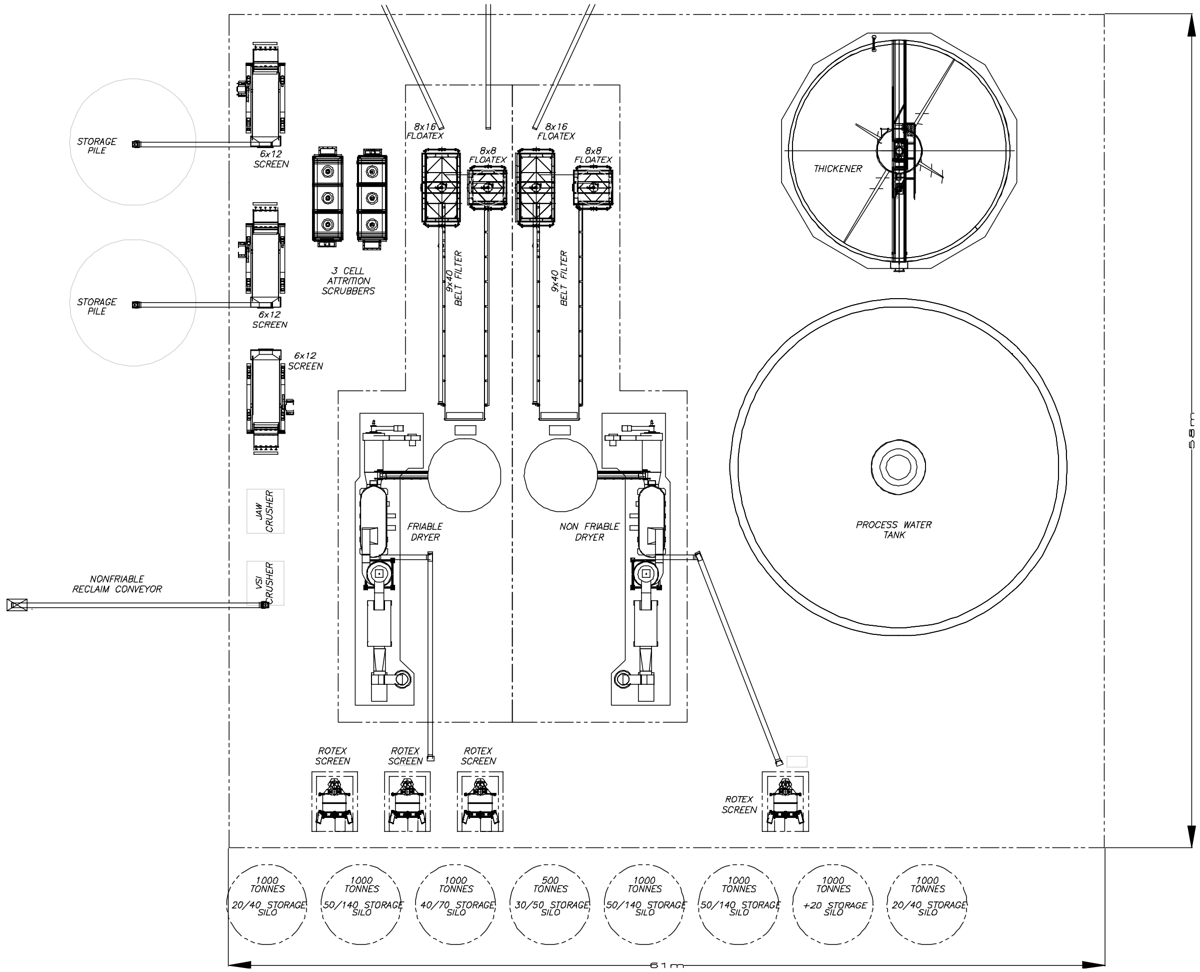
Figures 2.10-11 and 2.10-12 illustrate the conceptual site layout of Minago's Frac Sand Plant. Figure 2.10-11 shows the overall site plan with winter stockpiles while Figure 2.10-12 details the proposed plant area and buildings. The plant site will require approximately 250 m x 250 m.

Details on the frac sand plant aspects and components including the electrical design, power and energy consumption; rail load-out facility; and process flow sheet diagrams are presented in the 2010 EAP/EIS document (Victory Nickel Inc., 2010). Therefore, these aspects are not discussed herein.



Source: Outotec, 2008

Figure 2.10-11 **Conceptual Layout of the Frac Sand Plant**



Source: Outotec, 2008

Figure 2.10-12 Conceptual Layout of the Frac Sand Plant (Zoomed in

2.11 Overburden Management

This section addresses the management of overburden material, which includes on-site clays and peat/muskeg. The management of dolomitic overburden will be presented in the Waste Rock Disposal Section (Section 2.12).

Overburden will be managed in several ways. The vast majority of peat and clay overburden that needs to be removed to gain access to the ore reserves and to build infrastructure will be stored in an Overburden Dump. Low permeability clays will be salvaged and stockpiled in sufficient quantities to enable the construction of low permeability liners where required. For example, a low permeability liner will be installed on the upstream side of the Tailings and Ultramafic Waste Rock Management Facility (TWRMF).

Dredging was previously selected as an overburden management option for the Minago Open Pit, because of logistical challenges, tight scheduling issues, and capital and operational costs related to safe disposal of mechanically excavated overburden (Wardrop, 2009b). However, upon further tests of the clay material, it was determined that the clay is not soft and can be removed by mechanical means (excavate-load-haul to a dump). The mechanical removed overburden material will be stored in an overburden dump.

The dump capacity will be approximately 15 Mm^3. The Overburden Dump will be capable of retaining a total of 9,285,000 Mt (~ 10.09 Mm^3) of overburden that will be discharged into the facility,

The dump will be located immediately south and east of the open pit. The design criteria for the overburden dump is given in Table 2.11-1.

The estimated total mass of the overburden material is 9,285,000 Mt (Table 3.2-2)

Table 2.11-1 Basic Engineering Design Parameters for the Overburden Dump

Item	Target	Comments
1. Geotechnical Slope Stability		
• Construction (in stages)	• Static F.O.S. 1.3, pseudo static F.O.S 1.05.	
• Normal Operating	• Same as above.	
• Closure	• Static F.O.S. 1.3, pseudo static F.O.S 1.05.	
2. Seismicity		
• Operating Design Basis Earthquake	• 1: 475 year return	
• Seismicity induced by pit blasting	•	• Input will be required for the detailed design.
• Closure Earthquake	1:2,475 year return	

Source: Wardrop, 2009b

2.11.1 Construction Considerations

2.11.1.1 Peat Overburden

The in-situ peat is unsuitable for construction purposes, but it may have potential for use in site reclamation. If pre-loaded, the peat may be used as foundation material for structures that are not sensitive to settlements, such as waste rock dumps (Wardrop, 2009b). Pre-loading tests on the peat were not carried out for determination of consolidation characteristics. These tests will be conducted during the detailed engineering design phase.

2.11.1.2 Clay Overburden

The construction of water containment structures and dykes across the site will require low permeability materials. Site clays were assessed during the pre-feasibility and feasibility geotechnical investigations and the results of laboratory tests on selected clay samples may be summarized as follows (Wardrop, 2009b):

- The optimum moisture content ranged from 16.3% to 18.6% at standard Proctor maximum dry densities (SPMDD) ranging between 1,600 and 1,752 kg/m^3.
- Clay with natural moisture contents reasonably close to the optimum for compaction may be found within the uppermost 5 m of the deposit. The moisture content of the tested clays was typically well above the optimum at depths greater than 5 m. The natural moisture content of tested clay was generally higher than 20% as depicted in the 2010 EAP/EIS (EAP/EIS 2010, Figure 7.3-7).
- It was found that site areas with shallow thickness of overburden contained stiff clays that exhibited natural moisture contents close to the optimum for compaction.
- Recovery of clays from perennially flooded terrain will pose formidable logistical challenges as the muskeg/peat is water logged. More specifically, these areas will require that the muskeg/peat are bermed off so that the upper stiff clay may be excavated in a “dry” condition. Also, clays may experience moisture uptake during excavation even if the borrow areas are bermed off (Wardrop, 2009b).

2.11.2 Further Geotechnical Investigations

Further geotechnical investigations of the proposed TWRMF that have some relevance to the overburden dump were conducted by Foth in 2012 (Foth Canada, 2012) and are presented in the Conceptual Design (Appendix 2.13-1) and Factual Report (Appendix 2.13-2)

The area of investigation was approximately 3 km by 4 km, centered on a wetland valley bounded on the east and west by bedrock ridges. The results of the geotechnical investigation are included in Appendices 2.13-1 and 2.13-2 (Foth, 2013). The flanking ridges define the long dimension of an asymmetrical bedrock valley that is partially filled with overburden formations. Previous investigation work was completed by Wardrop in 2007 and 2008 (Wardrop, 2010) and focused on the current TWRMF site, east of the site proposed herein.

In general the subsurface soils in at the proposed TWRMF site comprise:

- Peat - coarse to fine fibrous peat varying in thickness between 0.8 and 2.3m.
- Upper Clay - soft to stiff, grey to brown, high plasticity clay (CH) varying in thickness between approximately 1 and 2 m.
- Intermediate Clay – firm to stiff, grey to brown, mottled, slightly weathered medium plasticity clay (CL) with a consistent thickness of approximately 5 m
- Lower Clay – very soft to firm, grey to brown, CH reaching a thickness of 16 m in the center of the valley.
- Dolomite Bedrock – fine grained, weak to

2.12 Waste Rock Disposal

During the operation of the open pit, a total of 268.695 Mt of waste rock will be mined out of which 111.03 Mt will be limestone and 151.81 Mt will be basement rock. Basement rock will consist of two types: 116.15 Mt of granite (non-acid generating) and 36 Mt of ultramafic (potentially acid-generating and selenium containing). A summary of projected material quantities that will be mined from the Open Pit until closure together with the yearly waste rock placement schedule is detailed in Table 2.12-1.

Waste rock will be deposited in three areas (Figure 2.1-2). Dolomitic waste rock will be deposited in the 191 ha Dolomite Waste Rock Dump, granitic waste rock will be deposited in the 301.4 ha Country Rock Waste Rock Dump, and ultramafic waste rock will be co-disposed with the tailings in the 595 ha Tailings and Ultramafic Waste Rock Management Facility (TWRMF). All of the waste rock disposal areas will be located close to the open pit to minimize haulage costs and to optimize utilization of the site.

Limestone will be used in the construction of roads, containment berms, the basement layer for the ultramafic waste rock and dykes inside the Tailings and Ultramafic Waste Rock Management Facility (TWRMF), and for the site preparation of a Crusher Pad and an Ore Stockpile Pad; excess limestone will be deposited in the Dolomite Waste Rock Dump (Dolomite WRD).

2.12.1 Design Criteria and Considerations for the Waste Rock Dumps

The key design objective is to construct non-reactive waste rock dumps in the proximity of the open pit within compact footprints to the maximum heights governed by geotechnical analyses to minimize operational costs. As the dolomitic and Country Rock waste rock is inert, no special environmental protection measures are necessary (Wardrop, 2009b).

Tables 2.12-2 and 2.12-3 summarize the basic design criteria and parameters adopted for the waste rock dumps.

2.12.2 Waste Rock Dump Designs

The design of the waste rock dumps focuses on minimizing dump footprints and maximizing their heights through staged construction and in accordance with the results of engineering analyses and the waste production schedule. With both dumps containing non-acid generating (NAG) waste rock, there will not be a need for a seepage collection system and the storm water can report directly to the natural environment.

The locations of Country Rock Waste Rock Dump (CRWRD) and Dolomite Waste Rock Dump (DWRD) were selected to be on muskeg/peat covered weak overburden clay characterized by average thicknesses of 15 m and 10 m, respectively.

Table 2.12-1 Tailings and Waste Rock Production Schedule (tonnes)

Unit (tonne)	Overburden	Dolomite	Country Rock	Mill (Ni) Production	Frac Sand Plant Production	Mill (Ni) Tailings to TWRMF	Frac Sand Tailings to TWRMF	Ultramafic (PAG) Waste Rock To TWRMF	Total Tailings to T&PAGWRM
Year - 2	6,600,000	29,653,000	0	0	0	0	0	0	0
Year - 1	2,685,000	41,066,000	3,389,000	0	285,000	0	68,000	2,026,000	68,000
Year 1		26,060,000	11,031,000	900,000	1,140,000	889,000	356,000	4,189,000	1,245,000
Year 2		13,928,000	12,465,000	3,600,000	1,140,000	3,555,000	356,000	5,896,000	3,911,000
Year 3		325,000	27,165,000	3,600,000	1,140,000	3,555,000	356,000	4,945,000	3,911,000
Year 4		0	27,200,000	3,600,000	1,140,000	3,555,000	356,000	4,100,000	3,911,000
Year 5		0	16,236,000	3,600,000	1,140,000	3,555,000	356,000	4,223,000	3,911,000
Year 6		0	11,043,000	3,600,000	1,140,000	3,555,000	356,000	5,218,000	3,911,000
Year 7		0	6,836,000	3,600,000	1,140,000	3,555,000	356,000	4,449,000	3,911,000
Year 8		0	786,000	3,600,000	1,140,000	3,555,000	356,000	613,0000	3,911,000
Year 9		0	0	3,600,000	1,140,000	3,555,000	356,000	0	3,911,000
Year 10		0	0	1,254,000	770,000	1,238,000	240,000	0	1,478,000
Year 11		0	0	0	0	0	0	0	0
Total	9,285,000	111,032,000	116,147,000	30,954,000	11,315,000	30,567,000	3,512,000	35,659,000	34,079,000

Table 2.12-2 Design Basis for Rock Dumps

Item	Value
Life of the Open Pit mine	12 years
Total Waste Rock	262,840,000 t
Total Dolomite Waste Rock	111,032,000 t
Total Country Rock Waste Rock	116,147,000 t
Country Rock Waste Rock Specific Gravity	2.07 t/m^3
Dolomite Waste Rock Specific Gravity	2.79 t/m^3
Swelling	30%
Total Required Volume for Country Rock Waste Rock Dump	~ 72,942,560 m^3
Total Required Dolomite for Construction of Mine Infrastructure (TWRMF, roads, dykes, etc.)	10,743,600 m^3
Total Required Volume for Dolomite Waste Rock Dump	41,000,000m^3

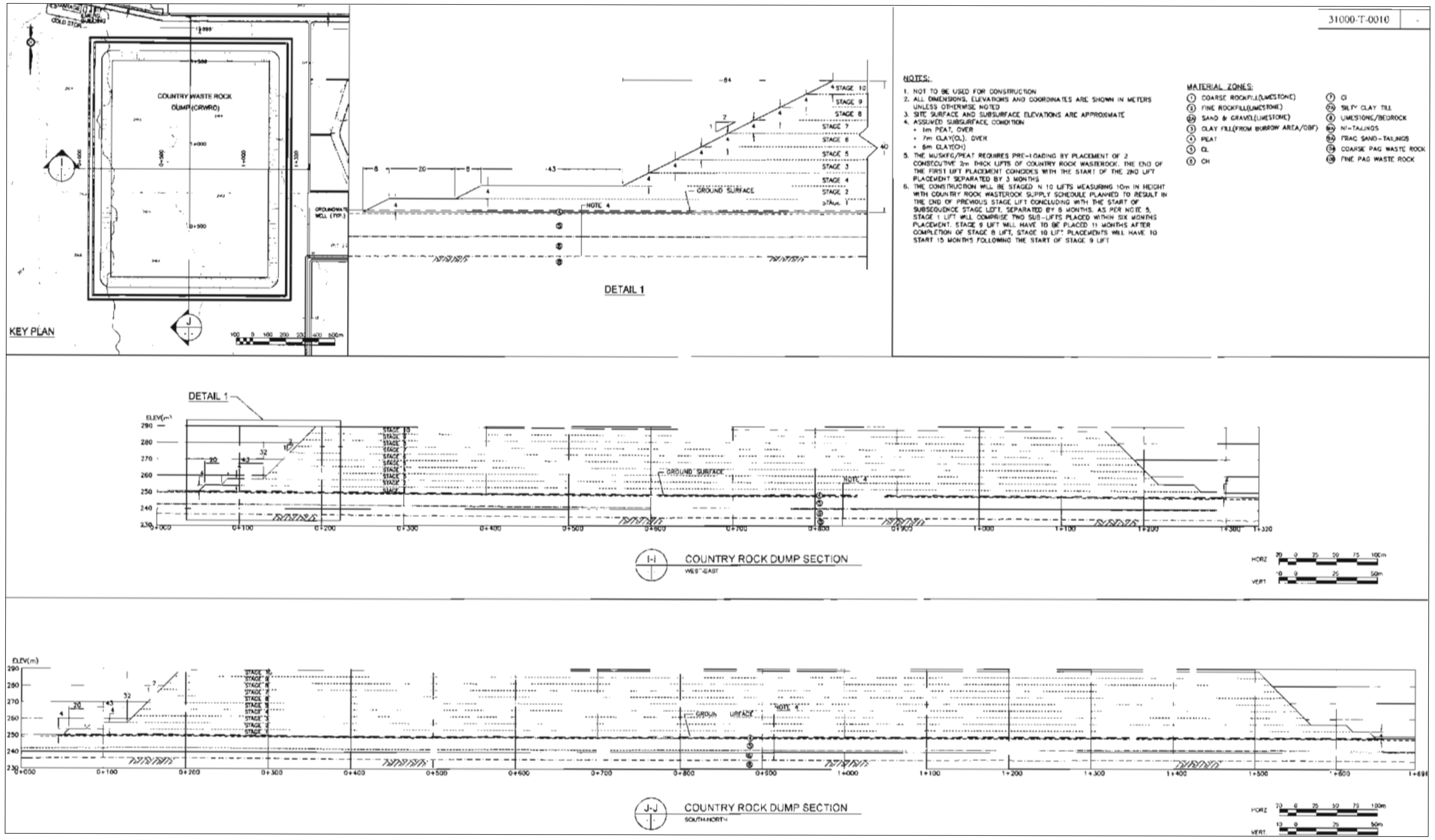
Source: Wardrop, 2009b

Table 2.12-3 Basic Engineering Design Parameters for Rock Dumps

Item	Target
1. Geotechnical Slope Stability: • Waste Dump	
• Construction (in stages)	• Static F.O.S 1.3, pseudo static F.O.S 1.05
• Normal Operation	• Same as above
• Closure	• Static F.O.S. 1.3, pseudo static F.O.S 1.05
2. Seismicity: • Operating Design Basis Earthquake	• 1: 475 year return
• Closure Earthquake	• 1: 2,475 year return
3. Max Dump Height	• Dependent on the results of engineering analyses in support of staged construction.

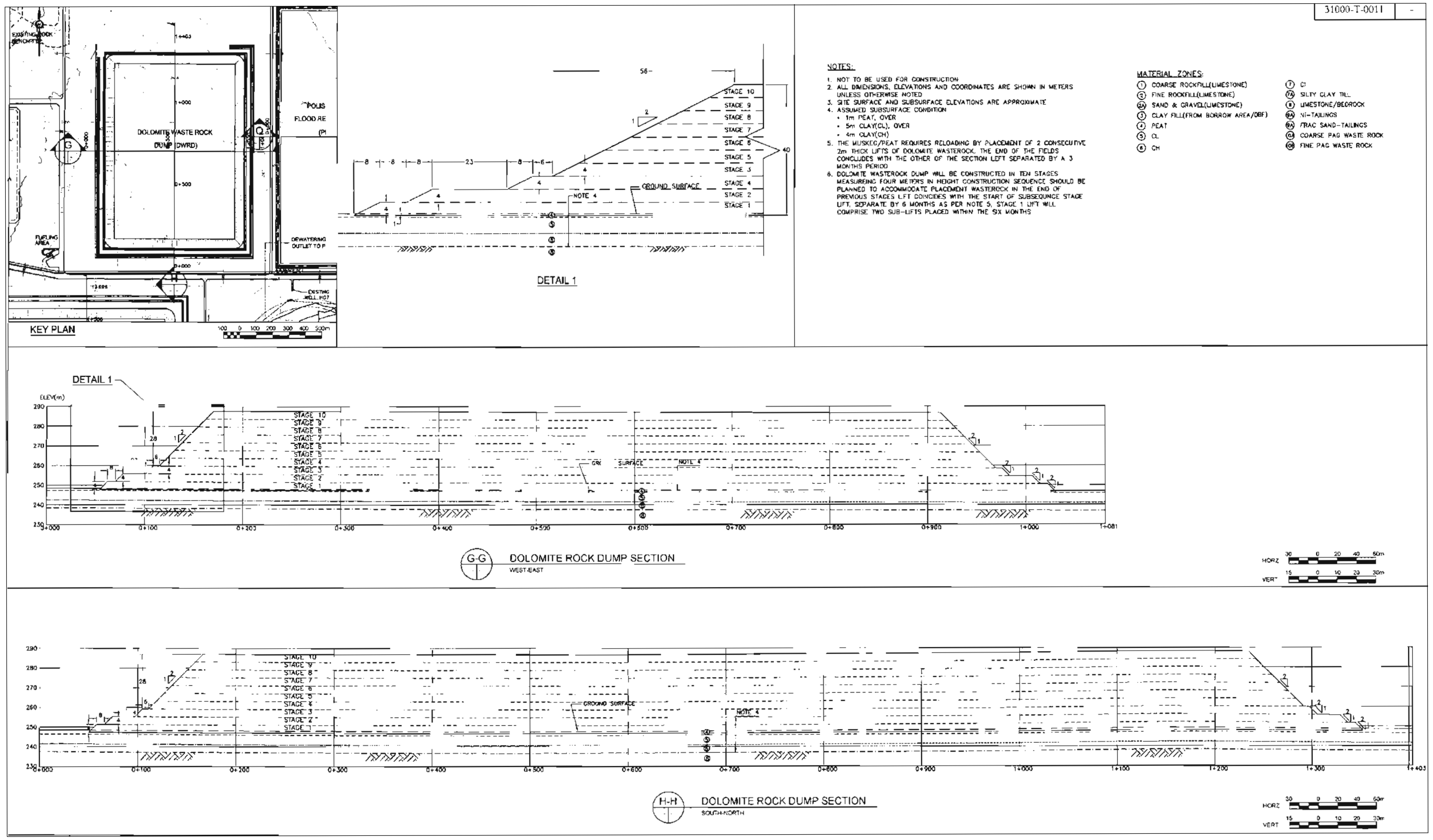
Source: Wardrop, 2009b

Plan and sectional details of the waste rock dumps are shown in Figures 2.12-1 and 2.12-2.



Source: adapted from Wardrop's drawing 0951330400-T0010 (Wardrop, 2009b)

Figure 2.12-1 Country Rock Waste Rock Dump Plan and Sections



Source: adapted from Wardrop's drawing 0951330400-T0011 (Wardrop, 2009b)

Figure 2.12-2 Dolomite Waste Rock Dump (DWRD) Plan and Sections

2.12.1.1 Country Rock Waste Rock Dump (CRWRD)

The Country Rock Waste Rock Dump (CRWRD) is designed for storing 59 Mm^3 of inert granitic waste rock. The dump will be founded on existing overburden comprised of muskeg/peat and clay averaging approximately 15 m in thickness. This dump will measure 1,596 m by 1,240 m in plan and will be staged in ten (10) lifts of 4 m for an ultimate dump height of 40 m. The dump configuration includes a 20 m and a 43 m setback for the toes of the Stage 2 and Stage 3 lifts with subsequent lifts set-back to give a 2H:1V slope (Wardrop, 2009b).

To allow for sufficient time for consolidation of the soft clay layer, successive lifts of this waste rock dumps will be sequenced with sufficient time for consolidation. Assuming 4 m lifts and a repetitive placement operation, any subsequent lift may only be started after the current lift has been in place for sufficient time for consolidation to be effective. Stages 2 to 8 may be sequenced 6 months after the previous stage, Stage 9, 11 months after that and Stage 10 after 15 months.

Construction of the Country Rock WRD will commence with the grubbing of all trees.

2.12.1.2 Dolomite Waste Rock Dump (DWRD)

The Dolomitic Waste Rock Dump is designed for storing 41 Mm^3 of inert dolomite rock. This dump will be founded on existing overburden comprised of muskeg/peat and clay averaging approximately 10 m in thickness. The dump will measure 1,303 m by 974 m in plan and will be staged in ten (10) lifts for a maximum height of 40 m. The dump configuration will be formed with overall slopes of 2H:1V and setbacks of 8 m, 23 m and 6 m for the toes of Stage 2, Stage 3 and Stage 4 lifts, respectively (Wardrop, 2009b).
Successive lifts of this dump will be sequenced with a set period of time (as will be done for the Country Rock WRD) to allow for sufficient time for consolidation of the soft clay layer underlying the dump. Assuming 4 m lifts and a repetitive placement operation, all subsequent lifts may only be started after a consolidation period of 6 months (Wardrop, 2009b).

Construction of the Dolomite WRD will commence with the grubbing of all trees.

2.12.1.3 Stability Analyses for the Waste Rock Dumps

Stability and settlement analyses were carried out in support of developing dump design sections that satisfy the design criteria (Table 2.12-2). Coupled analyses using Sigma/W and Slope/W, components of GeoStudio 2007, were used in the dam stability and settlement analyses. Sigma/W uses finite element methods to solve both stress-deformation and seepage dissipation equations simultaneously. Pore water pressures generated during lift placement were calculated with Sigma/W and then incorporated into Slope/W for stability analysis. Slope/W was used to locate failures with the least factor of safety within defined search limits (Wardrop, 2009b).

The Country Rock WRD and Dolomite WRD were modeled as underlain by 15 and 10 m of overburden, respectively. In the modeling, the overburden was divided into peat, and, upper (CI) and lower (CH) clay horizons. Both clay horizons were modeled using the non-linear Modified Cam-Clay (MCC) constitutive relationship (Wardrop, 2009b).

Initial pore pressure conditions were defined with an initial water Table at the ground surface in the peat material. Zero pressure boundary conditions were applied to the bottom of the bedrock to model dewatering wells pumping water out of the bedrock layer. The duration between placement of each lift was assumed to be 6 months (Wardrop, 2009b). However, the Stage 9 and Stage 10 lifts of the Dolomite WRD were assumed to have a longer time interval between the placement of successive lifts. The time interval was assumed to be 11 and 15 months for the Stage 9 and the Stage 10 lifts, respectively. In the modeling for lifts 1 through 8, each lift was assumed to be placed on the first day, and then 182 days were allowed for consolidation prior to the placement of the next lift.

The stability analyses are representative of conditions immediately after placement of each lift (Wardrop, 2009b).

Pseudo static analysis was performed to simulate an earthquake condition of 0.03 g (Wardrop, 2009b).

Material Properties

Material properties for soft clays (CL and CH) and bedrock properties were based on laboratory data; whereas peat and waste rock material properties were based on professional judgment and previous experience (Wardrop, 2009b). Table 2.12-4 and Table 2.12-5 present the material properties used for the waste rock dump stability analyses in Sigma/W and Slope/W models, respectively.

2.12.1.3.1 Results of Stability Analyses for the Waste Rock Dumps

Table 2.12-6 presents results of the stability analyses. These results satisfy the minimum factor of safety requirements for static and pseudo static conditions, except for the short times following completion of some lifts in the Country Rock WRD, shown bolded numbers in Table 2.12-6. For these cases, the lower factors of safety are considered acceptable, because of their very short duration and their relatively fast increase beyond the specified factor of safety (Wardrop, 2009b). For the Country Rock WRD, lifts 9 and 10 will reach a factor of safety of 1.3 after 11 and 15 months of placement of the last lift, respectively. Detailed slope stability results for Country Rock WRD and Dolomite WRD are presented elsewhere (Wardrop, 2009b).

Table 2.12-4 Assumed Sigma/W Material Properties for the Waste Rock Dump Stability Analyses

Materials	Material Category	Material Model	Poisson's Ratio	Young's Modulus (kPa)	Hydraulic Conductivity (cm/s)
Waste Rock	Effective Drained Parameters	Linear Elastic	0.35	70,000	-
Peat	Effective Parameters w/PWP Change	Linear Elastic	0.35	2,000	1.00E-01
Soft Clay (CL)	Effective Parameters w/PWP Change	Soft Clay (MCC)	0.36	-	1.36E-08
Soft Clay (CH)	Effective Parameters w/PWP Change	Soft Clay (MCC)	0.37	-	4.97E-09
Bedrock	Effective Parameters w/PWP Change	Linear Elastic	0.49	100,000	6.89E-04

Source, Wardrop, 2009b

Note: PWP Porewater pressure.

Table 2.12-5 Assumed Slope/W Material Properties for the Waste Rock Dump Stability Analyses

Materials	Model	Unit Weight (kN/m^3)	Cohesion (kPa)	Phi (º)
Waste Rock	Mohr-Coulomb	20	0	40
Peat	Mohr-Coulomb	13	18	0
Soft Clay (CL)	Mohr-Coulomb	21	20	29
Soft Clay (CH)	Mohr-Coulomb	18	10	25
Bedrock	Bedrock (Impenetrable)			

Source, Wardrop, 2009b

Table 2.12-6 Slope Stability Results

Lift No.	Country Rock Waste Rock Dump (CRWRD)			Dolomite Waste Rock Dump (DWRD)		
	Static (10 day) Required/ Computed	Static (6 months) Required/Computed	Pseudo static (6 months) Required/ Computed	Static (10 day) Required/ Computed	Static (6 months) Required/Computed	Pseudo static (6 months) Required/ Computed
1	1.30/**1.15**	1.30/1.69	1.05/1.53	1.30/1.90	1.30/2.04	1.05/1.87
2	1.30/**1.28**	1.30/1.46	1.05/1.20	1.30/1.34	1.30/1.33	1.05/1.18
3	1.30/1.67	1.30/1.93	1.05/1.45	1.30/1.37	1.30/1.31	1.05/1.20
4	1.30/1.75	1.30/1.89	1.05/1.47	1.30/1.37	1.30/1.46	1.05/1.23
5	1.30/1.77	1.30/1.75	1.05/1.46	1.30/1.36	1.30/1.45	1.05/1.24
6	1.30/1.53	1.30/1.58	1.05/1.36	1.30/1.37	1.30/1.46	1.05/1.26
7	1.30/1.35	1.30/1.38	1.05/1.31	1.30/1.38	1.30/1.44	1.05/1.27
8	1.30/**1.26**	1.30/1.32	1.05/1.22	1.30/1.39	1.30/1.44	1.05/1.28
9	1.30/**1.22**	1.30/1.30*	1.051.20*	1.30/1.40	1.30/1.45	1.05/1.29
10	1.30/**1.23**	1.30/1.30**	1.05/1.18**	1.30/1.40	1.30/1.44	1.05/1.29

Source: adapted from Wardrop, 2009b

Notes: * 11 months after lift placement.
** 15 months after lift placement.

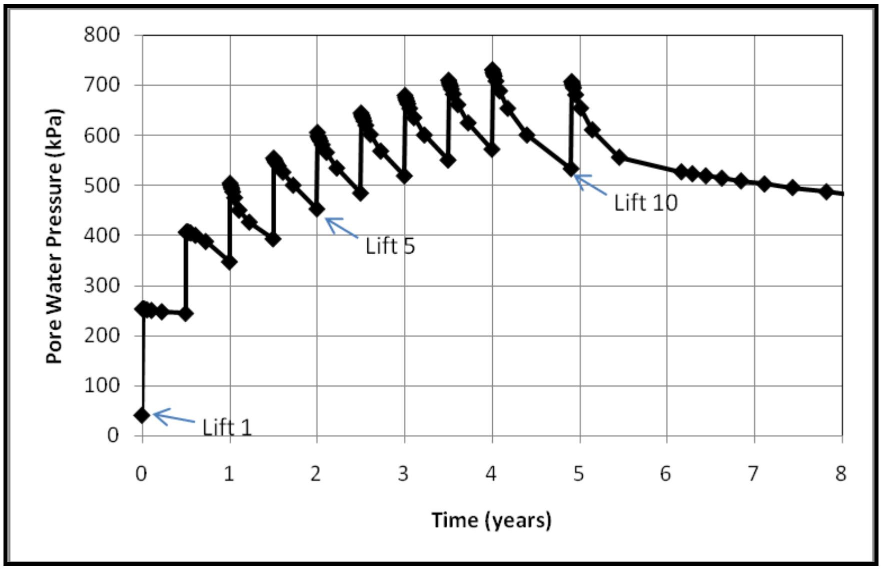
In order to achieve design heights of 40 m, the configuration of the dumps must include setbacks as summarized in Table 2.12-7 (Wardrop, 2009b).

Table 2.12-7 Required Setbacks for the Waste Rock Dumps

Lift No.	Country Rock Waste Rock Dump Setback (m)	Dolomite Waste Rock Dump Setback (m)
Stage 1	20	8
Stage 2	43	23
Stage 3	0	6

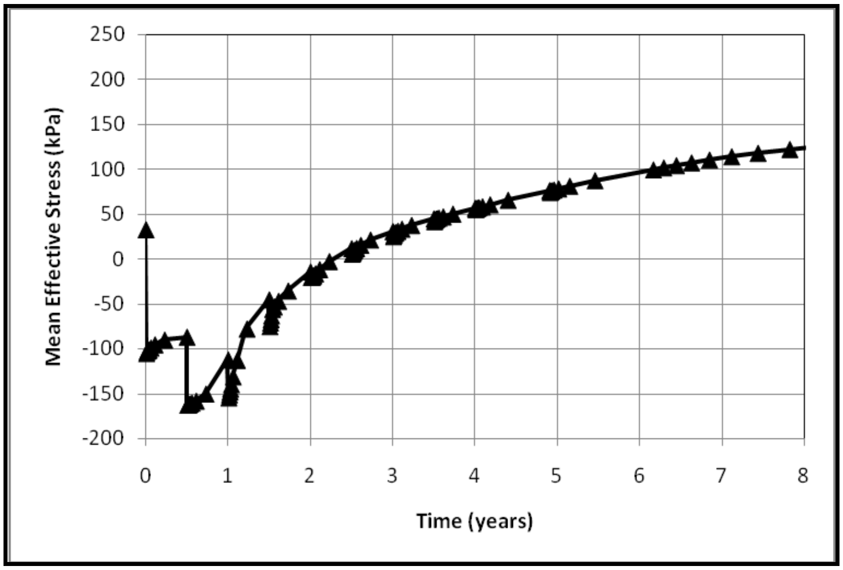
Source: Wardrop, 2009b

Figure 2.12-3 through Figure 2.12-10 show the effective stress versus time, and pore water pressure versus time for the short- and long-term conditions as computed in the foundation soils underneath the Dolomite WRD and Country Rock WRD. Figures 2.12-3, 2.12-5, 2.12-7 and 2.12-9 illustrate the effective stress increases after placement of each lift and their stabilization over time. Figures 2.12-4, 2.12-6, 2.12-8 and 2.12-10 show the pore water pressure generation after placing each lift and its dissipation over time. The estimated period for the pore water pressures to dissipate are 31 years for the Country Rock WRD and 16 years for the Dolomite WRD (Wardrop, 2009b).



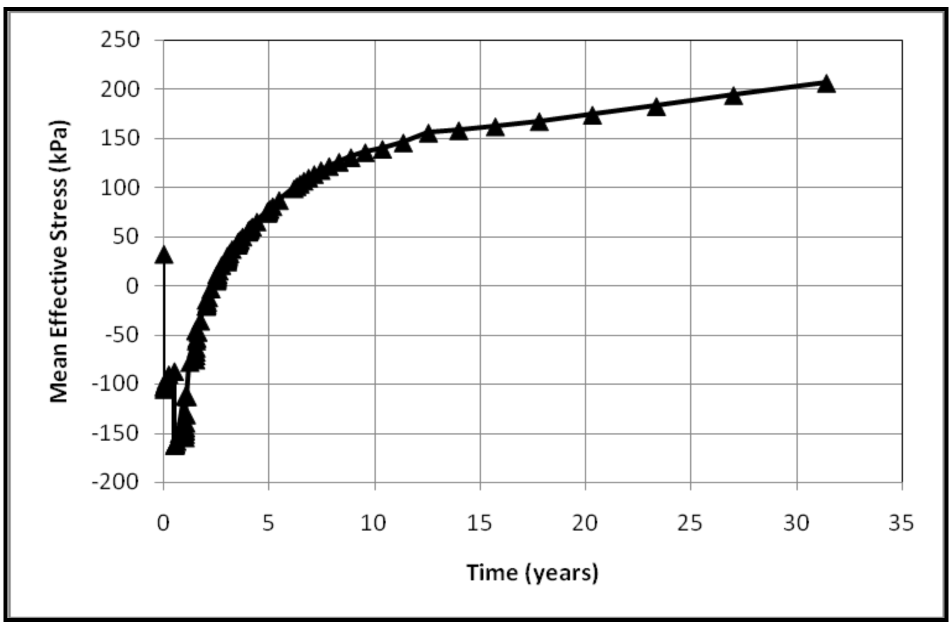
Source: Wardrop, 2009b

Figure 2.12-3 Short-term Mean Effective Stress versus Time for the Country Rock WRD



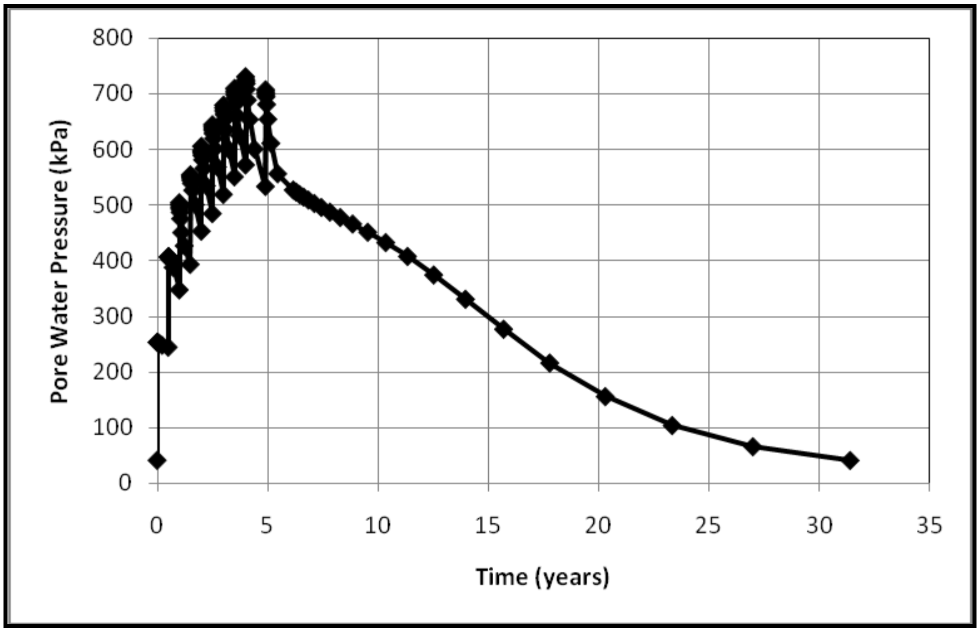
Source: Wardrop, 2009b

Figure 2.12-4 Short-term Pore Water Pressure versus Time for the Country Rock WRD



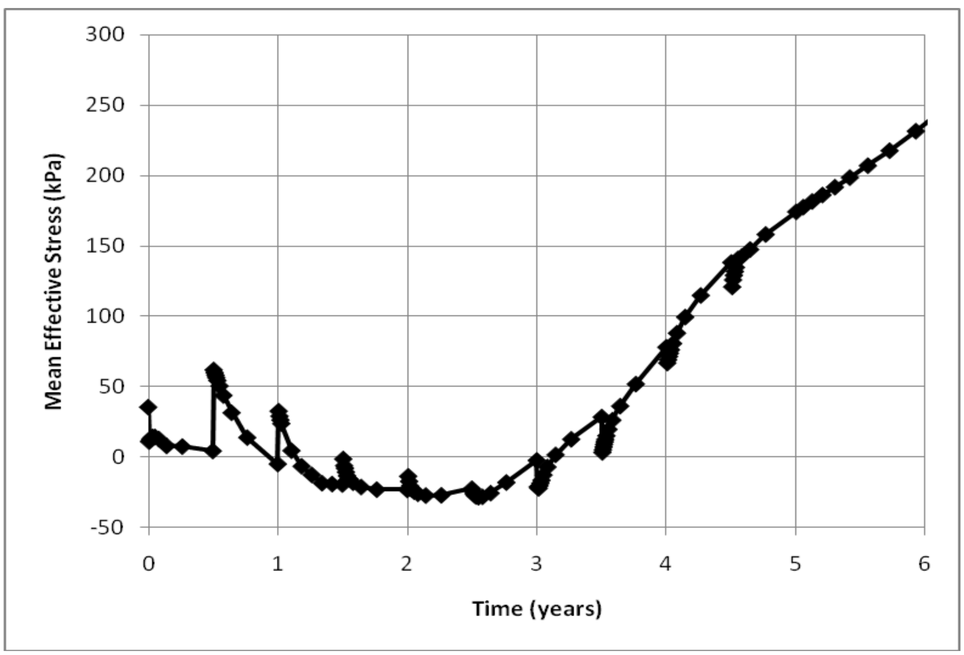
Source: Wardrop, 2009b

Figure 2.12-5 Long-term Mean Effective Stress versus Time for the Country Rock WRD



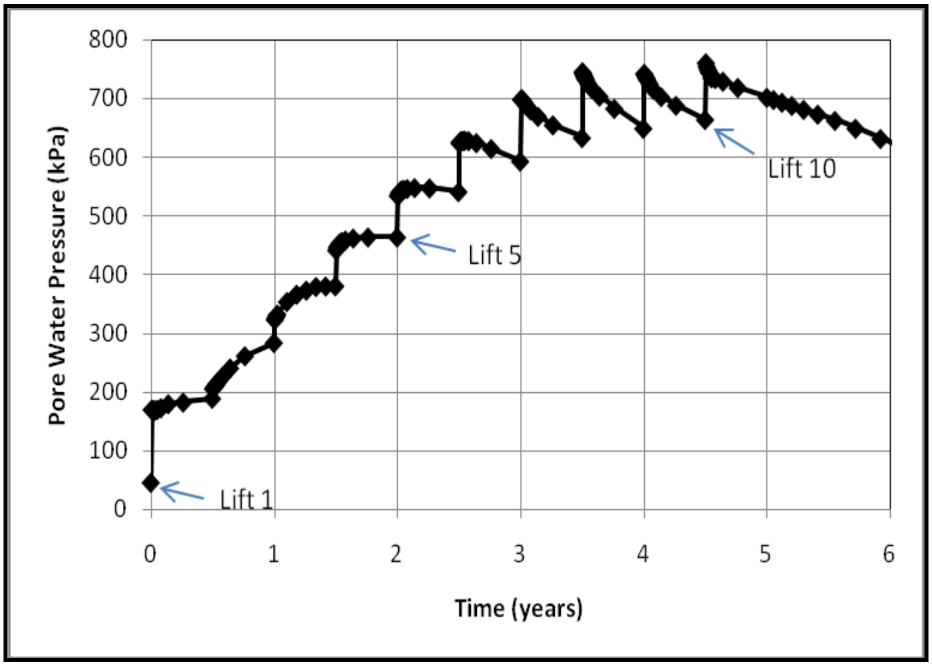
Source: Wardrop, 2009b

Figure 2.12-6 Long-term Pre Water Pressure versus Time for the Country Rock WRD



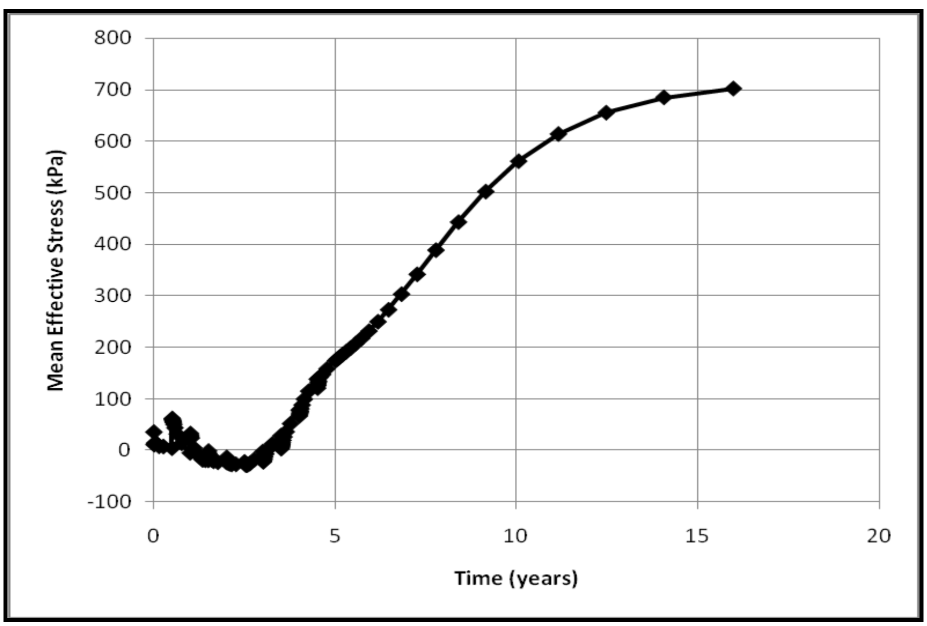
Source: Wardrop, 2009b

Figure 2.12-7 Long-term Pre Water Pressure versus Time for the Country Rock WRD



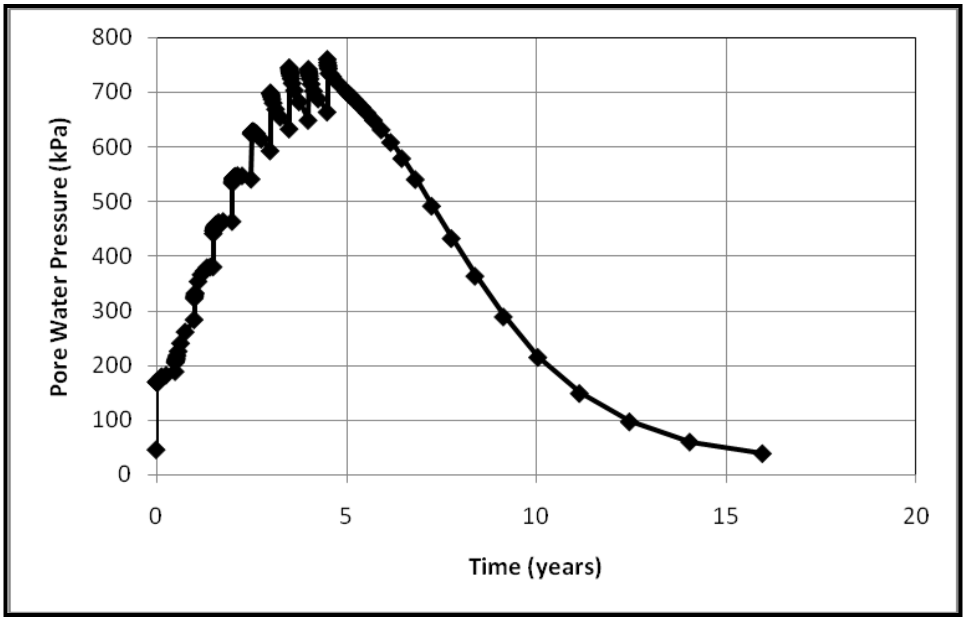
Source: Wardrop, 2009b

Figure 2.12-8 Short-term Pore Water Pressure versus Time for the Dolomite WRD



Source: Wardrop, 2009b

Figure 2.12-9 Long-term Mean Effective Stress versus Time for the Dolomite WRD



Source: Wardrop, 2009b

Figure 2.12-10 Long-term Pre Water Pressure versus Time for the Dolomite WRD

2.12.2 Deposition Strategy for Waste Rock Dumps

The main construction issue in relation to the dumps is foundation preparation by pre-loading. This will be achieved by placing 2 consecutive 2 m thick waste rock lifts as a part of the Stage 1 lift. The start of the second lift will have to coincide with the end of the first lift placement, separated by 3 months (Wardrop, 2009b). The second lift will have to be completed by the end of 6 months. Spreading of waste rock will be progressive over the entire dump area in advance of the Stage 2 lift placement (Wardrop, 2009b).

From a construction standpoint, it is preferable to proceed with the preloading during the winter season. It is estimated that the preloading will need to remain in place for at least 90 days (~3 months). This estimate can be confirmed by test fills during the detailed design stage. The placement of the Stage 2 lift in both dumps should proceed by slow gradual advancement of another 4 m of waste rock over larger areas to promote finalization of consolidation of the muskeg and peat and gradual load transfer into underlying clays in accordance with the staged construction (Wardrop, 2009b).

2.13 Tailings and Ultramafic Waste Rock Management Facility and Polishing Pond

The Tailings and Ultramafic Waste Rock Management Facility (TWRMF) is a key component of the water and waste management system at Minago for tailings, liquid waste and ultramafic waste rock. The disposal of tailings and waste rock has been studied from a number of different perspectives. The selected alternative is tailings co-disposal with ultramafic waste rock behind a lined rockfill embankment dam. Muskeg and/or clay will be forming the base of the embanked repository. The remaining waste rock from the open pit will be disposed of in the Dolomite Waste Rock Dump and in the Country Rock Waste Rock Dump as depicted in Figures 2.13-1 and 2.13-2.

The TWRMF is proposed to occupy a long, narrow water-saturated muskeg/peat wetland with some forested areas approximately four km northwest of the proposed pit. This lowland extends approximately 8 km from the southwest to the northeast and is bound on the east and west by sub-parallel dolomite bedrock ridges, approximately 2.5 km apart. The ridges rise nearly 20 meters above the wetland valley that slopes gently at approximately 0.2% but consistently to the north-northeast. The TWRMF structures would be oriented between the ridges, and along the lowland as depicted in Figures 2.13-2 and Figure 2.13-2a.

One key objective for the co-disposal is to initially induce invasion of tailings into the voids of end-dumped PAG/ML waste rock to encapsulate the PAG waste rock in tailings for the ultimate goal of providing acceptable seepage water quality from the facility. Other key objectives are to facilitate closure without long-term water treatment and to significantly lower CAPEX/OPEX and closure cost (Wardrop, 2009b).

Material in the TWRMF will be stored subaqueously whenever possible. Subaqueous disposal is practiced at many metal mines to keep oxidative rates at a minimum and to minimize metal leaching. Based on geochemical work done to date, Minago's mill tailings contain low sulphide levels and were deemed to be non acid generating (NAG) (URS, 2009i). Sulphide levels were less than or equal to 0.07 % in the Master tailings samples tested. However, ultramafic waste rock has been found to be potentially acid generating (PAG) (URS, 2009i).

The TWRMF will remain in place after all operations have ceased at the site. The TWRMF inflow will consist of:

1) mill tailings;
2) tailings and liquid waste from the Frac Sand Plant;
3) outflow from the sewage treatment system;
4) sludge from the potable water treatment plant; and
5) precipitation.

Outflows from the TWRMF include the TWRMF Decant, losses due to evaporation and sublimation, and seepage. Seepage will be captured by interceptor ditches surrounding the TWRMF and will be pumped back to the TWRMF. The seepage design criteria have tentatively been set to satisfy walk-away requirements (Wardrop, 2009b). The TWRMF Decant will be discharged to the Polishing Pond as shown in Figure 2.13-3 and will be regulated automatically by a control system.

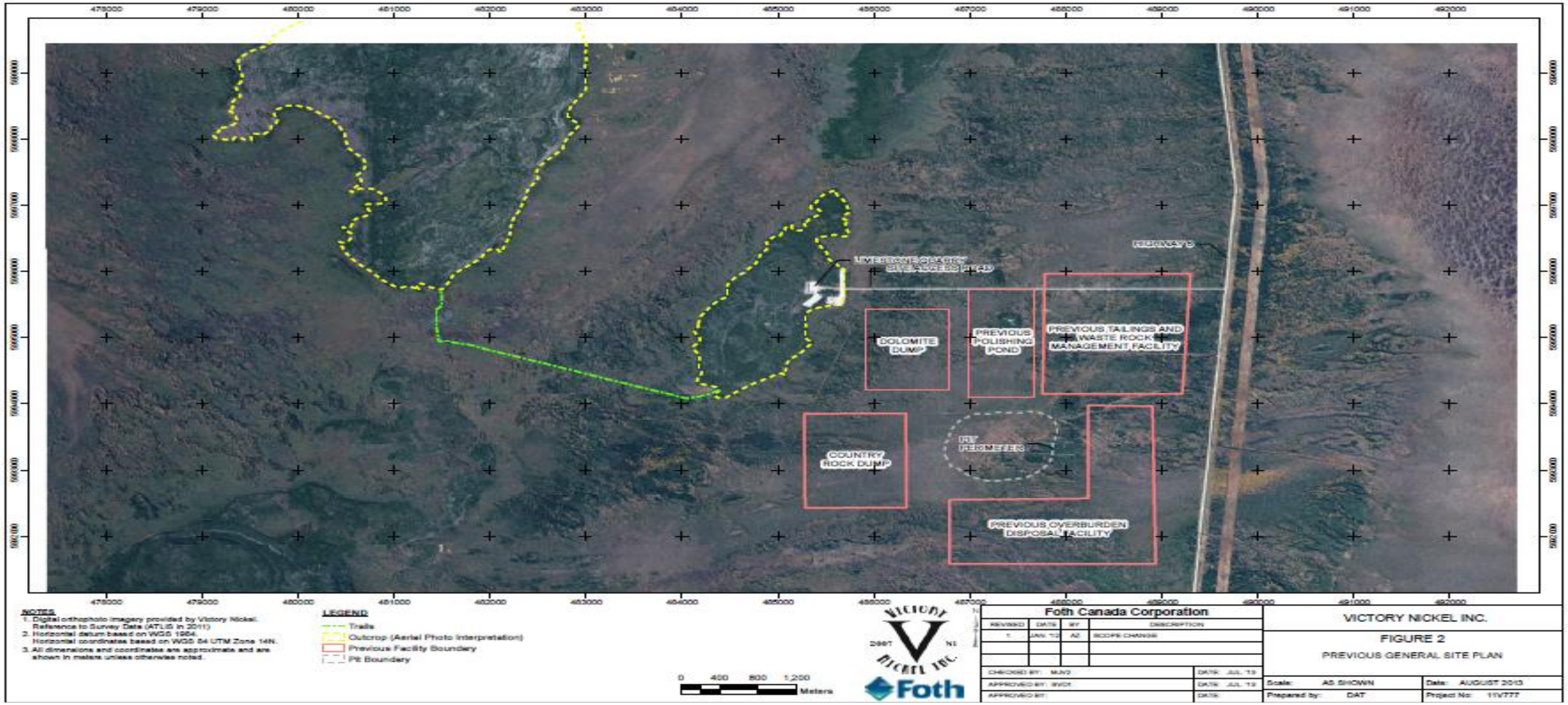


Figure 2.13-1 Previous General Site Plan

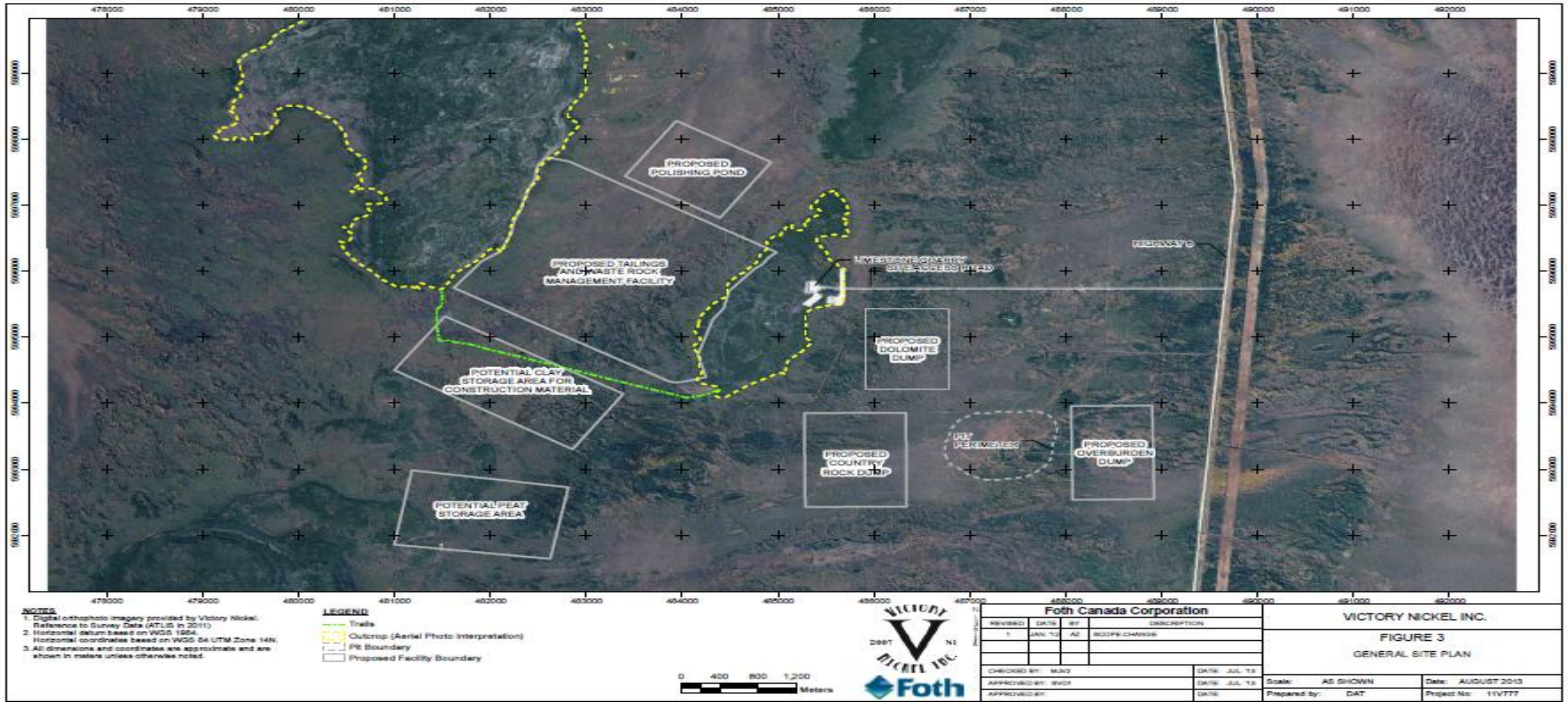


Figure 2.13-2 General Site Plan

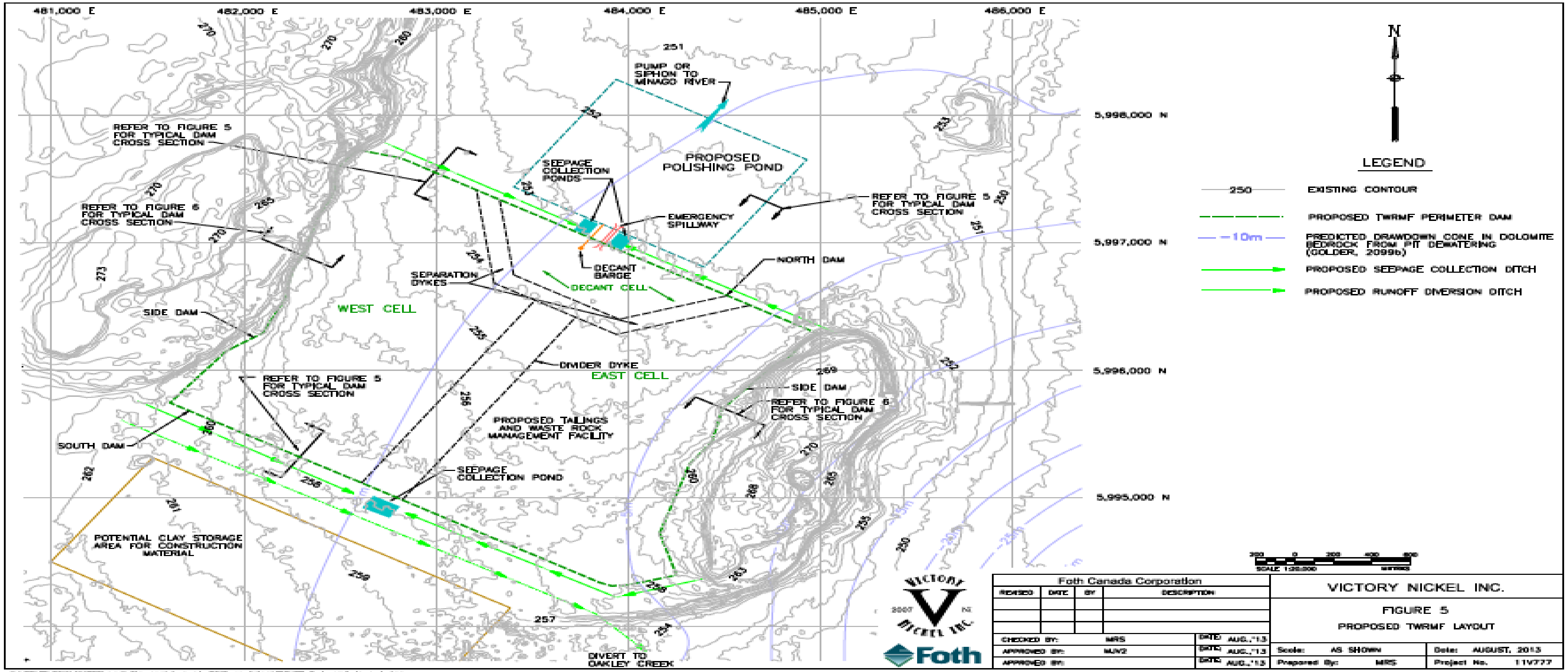


Figure 2.13-3 Detailed Layout of the Proposed TWRMF

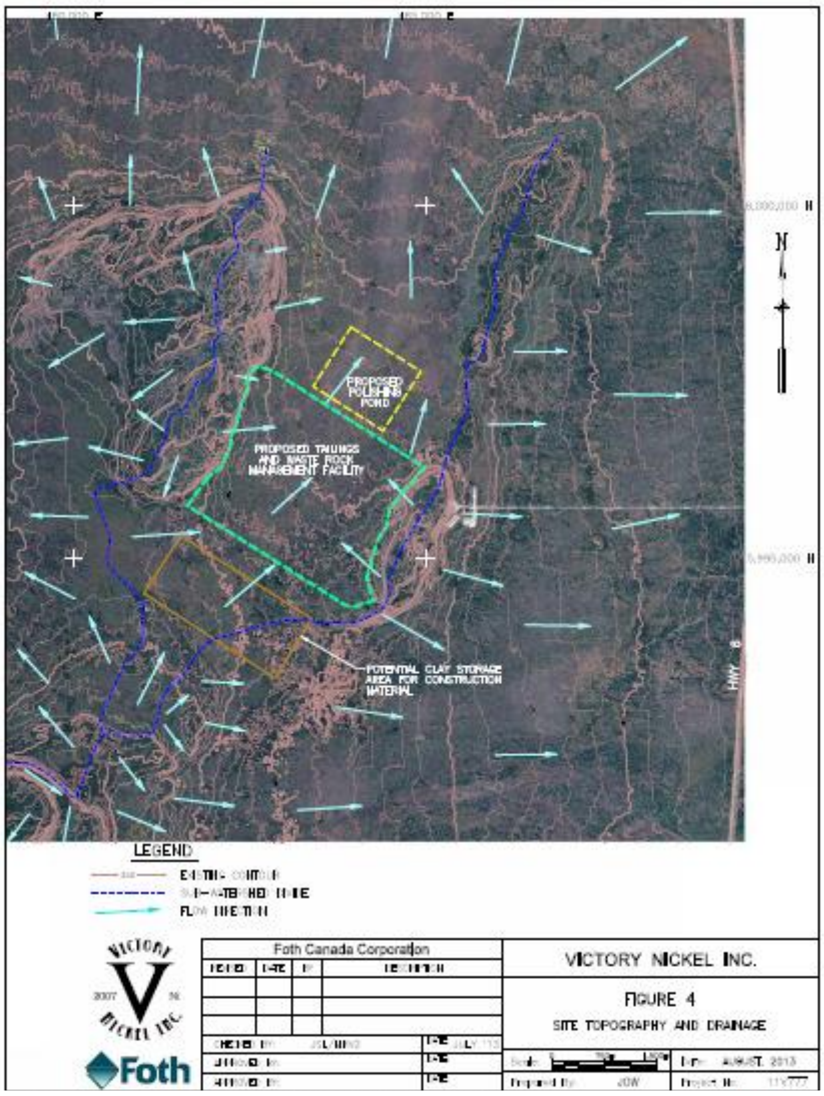


Figure 2.13-4 Site Topography and Drainage

Site Topography and Drainage

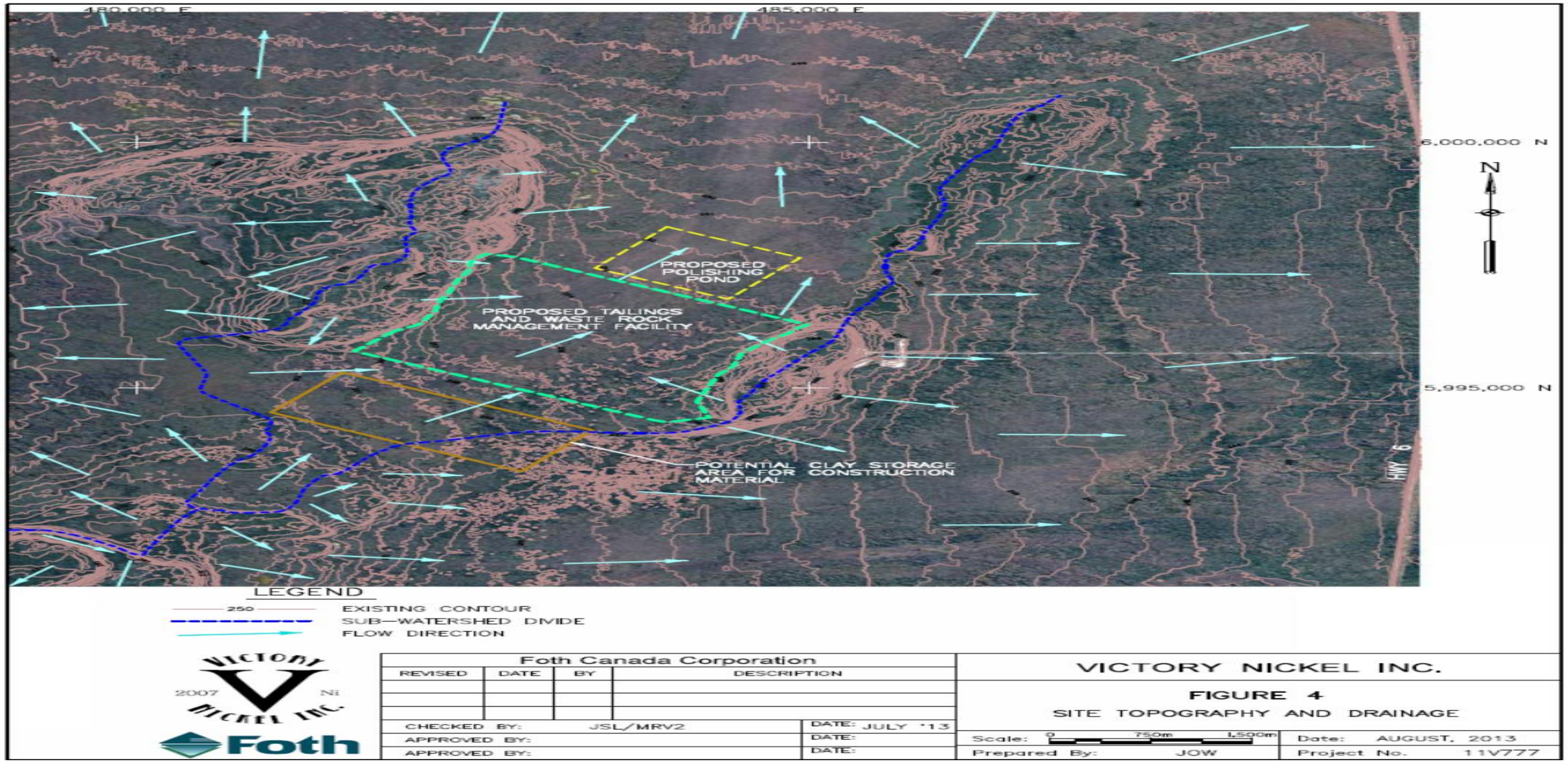
A Hydrologic Baseline Study was completed by Golder in 2008 (Golder, 2009a).

Regionally the project site is located within the Nelson River sub-basin, which contains the Minago River, Hargrave River, and William River with the Oakley Creek tributaries. The catchments of these three rivers are within the Lake Winnipeg basin, which ultimately drains northward into Hudson Bay. Within a 30 km radius of the project site there are several small-to-medium sized lakes, along with Limestone Bay on the northwestern edge of Lake Winnipeg.

The Minago and Hargrave Rivers flows in the northeast direction into Cross Lake, before reaching the Nelson River. The Oakley Creek flows in the southeast direction into the William River. The William River flows from William Lake in the northeast direction until reaching about 20 km downstream of Highway 6, where if turns 90 degrees to the southeast direction, draining into Limestone Bay (part of Lake Winnipeg).

Average surface runoff from the overall area was estimated by Golder (Golder, 2009a) to be approximately 117 millimetres per year (mm/yr) based on precipitation and stream gauging records. Recharge and evaporation in muskeg areas has not been directly measured.

Areas on the dolomite ridges will produce surface water runoff that will report towards the area under consideration. Inferred groundwater flow direction is north to northeast towards the Minago River, as shown in Figure 2.13-4. Although this will reflect pre-construction and post-closure conditions at the Minago project, open pit dewatering during site preparations and operations may have an impact on the groundwater flow pattern.



X:\GB\IE\2011\11V777\cad\figures\August 2013 revision\FIGURE 4 existing conditions.dgn
8/28/2013 JOW

Figure 2.13-5 Site Topography and Drainage

2-104

2.13.1 TWRMF Design Criteria

The TWRMF design requires compliance with permitting requirements as well as dam design and water quality guidelines. The TWRMF dam design is controlled to a significant extent by the presence of weak peat and clay foundation soils and a sufficient separation of the dam from Highway 6. The TWRMF must accommodate a total of 34,079,000 Mt of nickel and frac sand tailings and 36 Mt PAG-waste rock over the course of 10 years and provide secure storage for the long-term.

The Design Basis and Basic Engineering Design Parameters are summarized in Tables 2.13-1 and 2.13-2, respectively. Additional Design Criteria for the TWRMF are as follows (Wardrop, 2009b):

- The rate for the construction of successive stages of the TWRMF Dam should be governed by foundation strength and consolidation characteristics as well as the mine waste production schedule.
- The cone of depression created by pit dewatering is predicted to extend laterally in the dolomite to a distance of approximately 5,000 m to 6,000 m from the proposed open pit. The cone of depression will provide under drainage for the overburden clays and should be considered in geotechnical analyses for the TWRMF dam.
- A designated decant pond should be located between the causeways.
- The tailings deposition plan should ensure minimal exposure of PAG waste rock to atmospheric conditions during operations, closure and post closure.
- The configuration of PAG waste rock within the facility should allow for 2 m tailings cover at the end of the tailings deposition.
- Based on experience, tailings deposition slopes of 0.5% sub-aerial and 2% subaqueous should be assumed in the design.

Table 2.13-1 Design Basis for the Proposed TWRMF

Item	Value
Life of TWRMF	10 years
Total Nickel Tailings (tonnes)	30,567,000
Total Sand Tailings (tonnes)	3,512,000
Total Combined Tailings to TWRMF (tonnes)	34,079,000
Total PAG Waste Rock (tonnes)	35,569,000
Tailings Specific Gravity (Nickel)	2.6
Initial Tailings Void Ratio (Nickel)	1.0
Initial Tailings Density (Nickel)	1.3 t/m^3
Average Final Tailings Density (Nickel)	1.5 t/m^3
Tailings Pulp Density (solid weight) (Nickel)[1]	45%
Average Initial Tailings Density (Sand)	1.4 t/m^3
Average Final Tailings Density (Sand)	1.6 t/m^3
Tailings Pulp Density (solid weight) (Sand)	20%
Ultramafic Waste Specific Gravity	2.59
Ultramafic Waste Swelling	30%
Void Space in PAG Waste Rock	5,369,502 m^3
Total Volume of Ni Tailings	20,807,560 m^3
Total Volume of Sand Tailings	2,195,000 m^3
Total Combined Tailings Volume	23,002,560 m^3
Total PAG Waste Rock	17,898,340 m^3
Total Ni-Tailings Ingress into Voids of Coarse Ultramafic Waste Rock (at initial tailings density)[2]	3,221,701 m^3
Required TWRMF	37,679,199 m^3
Required TWRMF Storage (with 15% contingency included)	43,331,079 m^3

NOTES:

1. A 45% tailings solids density is used in the current study. However, higher water-to-solids ratios to enhance transport into and through the rock fill are recommended for consideration in detailed engineering.

2. It is assumed that 60% of the voids in the PAG ultramafic waste rock will be filled with tailings during co-disposal. The actual amount of tailings ingress into waste rock voids is dependent on the grain size of the PAG waste rock and the method of deposition. Sensitivity analysis should be carried out to assess the impact of varying levels of tailings ingress into the voids of the waste rock. During construction, field trails should be carried out to determine the actual amount of tailings migration into waste rock voids that can be achieved.

Table 2.13-2 Basic Engineering Design Parameters for the Proposed TWRMF

Item	Target	Comments
• **Geotechnical Slope Stability Factor of Safety (F.O.S)**		
• Construction (in stages)	• Static F.O.S. 1.3, pseudo static F.O.S 1.05.	
• Normal Operating	• Same as above.	
• Closure	• Static F.O.S. 1.5, pseudo static F.O.S 1.05.	
2. Seepage		
	• Target seepage volume of less than 50 m³/day[1].	• Analyses to be carried out using Geostudios SEEP/W software. • Low permeability barrier to be provided on the upstream face of the containment structure to reduce seepage through the ultramafic waste rock – tailing composite. • Seepage from the TWRMF to be collected via collection ditches and ponds.
3. Hydrotechnical		
• Construction Diversion Peak Flow	• 1:20 yr - 24 hr rainfall	• All peak flows are estimated from catchment times of concentration and storm. Seepage to be collected via collection ditches or ponds reporting to the overall water management system.
• Operation peak flow	• 1:200 yr – 24 hr rainfall	• Runoff to be segregated from seepage, with seepage reporting to the overall water management system.
• Closure Spillway and Diversion peak flow	• **1:1000 yr – 24 hr rainfall**	• Determine wave run-up in the freeboard.
• Freeboard	• 1.0 m on the top of Closure Spillway wet section for 1:200 year runoff. • 1.0 m operational freeboard	
• Closure Flood	• 1:1000 yr – 24 hr rainfall	
• Runoff Coefficient	• 1	• All runoff derived from precipitation falling on the TWRMF will report to the PP, via decant structure, emergency spillway, or seepage collection ditches and ponds.
4. Polishing Pond		
• Water Storage	• Minimum seven days retention.	
5. Closure Cover		
	• A minimum of 0.5 m of water in the permanent tailings pond at closure, a minimum o 1.0 m of saturated tailings and water over PAG waste rock at all times.	• Consider runoff (dry year), seepage, infiltration and evaporation to ensure a minimum thickness water cover.
6. Seismicity		
• Operating Design Basis Earthquake	• 1: 475 year return	
• Closure Earthquake	• 1:2,475 year return	

Source: Foth Canada, 2013 Prepared by: MJV2/ Checked by: JBH1

Note: Seepage target rate was selected by Foth based on the results of seepage sensitivity and analysis.

2.13.1.1.1 Seismicity

As the Minago project is located in a region historically exhibiting low seismicity an extensive evaluation extending beyond an examination of historic earthquakes is not considered necessary. The 2005 National Building Code seismic hazard calculation indicating the acceleration levels for given probabilities is presented below:

Probability of Exceedance per Annum	Probability of Exceedance in 50 Years (%)	Return Period (years)	Peak Ground Acceleration (PGA) g
0.01	40	100	0.007
0.0021	10	475	0.021
0.001	5	1,000	0.035
0.000404	2	2,475	0.059

A return period of 475 years is identified for use in design of structures at the site with a corresponding Peak Ground Acceleration (PGA) of 0.021 acceleration due to gravity(g). This design value has been assumed to be applicable for the operational life of the mine. For the longer term post-closure phase a return period of 2,475 years has been assumed with a corresponding PGA of 0.059 g.

2.13.1.1.2 Subsurface Conditions

A geotechnical investigation of the proposed TWRMF site was completed by Foth in 2012. The area of investigation was approximately 3 km by 4 km, centered on a wetland valley bounded on the east and west by bedrock ridges. The results of the geotechnical investigation are included in the Conceptual Design and Factual Report by Foth, 2013 (Appendix 2-13-1). The flanking ridges define the long dimension of an asymmetrical bedrock valley that is partially filled with overburden formations. Previous investigation work was completed by Wardrop in 2007 and 2008 (Wardrop, 2010) and focused on the current TWRMF site, east of the site proposed herein.

In general the subsurface soils in at the proposed TWRMF site comprise:

- Peat - course to fine fibrous peat varying in thickness between 0.8 and 2.3m.
- Upper Clay - soft to stiff, grey to brown, high plasticity clay (CH) varying in thickness between approximately 1 and 2 m.
- Intermediate Clay – firm to stiff, grey to brown, mottled, slightly weathered medium plasticity clay (CL) with a consistent thickness of approximately 5 m.
- Lower Clay – very soft to firm, grey to brown, CH reaching a thickness of 16 m in the center of the valley.
- Dolomite Bedrock – fine grained, weak to medium strong, moderately weathered, moderately jointed, dolomite.

The groundwater Table is generally at the ground surface and several bodies of water are present around the site. Relatively high piezometric heads were observed in the dolomite bedrock observations wells, suggesting confined aquifer conditions. There is also presumptive evidence of upward vertical gradients in the dolomite relative to the overburden.

2.13.1.2 Material Characterization

2.13.1.2.1 Geochemistry

A geochemical characterization study was completed by URS in 2007 (URS, 2008). The key findings are summarized below.

2.13.1.3 Waste Rock

According to the results of the geochemical characterization program undertaken by URS in 2007 (URS, 2008), the overburden, Ordovician dolomite, and Ordovician sandstone overlying the altered Precambrian basement and Precambrian basement lithologies are considered non-acid generating (NAG) material with a minimal potential for metal leaching (ML). The altered Precambrian basement and the Precambrian basement lithologies amphibolite and mafic dike also are considered to be NAG.

Although the Precambrian granite is typically considered to be NAG, localized areas with moderate to high sulphide sulphur and negligible carbonate content may create PAG granite. Precambrian serpentinite is considered to be NAG, primarily due to a high of carbonate content.

Precambrian mafic metavolcanic material is considered to be PAG based on the presence of sulphide content and negligible carbonate content. Precambrian mafic metasedimentary material is considered to be PAG due to low to high variability sulphide sulphur content and low carbonate content.

The Minago Project will produce three types of waste rock, namely, dolomite, country rock (predominantly granitic), and ultramafic rock. The overall quantities for dolomite, granitic country rock and ultramafic PAG waste rock are 111, 116, and 36 million tonnes, respectively.

Based on low estimated mafic metavolcanic and metasediment waste rock quantities and low potentially acid generating granite quantities expected to be generated during mining operations,

URS recommends that an operational program for static testing on blast hole cuttings be undertaken and built into a geologic block model, and that it be communicated with open pit operators so that PAG and NAG waste rock can be separated, with PAG waste rock disposed of in an appropriate facility. Based on kinetic test carbonate molar ratios, a preliminary Neutralization Potential Ratio criterion of 1.7 is recommended for segregation PAG from NAG.

The humidity cell test results suggested that dolomite mixed with Precambrian lithologies (cap rock and ore zone) would be effective in providing excess acid neutralization capacity to compensate secondary sulphide oxidation products on a micro-scale or meso-scale in situ.

2.13.1.4 Mill Nickel Tailings

Static and laboratory kinetic subaqueous column test results indicate that potential tailings material is NAG, due to very low sulphide sulphur content and moderate carbonate mineral content. Based on URS 2008, static and kinetic subaqueous column test results indicate NAG tailings due to very low sulphide sulphur content and moderate carbonate content. Based on their geochemical characteristics, concurrent disposal of tailings and PAG waste rock would mitigate Acid Rock Drainage (ARD) issues associated with ultramafic waste by encapsulating the PAG waste rock in tailings and water cover to minimize sulphide oxidation.

2.13.1.5 Sand Tailings

The Ordovician sandstone will be processed to produce marketable frac sand and frac sand tailings. As mentioned above, the Ordovician sandstone is considered to be NAG (URS, 2008).

2.13.1.6 Tailings Physical Properties

2.13.1.7 Mill Nickel Tailings

A geotechnical characterization of the nickel tailings was conducted by SGS Lakefield (Wardrop, 2010). The tailings sample was generated from the lock cycle test, one of several metallurgical programs set up for the Minago Project.

The tailings sample obtained from the lock cycle testing had a solids content of 45% by weight. Additional testing included settling tests, sieve and hydrometer analysis, specific gravity test, atterberg limits, standard proctor compaction test, hydraulic conductivity test, consolidated undrained triaxial test and an air drying test.

Settling tests were conducted for both undrained and drained conditions. The settled sample in the drained settling test was further subjected to a constant head hydraulic conductivity test. Hydraulic conductivity tests were carried out on compacted samples using a flexible wall permeameter. Specific gravity, sieve and hydrometer tests were conducted as per American Society of Testing and Materials (ASTM) requirements. The column drying test was conducted as per generic mining method rather than ASTM.

The grain size distribution test showed that the tailings sample was relatively fine grained, containing 5% clay, 77% silt and 18% fine sand. Atterberg limits test gave a liquid limit of 42%, a plastic limit of 28% and a plasticity index of 14%. A standard Proctor test resulted in a maximum dry density of 1,697 kg/m^3 at an optimum moisture content of 16.6%. The initial pulp density for both, drained and undrained conditions was 1.39t/m^3. When the test was completed nine days later, the density in drained and undrained conditions increased to 1.66 T/m^3 and 1.54 T/m^3, respectively.

Hydraulic conductivity tests on two combined tailings samples (i.e., on initially dry specimen and on slurried sample) were carried out using falling head testing method. Prior to conducting the tests, both samples were saturated. Based on the test results, the hydraulic conductivities were 8.2 x 10-6 cm/s and 2.0 x 10-5 cm/s for the initially dry and slurried samples, respectively.

The air drying test was carried out by SGS on a combined tailings sample. The test results show that the bulk of the volume reduction at average room temperature with relative humidity varying between 20 and 50% occurs during the first 800 hours.

2.13.1.8 Frac Sand Tailings

From a total of 11.5 million tonnes of mined frac sand, approximately 3.5 million tonnes will be sent to the TWRMF as tailings. Primarily, this fraction of the frac sand represents the finest portion of the sand which is that portion passing the American Petroleum Institute (API) Screen Number 140, or less than 116.5 microns and will consist primarily of silt.

2.13.2 Design Requirements

2.13.2.1 Design Considerations

The Minago TWRMF is designed for concurrent disposal of tailings and the PAG ultramafic waste rock in a stand-alone facility to mitigate ARD issues and facilitate regulatory compliance with Manitoba Provincial Tier III and CCME Guidelines. Figure 2.13-3 shows a plan view of the TWRMF centered on a wetland valley bounded on the east and west by bedrock ridges. The following design considerations were applied in the design.

- The peat and clay foundation soils have variable consistency and thickness.
- Displacement and compression of the peat is expected.
- The thick layer of native clay along the valley floor will provide effective seepage containment at the base of the TWRMF.
- A compacted clay liner will be constructed along the upstream slopes of the containment dams to minimize seepage flows into the environment.
- Clause 17 of Manitoba Conservation Environment Act License No.2981 stipulates a clay seal comprising at least 1.000 m of clay with permeability less than 1x10-7 m/s.
- The low permeability of the tailings placed along the upstream slope of the containment dam will minimize the seepage flows into the environment.
- The PAG waste rock will be co-mingled with tailings with the following benefits:

  Reduced oxygen infiltration in the waste rock to minimize ARD.

  Increased storage capacity of the facility by filling the voids with tailings.

  Voids not filled with tailings will be filled with water in within PAG rock mass.
- The materials from the open pit mining operation will provide the construction materials for the TWRMF containment dam. In addition, a search for borrow material should be considered to find equivalent volumes of local eskers as a part of future studies.
- Selective disposal of clay overburden excavated from the open pit and TWRMF in attempt to sort the material by moisture content. This will facilitate the sourcing of clay material that is suitable for construction.

- The pit dewatering will create a cone of depression of hydraulic head in the dolomite and provide effective under-drainage to the overburden clays that underlie the dolomite and a portion of the TWRMF.

A geotechnical monitoring program that includes the installation of vibrating wire piezometers and settlement plates should be considered during early stages of construction of the TWRMF containment dam to measure pore pressure dissipation and settlement.

Three containment cells (East Cell, West Cell and Decant Cell) are designed to provide operational flexibility and to facilitate progressive closure of the TWRMF. During operation, ARD mitigation measures will be undertaken concurrently by encapsulating the PAG waste rock in low permeability NAG tailings. Drainage water is to be captured by the decant pond and ultimately the PP. The quality of the water is to be monitored to ensure all applicable water quality standards are met prior to release to the receiving environment.

2.13.2.2 Hazard Potential Classification

The hazard potential classification has been made in accordance with the Canadian Dam Association (CDA) Dam Safety Guidelines 2007. This classification evaluates the consequences of dam failure in terms of risk to population, loss of life, and environmental, cultural, and economic losses. A failure of the TWRMF dam would result in the release of the contained tailings and PAG ultramafic waste rock to the environment. There would be potential for injury or loss of life of temporary workers and loss of marginal habitat. Accordingly, the TWRMF dam may be classified as a “Significant Dam Class” structure and the hydrological, hydro technical and seismic design criteria are selected in accordance with the CDA.

2.13.2.3 Design Basis

The TWRMF must accommodate a total of 34.1 Mt of nickel and frac sand tailings and 35.7 Mt PAG waste rock over an anticipated 10-year mine life and the facility must provide secure storage for the long-term. On the basis of the current production plan, the Tailings and Waste Rock Production Schedule is shown in Table 2.13-3 and the Design Basis for the TWRMF is summarized on Table 2.13-2.

2.13.2.4 Design Criteria

The design criteria for the proposed TWRMF are provided on Table 2.13-2.

2.13.3 Conceptual Design of TWRMF

2.13.3.1 Sizing

The sizing of the TWRMF is based on the projected production schedule shown on Table 2.13-3. The Volumes shown on Table 2.13-1 were generated based on the tonnages shown on Table 2.13-3.

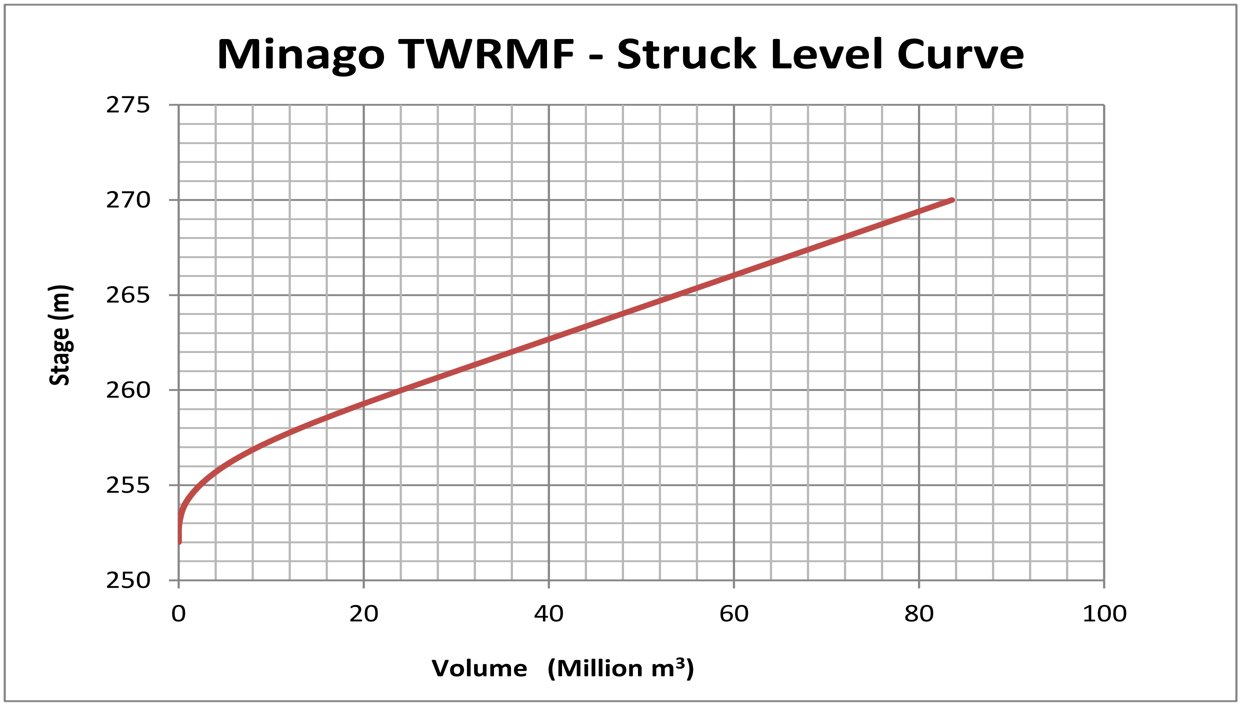
The TWRMF is designed to contain all of the PAG waste rock and tailings produced during the life of the mine. As shown in Table 2.13-1, the total volume of tailings produced is 23 M-m^3 (Frac Sand Tailings and Nickel Tailings) and the total volume of PAG waste rock is 17.9 M-$m^{3.}$ The total volume required to accommodate all the waste material is 37.7 M-m^3, or 43.3 M-m^3 including a 15% contingency.

Table 2.13-3 Tailings and Waste Rock Production Schedule (tonnes)

Unit (tonne)	Overburden	Dolomite	Country Rock	Mill (Ni) Production	Frac Sand Plant Production	Mill (Ni) Tailings to TWRMF	Frac Sand Tailings to TWRMF	Ultramafic (PAG) Waste Rock To TWRMF	Total Tailings to T&PAGWRM
Year - 2	6,600,000	29,653,000	0	0	0	0	0	0	0
Year - 1	2,685,000	41,066,000	3,389,000	0	285,000	0	68,000	2,026,000	68,000
Year 1		26,060,000	11,031,000	900,000	1,140,000	889,000	356,000	4,189,000	1,245,000
Year 2		13,928,000	12,465,000	3,600,000	1,140,000	3,555,000	356,000	5,896,000	3,911,000
Year 3		325,000	27,165,000	3,600,000	1,140,000	3,555,000	356,000	4,945,000	3,911,000
Year 4		0	27,200,000	3,600,000	1,140,000	3,555,000	356,000	4,100,000	3,911,000
Year 5		0	16,236,000	3,600,000	1,140,000	3,555,000	356,000	4,223,000	3,911,000
Year 6		0	11,043,000	3,600,000	1,140,000	3,555,000	356,000	5,218,000	3,911,000
Year 7		0	6,836,000	3,600,000	1,140,000	3,555,000	356,000	4,449,000	3,911,000
Year 8		0	786,000	3,600,000	1,140,000	3,555,000	356,000	613,0000	3,911,000
Year 9		0	0	3,600,000	1,140,000	3,555,000	356,000	0	3,911,000
Year 10		0	0	1,254,000	770,000	1,238,,000	240,000	0	1,478,000
Year 11		0	0	0	0	0	0	0	0
Total	9,285,000	111,032,000	116,147,000	30,954,000	11,315,000	30,567,000	3,512,000	35,659,000	34,079,000

Prepared by: JMH3
Checked by: JBH1

An approximate struck level capacity curve for the proposed TWRMF is shown below:



The available storage in the proposed facility is approximately 48.3 M-m^3, assuming the facility is filled to a constant elevation of 264m (2m below dam crest) and 55.0 M-m^3 assuming the facility is filled to a constant elevation of 265m (1m below dam crest). In reality, the tailings will not be deposited to a constant elevation. Assuming a 360 degree deposition from an elevation of 264m toward the center of the facility and a final average deposition slope of 0.2%, a reduction in available storage of approximately 10.5 M-m^3 is expected from the 48.3 M-m^3 struck level volume. Therefore, the effective storage volume is reduced to approximately 37.7 M-m^3, assuming a 2 m freeboard.

2.13.3.2 Layout

The proposed layout of the TWRMF is shown on Figure 2.13-3. The two existing dolomite bluffs have been utilized to provide containment along the “sides” of the storage area. Dams are proposed on the northeast (North Dam) and south west (South Dam) ends, along with smaller dams along the sidewalls to provide additional containment and prevent infiltration of water into the dolomite bluffs.

The top elevation of the dams is proposed to be at an elevation of 266 m. The floor of the facility will be the existing ground. A PAG waste rock divider dyke and separation dykes will be constructed across the floor as shown on Figure 2.13-3. The dykes are intended to divide deposition cells and facilitate deposition and decanting of supernatant water.

The PP is situated to the northeast of the TWRMF and seepage collection ditches are included along the North and South Dams. An additional ditch for runoff diversion is included south of the TWRMF and is designed to intercept water from the head of the valley across to the drainage system around the pit.

2.13.3.3 Alternative Analyses

Three design options were considered:

1. A repeat of the existing Wardrop design.
2. The current design with the TWRMF nestled between the bluffs.
3. An option with the side walls moved in to facilitate drainage around TWRMF.

The first Option was discounted because the new proposed site offered 600 ha in valley (Figure 2.13-2) underlain by a thick clay deposit which allowed for minimizing the height of the dam.

The alternative TWRMF arrangement, option 3 involved moving the side dams away from the dolomite bluffs by 100 m to areas of greater clay thickness. This would have resulted in an increased dam height along the sides of the TWRMF but allowed for the construction of seepage collection ditches along the sides of the facility.

Option two was selected as the preferred solution to take full advantage of the natural landscape and the containment afforded by the dolomite bluffs. By careful selection of the side dam location to position these where the in situ clay thickness is assured, option 2 will be the lower cost option. In addition to the in situ clay, the seepage through the sides of the facility is minimized by the compacted clay liner.

2.13.3.4 Dam Design

The perimeter containment dams are to be raised from a starter dam to afford a consolidation period before the construction of the balance of the dam. The dam is designed with the required factor of safety against failure in accordance with the design criteria. Figures 2.13-5 and 2.13-6 show the typical design sections for TWRMF containment dams. The dams are constructed in two main phases: the Pre-load / Starter dam and the Ultimate Dam.

The objectives of the Pre-load / Starter Dam are to:

- allow for displacement and compression of the peat foundation soils;

- develop sufficient strength gain in the clay foundation soils by consolidation before construction of the ultimate dam;
- provide a working platform for construction of the ultimate dam; and
- provide containment for the initial quantities of frac sand tailings and ultramafic PAG waste rock produced during Year -1 (Table 2.13-3).

The dams are to be constructed of the dolomite waste rock with a 15 m wide crest at an elevation of 266 m, with 3H: 1V side slopes. A 1 m thick zone of compacted clays is provided as a low permeability liner on the upstream slope of the dam and the liner will extend to the TWRMF floor and be keyed into the existing native clay (Foth, 2013) as shown in Figures 2.13-4 and 2.13-5. Layers of crushed dolomite filters are to be provided between the compacted clay liner and dam fill materials if the gradation of the fill materials warrant.

Given the abundance of dolomite rock available during the Mine Development Phase, this was the obvious choice for construction. Similarly, the abundance of clay of suitable moisture content is available from the Open Pit and the TWRMF Site. The option to use crushed dolomite as potential filter materials will be addressed during the Detail Design Phase. Alternatively, outwash sand and gravel could be considered as suitable filter materials if identified by future investigations.

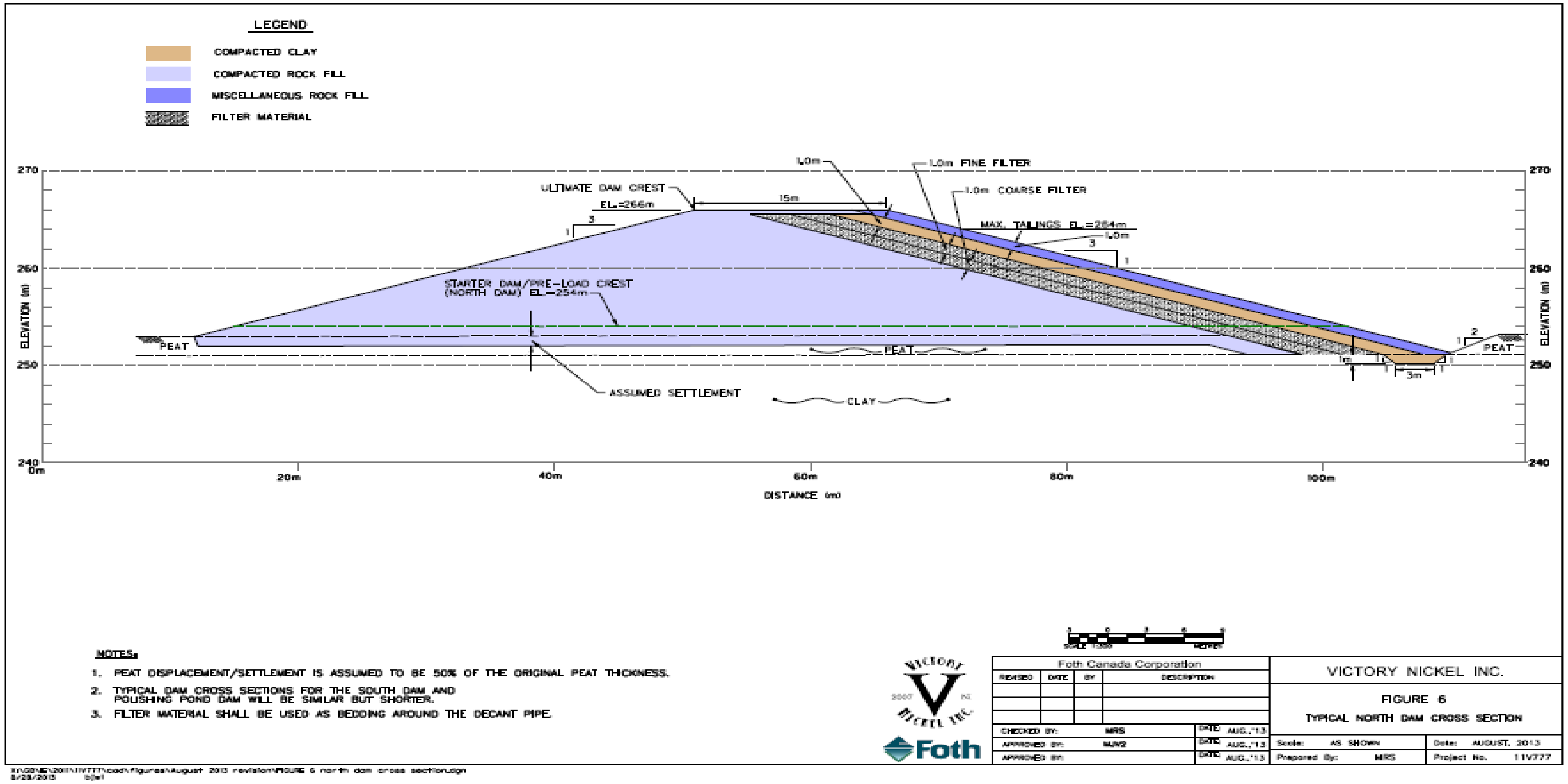


Figure 2.13-6 Typical North Dam Cross Section

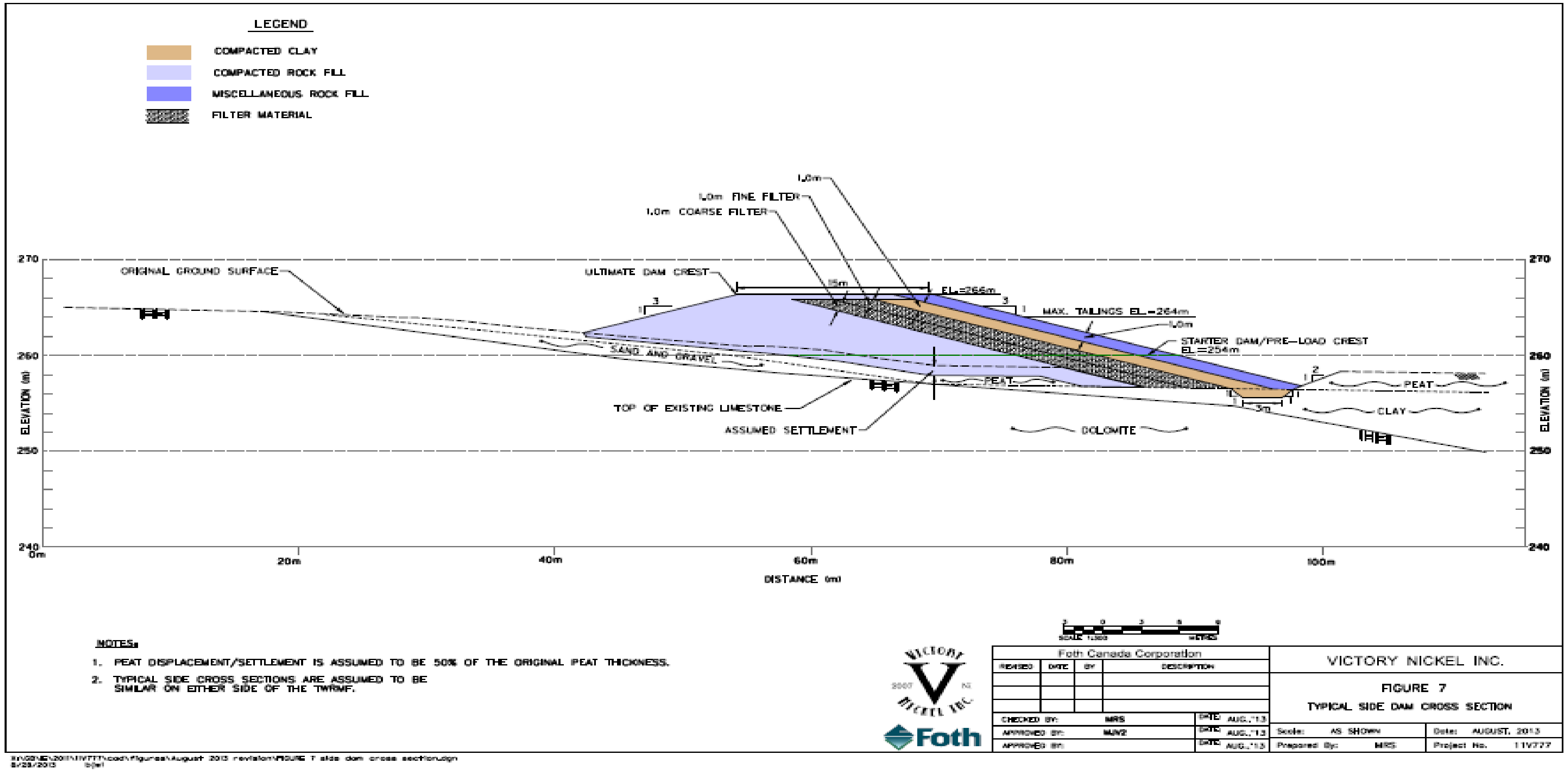


Figure 2.13-7 Typical Side Dam Cross Section

2.13.3.5 Stability

The stability of the downstream slopes of the Ultimate Dam at Closure was analyzed using a limit equilibrium method with slope stability software Geostudios Slope/W (version 7.21). The upstream slope of the Ultimate Side Dams along the dolomite ridges was also analyzed. The minimum factors of safety against slope failure were calculated using the Morgenstern-Price Method. The slope stability analyses were performed at the critical sections under both static loading and pseudo static earthquake loading conditions.

Different failure modes and mechanisms were considered in the analyses including potential shallow or deep-seated slip surfaces and optimized circular or block type slip surfaces with minimum calculated factors of safety reported. Appendix 2.3-1 presents the details of the stability analyses carried out for the TWRMF dams.

The calculated factors of safety against dam failure for all stability analyses ranged from 1.3 to 1.7 and meet the requirements of the design criteria.

2.13.3.6 Seepage

The compacted clay liner and thick base of native clay is intended to minimize seepage flows from the TWRMF to the environment. Seepage flow through the North and South dams make up the majority of the seepage flows leaving the TWRMF, and will be directed to the PP. The rate of seepage flows through both the typical North/South Dam section and the typical Side Dam section at the final stage of the deposition were estimated by carrying out seepage analyses using Geostudios Seep/W (version 7.21).

The calculated seepage flow through the dams for the entire TWRMF at closure is 23.1m^3/day with a compacted clay liner thickness of 1 m, which meets the requirements of the design criteria (Table 2.13-2). Sensitivity analysis results indicated a seepage rate of 853.1 m^3/day for an unlined rock fill dam. Actual seepage flow may vary due to uncertainties associated with hydraulic conductivity of the clay liner, tailings, and waste rock.

2.13.4 Appurtenances

2.13.4.1 Decant Siphon System

A Decant Siphon System is included to allow passive overflow from the Decant Cell to the PP (Figure 2.13-3). The siphon inlet will be raised as required. Additional siphons will be employed as needed to accommodate increasing levels of hydraulic head in the Decant Cell.

2.13.4.2 Emergency Spillway

An emergency overflow spillway is provided on the North Dam as shown on Figure 2.13-3. The spillway is to be constructed out of dolomite waste rock and non-woven geotextile and remain in a single location for the life of the mine. This will be raised with the dam, and will be design for a 1 in 1000 year 24 hours storm in accordance with the Design Criteria (Table 2.13-2).

Typically, the design of the Emergency Spillway would be included in the FSU.

2.13.4.3 Polishing Pond

The total water output from the TWRMF varies from 23 m^3/day (seepage only) during freezing conditions, to as much as approximately 312,000 m^3/day following an extreme runoff event such as the May freshet or a storm.

2.13.4.4 Ditches

Seepage collection ditches are proposed along the North and South Dams of the TWRMF to collect seepage and pump back to the TWRMF. The compacted clay liner along the east and west Side Dams minimizes seepage into the Dolomite Bedrock.

A runoff diversion ditch is required along the southwest side of TWRMF (Figure 2.13-3) to collect water from the head of the sub-watershed. As noted previously this ditch will drain to the perimeter drainage systems to be constructed for the Open Pit. In the current plan, this drainage is taken to a silt trap at Highway 6 and ultimately to the wetland area to the east of Highway 6.

2.13.5 Deposition Strategy

- The TWRMF comprises three cells designed to facilitate tailings deposition and co-mingling with waste rock. The deposition plan has flexibility in the design that allows for modifications, if required, in the future once actual deposition characteristics are determined during the initial years of operation. The deposition plan and staged construction plan for the TWRMF is shown on Figures 2.13-7 and 2.13-8 and summarized on Table 2.13-4. An adaptive management program shall be in place during operations to optimize the deposition plan based on the observed conditions.

Table 2.13-4 TWRMF Construction and Deposition Schedule

Operating Period	Duration (years)	TWRMF Operating Phase	Dolomite Placement		Compacted Clay Placement		Frac Sand Tailings Deposition		Nickel Tailings Deposition		PAG Waste Rock Deposition	
			Quantity (M-m^3)	Location	Quantity (M-m^3)	Location	Quantity (M-m^3)	Location	Quantity (M-m^3)	Location	Quantity (M-m^3)	Location
Year -2	1	Starter Dam / Pre-load Construction	1.3	TWRMF Dams	0.1	TWRMF Dams	-	-	-	-	-	-
			0.3	Polishing Pond Dams	0.05	Polishing Pond Dams	-	-	-	-	-	-
Year -1	1	Ultimate Dam Construction	1.9	TWRMF Dams	0.2	TWRMF Dams	0.04	Decant Cell	-	-	1.0	Divider Dyke and Separation Dyke
Year 1	1	Operations	-	-	-	-	0.3	Decant Cell	0.6	East Cell	2.1	West Cell
Year 2 to Year 3	2	Operations	-	-	-	-	0.4	Decant Cell	4.8	Alternating between East and West Cells	5.5	Alternating between East and West Cells
Year 4 to Year 6	3	Operations	-	-	-	-	0.7	Decant Cell	7.3	Alternating between East and West Cells	6.8	Alternating between East and West Cells
Year 7 to Year 8	2	Operations / Closure	-	-	-	-	0.4	Tailings Cover	4.8	Tailings Cover	2.5	Decant Cell
Year 9 to Year 10	2	Operations / Closure		-	-	-	0.4	Tailings Cover	3.3	Tailings Cover	-	-
		Total	3.5		0.35		2.2	-	20.8	-	17.9	-

Prepared by: MJV2
Checked by: JBH1

2.13.5.1 Deposition Quantities

The following assumptions for deposition quantities have been made for the design:

- The TWRFM will receive approximately 34.1 Mt of nickel and frac sand tailings, and 35.7 Mt of ultramafic PAG waste rock.
- Approximately 60 % of the voids in the ultramafic PAG waste rock will be filled with tailings.
- Maximum tailings elevation in the proposed deposition plan (Figure 2.13-7) is at an elevation of 264 m with the dam crest at an elevation of 266 m.
- The design allows for contingency capacity for entrapped ice, modifications to geochemical characterization of waste, and increased project resource.
- The nickel and frac sand tailings are deposited as conventional slurry at approximately 45% and 50% solids, respectively.
- The average final density of the nickel and frac sand tailings is 1.5 t/m3 and 1.6 t/m3, respectively.
- The average final density of the ultramafic PAG waste before tailings ingress is 2.0 t/m^3.

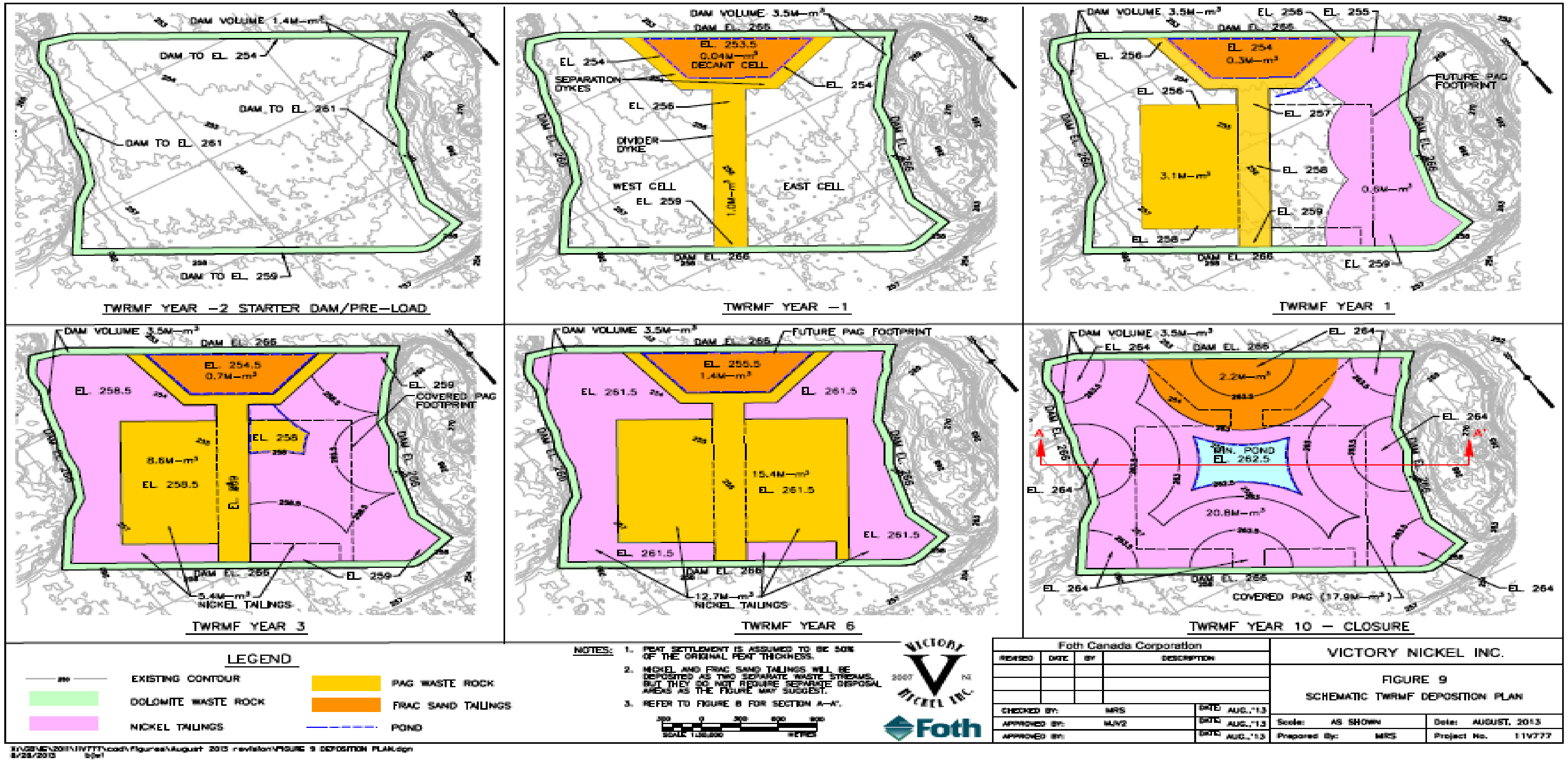


Figure 2.13-8 Schematic TWRMF Deposition

2.13.5.2 Deposition Method

The following assumptions for the deposition method have been made for the design:

- Tailings deposition will be sub-aerial from around the perimeter of the cells to promote drainage northeast towards the Decant Cell, and to encapsulated the PAG waste rock in the center of the facility.
- Tailings can be deposited from the cell divider dyke.
- Separation dykes will provide containment for the decant cell and prevent significant amounts of silt from entering decant pipes and then PP. The Decant Cell will ultimately be filled with tailings and PAG waste rock.
- A beach will form with a slope of approximately 0.5 %.
- Trestles may be used to achieve flatter overall slopes or to optimize the filling and closure of the TWRMF.
- PAG waste rock will be mechanically placed within the PAG waste rock footprint shown in Figure 2.13-8, in lifts of 0.5 to 1.0 m thickness, with alternating layers of tailings in lifts of 0.5 to 1.0 m thickness.

2.13.5.3 Operational Considerations

The following operational considerations will apply:

- During operations, PAG waste rock will not be exposed to the atmosphere for more than one year before being covered and saturated by tailings and water to minimize ARD.
- Maximum PAG waste rock elevation at 261.5 m. A piezometric surface must be maintained above an elevation of 262.5 m post-closure to maintain the minimum water cover thickness criteria of 1.0 m.
- A key objective of the co-disposal plan is to induce migration of tailings into the voids of the PAG ultramafic waste rock and to encapsulate the PAG waste rock in tailings. The following practices should be considered to enhance migration of tailings into PAG waste rock voids :
    - Placing alternating layers of PAG waste rock and tailings in a “layer-cake” fashion.
    - Ripping upper surfaces of disposed waste rock the enhance tailings ingress.
    - Blasting of tailings to induce liquefaction and enhance migration of tailings into waste rock voids, provided stability of the TWRMF containment dam is not compromised.
    - Maintaining a hydraulic head difference across the disposed waste rock.

The configuration of PAG waste rock disposal should allow for a minimum of 1 m of saturated tailings and water cover at the end of the deposition, in accordance with the design criteria. During operations, the water level in the TWRMF shall be maintained sufficiently below the PAG waste rock surface to ensure stability and the safety of personnel and equipment operating on the PAG waste rock.

2.13.5.4 Deposition Phases

Mine waste deposition activities are divided into the following 4 phases as depicted in Figure 2.13-8:

- Construction – Years -2 to -1
- Normal Operations – Years 1 to 6
- Pre-closure Operations – Years 7 to 10
- Post-closure – After Year 10

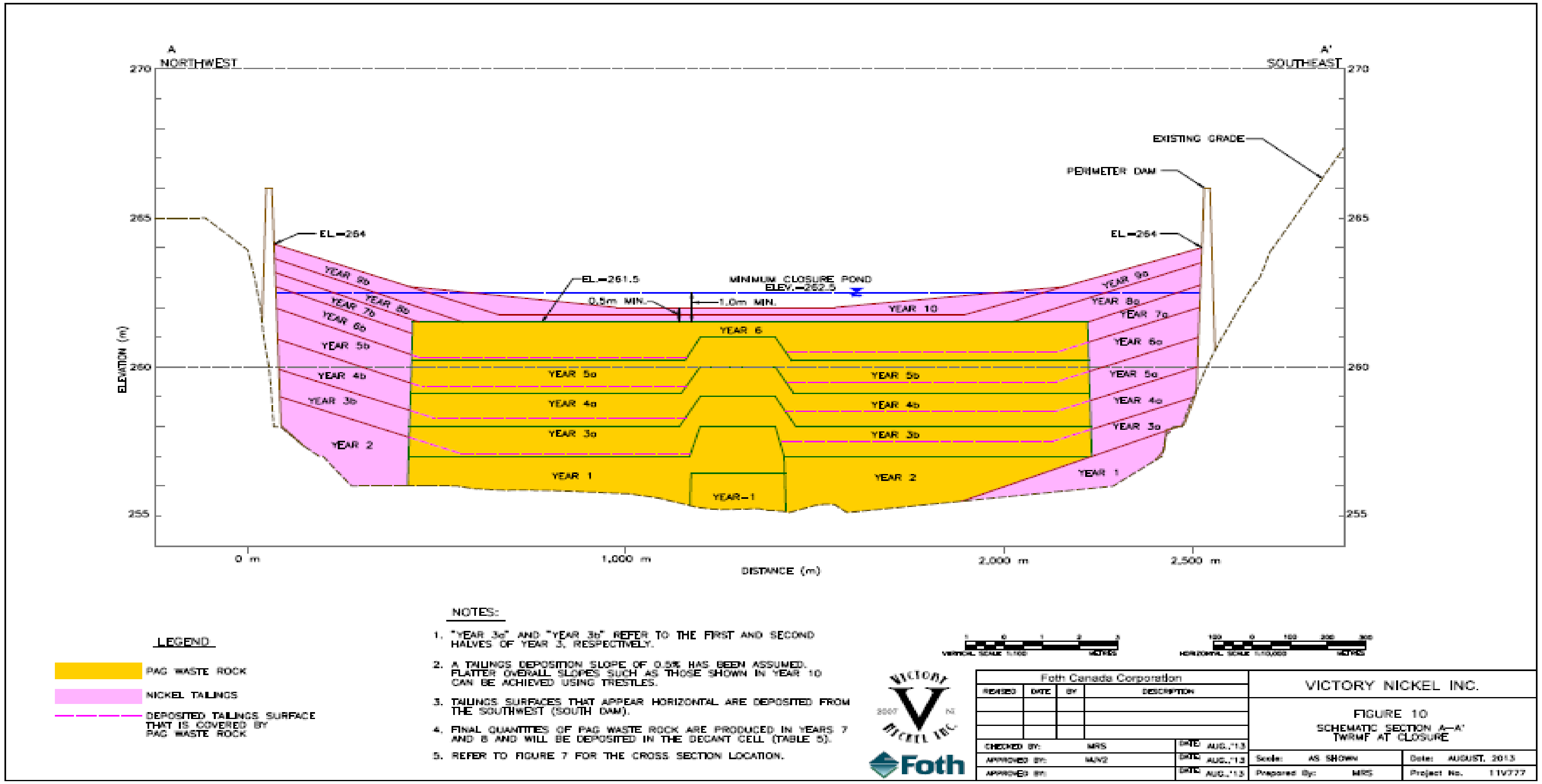


Figure 2.13-9 Schematic Section A-A TWRMF At Closure

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2.13.5.4.1 During Construction

Following construction of the Starter Dam / Pre-load in Year -2, deposition of initial quantities of PAG waste rock and frac sand tailings will begin (Year -1), as shown in Figure 2.13-7. It is proposed that the PAG waste rock is used to construct the Divider Dyke and Separation Dykes which will divide the three disposal cells. It is proposed that the frac sand tailings are deposited in the proposed Decant Cell.

2.13.5.4.2 During Normal Operations

During normal operations (Years 1 to 6), deposition of frac sand tailings, mill tailings, and PAG waste rock will be taking place (Figure 2.13-7). It is proposed that the frac sand tailings are discharged sub-aqueously in the Decant Cell. The Decant Cell was selected as the proposed disposal area for the frac sand tailings for the life of the mine with the intention of minimizing the operational requirements associated with moving multiple discharge locations. Alternatively, the frac sand tailings could be discharged sub-aerially in the East and/or West Cell. The initial quantities of the mill tailings are deposited in the East Cell, while PAG waste rock is deposited in the West Cell (Figure 2.13-7).

Further deposition of mill tailings and PAG waste rock shall be in lifts of approximately 0.5 to 1 m thick and alternate between the East and West Cells approximately every 6 months, so that PAG waste rock is placed on top of a previously placed lift of tailings, before being covered by the subsequent lift of tailings in a “layer-cake” fashion, as shown in Figure 2.13-7. This alternating disposal scheme will promote co-mingling of the tailings and PAG waste rock (tailings ingress into the voids of the PAG waste rock). At no time shall mill tailings and PAG waste rock be disposed of in the same cell simultaneously.

Supernatant water from the mill tailings along with storm runoff will be collected in the Decant Cell, either by seeping through the Separation Dykes or through temporary cross sectional swales cut across the crest of the Separation Dykes. The Separation Dyke shall be raised progressively with the tailings pond level so that swales can be easily excavated as needed.

2.13.5.4.3 During Pre-closure Operations

After Year 6, the deposition strategy will be altered so that the desired post-closure geometry of the facility can be achieved (Figures 2.13-7 and 2.13-8). During this period, the crest of the central PAG waste rock stockpile will remain at its ultimate elevation of 261.5 m and there will no longer be division between the East and West Cells. The final quantities of PAG waste rock in Years 7 and 8 will be dumped into the Decant Cell and the frac sand tailings disposal site will change to the north ends of the East and West Cells, to ensure there is sufficient capacity for disposal of PAG waste rock in the Decant Cell, and to contribute to the tailings cover in the East and West Cells. Mill tailings will continue to be discharged from the perimeter dam towards the center of the facility, while contributing to the tailings cover and desired post-closure tailings beach geometry.

During Years 9 and 10, there will be no further PAG waste rock disposal and only frac sand tailings and mill tailings will be deposited in the TWRMF. Frac sand tailings (or mill tailings) will be used to cover the PAG waste rock in the Decant Cell, filling the cell so there will no longer be division between the East, Well, and Decant Cells. Mill tailings will continue to be discharged from the outer portions of the facility towards the center, as shown in Figure 2.13-8. At this time, trestles will be required to achieve overall deposition slopes flatter than the angle of repose of the tailings (assumed to be 0.5%) to contribute to the final tailings cover and desired post-closure tailings beach geometry near the center of the facility.

2.13.5.4.4 Post-closure

After Year 10, there is no further deposition in the TWRMF and the desired post-closure geometry of the facility will be achieved, which will consist of a conical shaped tailings beach with a central closure pond, as shown in Figures 2.13-7 and 2.13-8. A permanent closure pond will exist to maintain saturation of the PAG waste rock to minimize the potential for ARD.

2.13.5.4.5 Safety

Careful planning is needed to ensure safety of personnel and equipment operating on the deposited PAG waste rock within the repository. Vibratory loads from haul trucks and dozers may cause liquefaction of the rock fill with voids filled with saturated tailings. The potential for liquefaction of the co-mingled tailings and PAG waste rock can be minimized by ensuring adequate compaction and by preventing saturation the PAG waste rock. This can be achieved by compacting the PAG waste rock and by controlling the water level in the TWRMF so it is at least 1 – 2 m below the crest of the current lift being placed.

2.13.6 Water Management

2.13.6.1 Water Management System

The overall water management system (Figure 2.13-3) incorporates the following components:

- A decant cell within the co-disposal.
- A decant siphon system which allows passive overflow from the Decant Cell to the PP (Figure 2.13-3).
- A PP that provides the minimum retention time for the settling out of suspended solids.
- An outlet structure and a siphon or pump to discharge PP effluent to the Minago River.

- An emergency spillway and stilling basin designed to convey the design storm (Figure 2.13-3).
- Seepage collection ditches along the north and south dams with collection ponds and a pump-back systems.
- A runoff diversion ditch along the south seepage collection ditch, to intercept runoff from the head of the valley where the proposed clay dump is located, and diverted to the site drainage system around the pit to avoid the Oakley Creek.
- Silt traps will be employed as needed.
- Water will be released to the receiving environment to feed the Minago River through two structures depending upon the season.
- In the summer months a distribution manifold will feed water to the muskeg over a reasonable width of muskeg to mimic the natural flow.
- In the winter months the pipe outlet will discharge to an open ditch located after the distribution manifold at the Minago River.

2.13.6.2 Water Management Phases

Similar to the mine waste deposition activities, the water management activities can also be divided into the following 4 phases:

- Construction – Years -2 to -1
- Normal Operations – Years 1 to 6
- Pre-closure Operations – Years 7 to 10
- Post-closure – After Year 10

2.13.6.2.1 During Construction

During site preparation (early Year -2, during frozen conditions), a drainage ditch will be excavated along center of the valley to promote drainage of the muskeg during the May freshet. This will facilitate the construction of the Starter Dam / Pre-load and the compacted clay key trench (Figures 2.13-4 and 2.13-5). The key trench, seepage collection ditches, and runoff diversion ditches will also be excavated at this time.

During construction of the Pre-Load / Starter Dam and PP (Year -2), runoff will be collected in the ditches and diverted to the environment in order to maintain dry site conditions and avoid pooling of water. Silt traps will be employed as needed.

During construction of the Ultimate Dam (Year -1), deposition of initial quantities of PAG waste rock and frac sand tailings will be under way (Figure 2.13-7). Water from the frac sand tailings and from storm runoff within the TWRMF will be collected at the northeast end of the facility in the Decant Cell. A temporary decant system will be employed while the permanent Decant Siphon System is constructed, and will involve siphoning or pumping of water from the Decant Cell to the PP through temporary pipelines. Once constructed, the Decant Siphon System will allow passive overflow from the Decant Cell to the PP. An Emergency Spillway will also be constructed to convey runoff from extreme storm events. Seepage will be collected in the Seepage Collection

Ditches (Figure 2.13-3) and pumped back to the TWRMF. Runoff from the head of the valley will be collected in the Runoff Diversion Ditch and diverted to silt traps and the environment.

2.13.6.2.2 During Normal Operations

During normal operations (Years 1 to 6), deposition of frac sand tailings, mill tailings, and PAG waste rock will be taking place. It is proposed that the frac sand tailings are discharged sub-aqueously in the Decant Cell and that the mill tailings and PAG waste rock are deposited in the East and West Cells (Figure 2.13-7). Supernatant water from the mill tailings along with storm runoff will be collected in the Decant Cell, either by seeping through the Separation Dykes (Figure 2.13-3) or through temporary swales in the Separation Dykes. The Decant Siphon System will continue to allow passive overflow from the Decant Cell to the PP. The Decant Siphon System will be designed appropriately to maintain the minimum retention time in the PP during extreme runoff events such as the May freshet or storms. Sufficient capacity will be maintained in the Decant Cell to accommodate these events. The Emergency Spillway will remain in place to convey runoff from extreme storm events or if ice blockage occurs. Seepage will continue to be collected in the Seepage Collection Ditches (Figure 2.13-3) and pumped back to the TWRMF. Runoff from the head of the valley will continue to be collected in the Runoff Diversion Ditch and diverted to silt traps and the environment.

2.13.6.2.3 During Pre-Closure Operations

After Year 6, the deposition strategy will be altered so that the desired post-closure geometry of the facility can be achieved (Figure 2.13-7). This period of time is being referred to as 'Pre-closure Operations' and will include Years 7 to 10. During this period, the crest of the central PAG waste rock stockpile will remain at its ultimate elevation of 261.5 m and be covered by tailings. The final quantities of PAG waste rock (in Years 7 and 8) will be dumped into the Decant Cell. During Years 7 and 8, the water management activities will be the same as during normal operations. However, during the final 'tailings only' years (Years 9 and 10), the PAG waste rock in the Decant Cell will be covered by tailings so that the tailings pond shifts from the Decant Cell, towards the center of the TWRMF. At this time, the Decant Siphon System will be decommissioned and another temporary decant system will be employed, which will involve siphoning or pumping of water from the tailings pond to the PP through temporary pipelines. The temporary Decant System will be decommissioned in the final weeks of Pre-closure Operations so that the desired closure pond is allowed to form (Figures 2.13-7 and 2.13-8). The Emergency Spillway and ditches will continue to operate normally.

2.13.6.2.4 Post-Closure

After Year 10, there is no further deposition in the TWRMF and the desired post-closure geometry of the facility will be achieved, which will consist of a conical shaped tailings beach with a central closure pond, as shown in Figures 2.13-7 and 2.13-8. The closure pond will increase in size due to precipitation and shrink due to evaporation. Evaporation rates will increase as the size of the pond increases, which will result in the closure pond reaching a steady-state size (essentially when precipitation equals evaporation). This process was modeled by performing a water balance of the post-closure TWRMF.

2.13.6.3 Control of Contaminant Limits

For the TWRMF design in the 2010 EAP/EIS document (Wardrop, 2010), Victory Nickel evaluated the contaminant levels at the final PP effluent and at various other stages in the water management system (Victory Nickel, 2011). As the contaminant levels have not changed and the quantity of storm runoff being routed through the TWRMF has increased (due to increased catchment area), the trace contaminant levels projected at the various stages will be further diluted with the proposed TWRMF design.

2.13.7 Construction Considerations

2.13.7.1 Construction Requirement

Effective drainage of the TWRMF area as a pre-construction activity perhaps a year prior will facilitate construction. The removal of water will improve excavation operations and reduce the amount of material to be removed as ice. Once drainage has been implemented, the tree clearing which is required beneath the perimeter dam footprint can begin.

The existing drainage trench which was cut in the area of the open pit in March 2012 has proved very effective at this location. This ditching exercise demonstrated that ditches cut along the existing 1/500 land profile would provide effective drainage.

Excavation of muskeg and soft clay will be facilitated by a frozen surface during the winter months suggesting a January start. With these initial activities complete the fill placement activities can commence in the spring, summer and fall. The placement of frozen fill containing snow or ice within the dam structure will limit these winter operations.

2.13.7.2 Construction Staging

Access to the site is available along the access road to the dolomite bluff which will serve as a staging post for the TWRMF site. The TWRMF construction could start with the east wall of the TWRMF which abuts the east dolomite bluff.

2.13.7.2.1 Starter Dam – Pre-load Construction

The Pre-load / Starter Dam lift has to be sufficient to safely support equipment but is limited to a maximum of 1.0 m above original ground. Proof rolling of the Pre-load/ Starter Dam lift is required to verify competent dam foundation conditions.

2.13.7.2.2 Ultimate Dam

Subsequent lifts of dolomite are to be placed in lifts of 0.5 to 1.0 m thickness and compacted to 95% of the Standard Proctor Maximum Dry Density (SPMDD). A field trial will be carried out to verify compaction requirements and the optimal lift thickness. The construction schedule has been structured to allow for displacement and compression of the muskeg and clay foundation. This will allow for the necessary strength gain in the supporting clay before the construction of the ultimate dam. To optimize the consolidation times, the initial lifts of dolomite will be placed at the north dam, where the dam height is highest and clay thickness is greatest. The construction quantities are included on Table 2.13-3.

2.13.7.3 Construction Schedule

The Pre-load / Starter Dam are scheduled to be constructed during the first year of mine development (Year -2) when dolomitic limestone will be available from overburden removal. The Ultimate Dam is scheduled to be constructed during the second year of mine development (Year -1) with the dolomite waste rock and clay overburden from the open pit. Direct disposal of the dolomite waste rock and clay overburden at the site of the TWRMF perimeter dam will minimize double handing of material.

The delivery of ultramafic PAG rock is schedule for the middle of Year -1, frac sand tailings at the end of Year -1 and nickel tailings at the end of Year 1. TWRMF site preparation and mine development will start approximately one year prior to the disposal of PAG ultramafic waste rock and 2 years prior to the deposition of nickel tailings.

A simplified construction schedule is shown in Figure 2.13-9.

Figure 2.13-10 Simplified Construction Schedule

2.13.8 Monitoring and Surveillance

Monitoring and surveillance requirements include the following:

- Daily monitoring of dyke for subsidence, cracking, and water flow, during construction.
- Regular surveying for as-build reporting, settlement identification and quantity measurements during construction.
- Monitor grain size distribution, bulk density and moisture content of all material used for dam construction or deposited in the TWRMF cells.
- Four cross sections instrumented with vibrating wire piezometers, thermistors, settlement plates and inclinometer casings will be included around the co-disposal facility to measure pore water pressure dissipation, temperature settlement and lateral deformation, during construction, operations, and closure.
- Environmental monitoring wells will be installed downstream of the TWRMF for future groundwater monitoring during operations and closure.

2.14 Site Water Management

This Section presents the general site water management and the description and discussion of a water balance model that was developed for the Minago Project based on the mine site layout as shown in Figure 2.14-1; metallurgical, hydrological, hydrogeological, and geochemical conditions; and related environmental baseline study results obtained to date. The goal is to manage and control site waters to ensure compliance with applicable regulations.

The water management components presented in this Section include:

- twelve dewatering wells to dewater the open pit area;
- a water treatment plant to produce potable water;
- a sewage treatment system (extended aeration system) for the disposal and treatment of on-site grey water and sewage;
- mill and Frac Sand Plant tailings and effluents that will be discharged into a Tailings and Ultramafic Waste Rock Management Facility (TWRMF);
- a Tailings and Ultramafic Waste Rock Management Facility (TWRMF) that will store tailings and the ultramafic waste rock permanently and effluents from various site operations temporarily;
- waste rock dump seepages that will be discharged to the receiving environment or into the TWRMF depending on their water quality;
- overburden dump runoff that will be discharged directly into the receiving environment (if it meets discharge requirements);
- an open pit dewatering system that will ensure safe working conditions in and around the open pit;
- a Polishing Pond and flood retention area to serve as holding pond for water that will either be recycled to site operations or discharged to the receiving environment (if it meets discharge water standards);
- a site drainage system to prevent flooding of site operations;
- site wide water management pumping systems; and
- discharge pipelines to Minago River to discharge excess water from the Polishing Pond to the receiving environment.

Among the sources of water that need to be managed are the pit dewatering well water, TWRMF supernatant and precipitation (rainfall and snowfall). Primary losses of precipitation include sublimation, evaporation, and retention as pore water in sediments and soils.

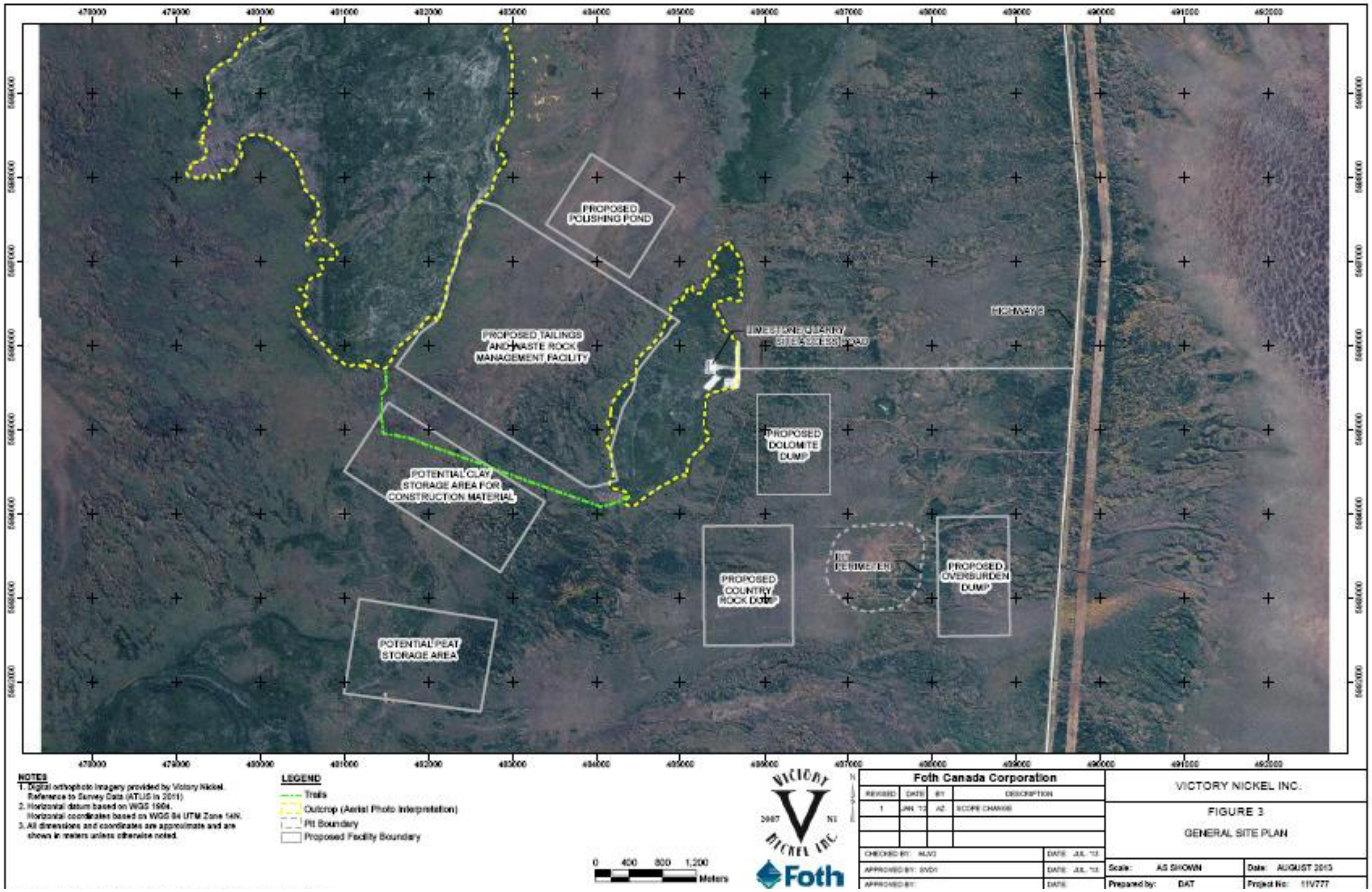


Figure 2.14-1 General Site Plan

The vertical hydraulic conductivity (K_V) of the overburden clay, which is an aquitard overlying the limestone, was estimated to range from 4×10^{-9} m/s to 6×10^{-9} m/s and the horizontal hydraulic conductivity, K_H, was estimated to range from 6×10^{-6} m/s to 6×10^{-9} m/s, with a geometric mean of 4×10^{-8} m/s (Golder Associates, 2008b). These hydraulic conductivities are indicative of an anisotropy ratio (K_H/K_V) of 10 (Golder Associates, 2008b).

2.14.1 General Description of the Site Water Management System

Water at Minago will be managed to ensure safe working conditions and minimum impacts to the local and regional surface and groundwater flow regimes and the aquatic environment. As water will be managed to suit site activities, the discussion of the site water management system was broken down into the following seven scenarios:

- Water Management during Nickel and Frac Sand Plants Operations (Yr 1 through Yr 10);
- Water Management during Closure;
- Water Management during Post Closure;
- Water Management during Temporary Suspension; and
- Water Management during the State of Inactivity.

Closure involves decommissioning of processing facilities and buildings and infrastructure that are no longer needed. The closure period is a transition stage between the operational and the post closure periods.

The post closure period refers to the period after all decommissioning activities of mining facilities and infrastructure have been completed and the site is in its final, post mining state.

“Temporary suspension” means that advanced exploration, mining or mine production activities have been suspended due to factors such as low metal prices and mine related factors such as ground control problems or labour disputes. Temporary suspension does not occur under normal operating conditions. The site will be monitored continuously during the Temporary Suspension (TS) of operations and dewatering of the open pit will continue as it did during operations. TS may become a “State of Inactivity”, if the TS is extended indefinitely.

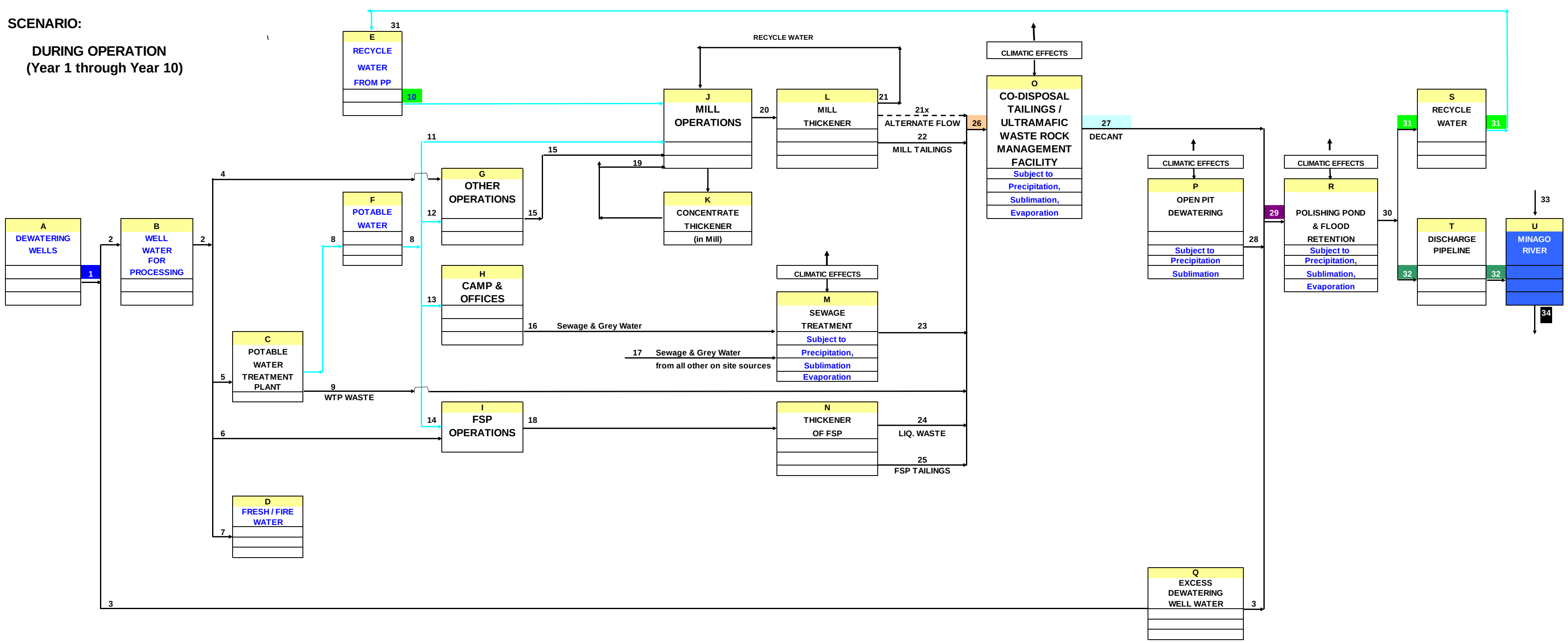
The “State of Inactivity” implies that mine production and mine operations at the mine site have been suspended indefinitely. The State of Inactivity also does not occur under normal operating conditions. The State of Inactivity (SI) may turn into a state of permanent closure, if prevailing conditions for the resumption of operations are not favorable. During the State of Inactivity, mine dewatering will be reduced significantly and only a minimal crew will be assigned to the site to monitor and ensure safety on site.

2.14.1.1 Water Management System during Operations

Both the Nickel Processing Plant and the Frac Sand Plant will be operating during the operational period at Minago (Year 1 through Year 10) (Figure 2.14-2).

To facilitate the description of the water management model, key components are illustrated with boxes in the schematic water balance diagram

(Flow is from left to right, except for recycle loops)



SYSTEM OF LINEAR EQUATIONS (FOR FLOWS)

DEWATERING WELLS	Q1 = Q2+Q3
PROCESS WATER	Q2 = Q4 + Q5 + Q6 + Q7
RECYCLED WATER FROM FINAL POLISHING POND	Q10 = Q31
TMF INFLOW	Q26 = Q9+Q21x+Q22+Q23+Q24+Q25
TMF DECANT	Q27
POLISHING POND INFLOW	Q29 = Q3+Q27+Q28
DISCHARGED WATER	Q32
MINAGO RIVER DOWNSTREAM	Q34 = Q32+Q33

Figure 2.14-2 Water Management System during the Nickel and Frac Sand Plants Operations (in Years 1 through 10)

and flow(s) in and out of each box are numbered (Q1 through Q34). All flows in the schematic water balance diagram are from left to right (which is the typical flow direction) except for flows in recycle loops, which flow from right to left.

Following is a description of the water management model during the Year 1 through Year 10:

- **Dewatering Well Water (Flow Q1):**

  To allow ore extraction, the open pit area needs to be dewatered. Based on pumping tests conducted by GAIA in 2008, a dewatering well system has been designed, which is detailed in **Section 7.6**. The design consists of 12 dewatering wells located at a distance of approximately 300 m to 400 m along the crest of the ultimate open pit, pumping simultaneously from the limestone and sandstone geological units. The total pumping rate for the wellfield is predicted to be approximately 40,000 m^3/day (7,300 USgpm), and the average pumping rate for an individual well is estimated to be about 3,300 m^3/day (600 USgpm) (Golder Associates, 2008b). The associated drawdown cone, defined using a 1 m drawdown contour, is predicted to extend laterally in the limestone to a distance of approximately 5,000 to 6,000 m from the proposed open pit. Based on sensitivity analyses, the actual dewatering rate for the entire wellfield could vary from 25,000 m^3/day (4,600 USgpm) to 90,000 m^3/day (16,500 USgpm) (Golder Associates, 2008b).

  In the Minago water balance model, presented towards the end of this section, a dewatering rate of 40,000 m^3/day was assumed (32,000 m^3/day originating from the dewatering wells and 8,000 m^3/day from dewatering of the Open Pit).

- **Process Water and Dewatering Well Water (Flows Q2, Q3, Q4, Q5, Q6, and Q7):**

  Water from the dewatering wells will be used as process water (Q2) in the industrial complex (Q4), as input to the potable water treatment plant (Q5), as input to the Frac Sand Plant (Q6), and as fire water (Q7). Any excess dewatering well water not required for processing purposes (Q3) will be discharged to the Polishing Pond.

- **Potable Water / Grey Water / Sewage (Flows Q8, Q9, Q11, Q12, Q13, Q14, Q16, Q17, and Q23):**

  A water treatment plant to produce potable water will be operated at the Minago site to produce sufficient potable water (Q8) for the camp and offices (Q13), all other on-site personnel (Q11, Q12, and Q14), and any other processes that require potable water. Sludge from the potable water treatment plant (Q9) will be disposed of in the TWRMF.

All on-site grey water and sewage (Q16 and Q17) will be collected and discharged to an extended aeration treatment system. Outflow from the sewage treatment system (Q23) will be discharged to the TWRMF.

The sewage treatment system will be subject to the climatic effects of precipitation, sublimation, and evaporation.

- **Mill complex (Flows Q10, Q11, Q15, Q19, Q20, Q21, Q21x, and Q22):**

  Milling operations at Minago will be located on the north western side of the site and north of the access. Schematically, the mill complex is illustrated with ‘Mill Operations’, ‘Concentrate Thickener in Mill’, and ‘Mill Thickener’ in

  The mill complex has the following inflows:

  1) Recycle water from the Polishing Pond (Q10);
  2) Potable water (Q11);
  3) primary crusher products and crushed ore from the Other Operations area (as well as water used for dust suppression) (Q15);
  4) recovered water from the concentrate thickener (Q19); and
  5) Recycle water from the mill thickener (Q21).

  Outflows from the mill complex are nickel concentrate that will be shipped for sale and tailings slurry (Q22) that will be discharged to the Tailings and Ultramafic Waste Rock Management Facility (TWRMF). If the quality of the mill recycle water does not meet the process water quality standards for the mill, a portion of the recycle water from the Mill Thickener (Q21x) may also be discharged into the TWRMF. However, the redirection of the recycle water from the Mill Thickener is not expected under normal operating conditions.

- **Frac Sand Plant (Flows Q6, Q14, Q18, Q24 and Q25):**

  The Frac Sand Plant will receive process water (Q6) consisting of dewatering well water and potable water (Q14). Liquid waste from the Frac Sand Plant (Q18) will be directed towards the thickener of the Frac Sand Plant.

  Frac Sand Plant tailings (Q25) and related liquid waste (Q24) from the Frac Sand Plant will be discharged to the TWRMF.

- **Other Operations (Flow Q15):**

  The term ‘Other Operations’ in the context of this site water management plan refers to the primary crusher, crushed ore tunnel, maintenance building, fueling area, and substation. The main outflow of the Other Operations Area (Q15) will be crushed ore that will be directed towards the mill complex. Grey water and sewage from the Other Operations Area will be discharged to the sewage treatment system. Hydrocarbons and other potentially deleterious substances in the Other Operations Area will be handled, stored and disposed of in an appropriate manner in compliance with all applicable regulations and guidelines and will not be discharged to the TWRMF.

- **Tailings and Ultramafic Waste Rock Management Facility (Flows Q9, Q21x, Q22, Q23, Q24 and Q25):**

The Tailings and Ultramafic Waste Rock Management Facility (TWRMF) is a key component of the water and waste management system at Minago for liquid waste, tailings and ultramafic waste rock management. The TWRMF will serve as repository for mill and Frac Sand Plant tailings and ultramafic waste rock.

Tailings and ultramafic waste rock will be disposed concurrently in the TWRMF and will be stored subaqueously. Key elements of the concurrent disposal of tailings and ultramafic waste rock are detailed in **Section 2.13**.

Submerging tailings containing sulphide minerals, or “subaqueous disposal”, is practiced at many metal mines to keep oxidative rates at a minimum and to minimize metal leaching. Based on geochemical work done to date, Minago’s mill tailings contain low sulphide levels and were deemed to be non acid generating (NAG) (URS, 2009i). Sulphide levels were less than or equal to 0.07 % in the Master tailings samples tested. However, the Precambrian ultramafic waste rock is potentially acid generating (URS, 2008i).

The TWRMF will remain in place after all operations have ceased at the site. The TWRMF inflow (Q26) will consist of:

- alternate flow from the mill thickener (only if warranted) (Q21x);
- mill tailings (Q22);
- sludge from the potable water treatment plant (Q9);
- liquid waste from the Frac Sand Plant (Q24);
- tailings from the Frac Sand Plant (Q25); and
- outflow from the sewage treatment system (Q23).

The TWRMF will also be subject to the climatic effects of precipitation, evaporation and sublimation.

Outflows from the TWRMF include the TWRMF Decant (Q27) and losses due to evaporation and sublimation, and seepage. Seepage will be captured by interceptor ditches surrounding the TWRMF and will be pumped back to the TWRMF. The flow volume of the TWRMF Decant will be regulated automatically by a control system.

During the operational phase, deposited waste will be kept under a nominal 0.5 m thick water cover. The final design of the facility will incorporate several baffles and/or barriers to encourage the settlement of suspended solids and to ensure that the TWRMF decant has a low suspended solids concentration.

The TWRMF will provide 43, 331, 079 m^3 (required TWRMF storage = 37, 679, 199 m^3 PLUS 15% volume = 43, 331, 079 m^3) of storage with a maximum water surface area of approximately 595 ha (Wardrop, 2010).

- **Open Pit Dewatering (Flow Q28):**

  During the mining phase, the open pit will be dewatered to ensure safe and dry working conditions in the pit. Open pit dewatering (Q28) will be subject to the climatic effects of precipitation and sublimation.

  The excess open pit dewatering water will be pumped to the Polishing Pond.

- **Polishing Pond (PP) (Flows Q3, Q27, Q28, Q29, Q30, Q31, and Q32):**

  The Polishing Pond will be used as water storage, final settling pond, and flood retention area. The Polishing Pond will be approximately 120 ha in area with a gross storage capacity of approximately 3.04 million m^3. (Area= 120 ha, Height= 2.5m (including Freeboard)). The retention time during normal operation is calculated to be 21.7 days. This water containment structure will ensure that quality standards are met prior to discharge. Water contained in the Polishing Pond will be pumped to the Minago River watershed and to the process water tank as reclaim water.

  The Polishing Pond will receive decant water from the TWRMF (Q27), dewatering water from the Open Pit (Q28), excess groundwater from the twelve (12) mine dewatering wells (Q3), and precipitation. Under normal operating conditions, when meeting water quality standards, water retained by the Polishing Pond (Q30) will either be recycled to the milling process (Q31 = Q10) or discharged to the receiving environment via a discharge pipeline system (Q32), which discharges water to the Minago River (Q33).

  Storm water from the waste rock dumps, the TWRMF and the in-pit dewatering system will also be channeled into the receiving environment if it meets discharge criteria.

  The Polishing Pond will also be subject to the climatic effects of precipitation, evaporation and sublimation.

- **Discharge System to Minago River (year round) (Flow Q32):**

  Discharge to the Minago River (Q32) will occur year round at rates that will be adjusted seasonally to ensure that the discharged flows will not impact the flow regime nor the flora and fauna in the Minago River negatively.

  In the water balance model, it was assumed that 100% of all excess Polishing Pond water will be directed towards the Minago River during the non-winter months (May to October) and that 65% of it will be discharged to the Minago River during the winter months (November to April).

2.14.1.2 Water Management System during Closure

During the closure period, site and infrastructure decommissioning and site reclamation will take place and all processing facilities and appurtenances will be shut down. Water management during the closure period is illustrated in Figures 2.14-3, 2.14-4 and 2.14-5. The first stage of the closure period is illustrated in Figure 2.14-3 and the second stage of the closure period is illustrated in Figure 2.14-4. Post-closure Water Management is illustrated in 2.14-5.

The following components will operate during the first stage of closure: dewatering wells, potable water treatment plant (at an appropriate rate based on on-site personnel), camp and offices, sewage treatment system, TWRMF, and the Polishing Pond. All of these components, with the exception of the dewatering wells, will be the same as was described for the Year 1 to Year 10 operational period. The dewatering wells will be used to install a 1.5 m high water cover on top of the TWRMF.

All water management components for the second stage of closure will be the same as for the first stage except for the dewatering wells. All dewatering wells will be decommissioned in the second stage of closure.

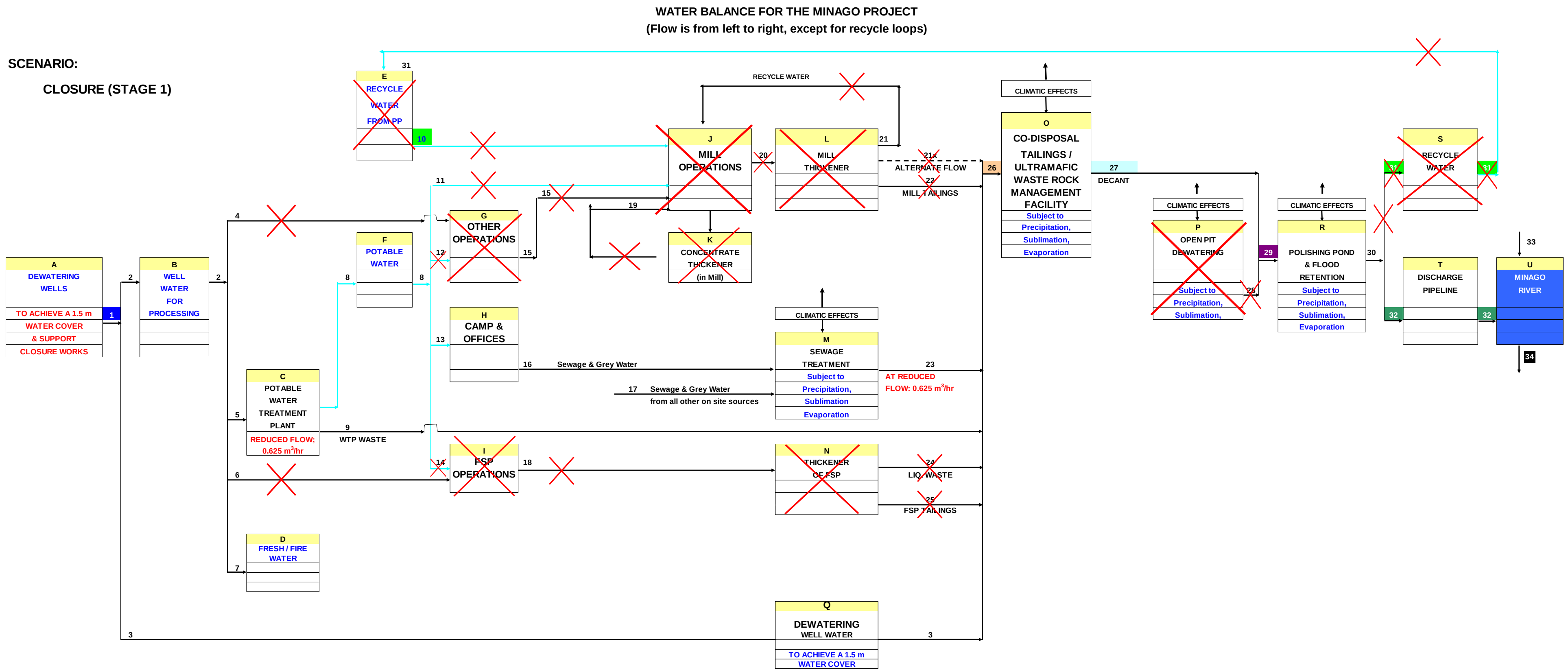
Water will be discharged from the Polishing Pond via a discharge pipeline to the Minago River.

During the closure phase, the Tailings and Ultramafic Waste Rock Management Facility (TWRMF) will be reclaimed as a permanent pond. The access road will remain in place. Reclamation goals are a stabilized surface and a native plant community to provide wildlife habitat. The TWRMF embankments will be modified to ensure long-term saturation of the tailings and the ultramafic waste rock and to provide a spillway for ultimate passive decanting of the TWRMF at post closure. The spillway will be installed with an invert elevation approximately 1.5 m above the deposited tailings. The spillway will be installed during the closure phase and will allow controlled discharge of TWRMF supernatant (Q27) that is in excess of the 1.5 m high water cover.

2.14.1.3 Water Management System during Post Closure

Water management during the post closure period is illustrated in Figure 2.14-5. In the post closure period, all mining facilities and infrastructure will have been decommissioned with the exception of the TWRMF and the Polishing Pond.

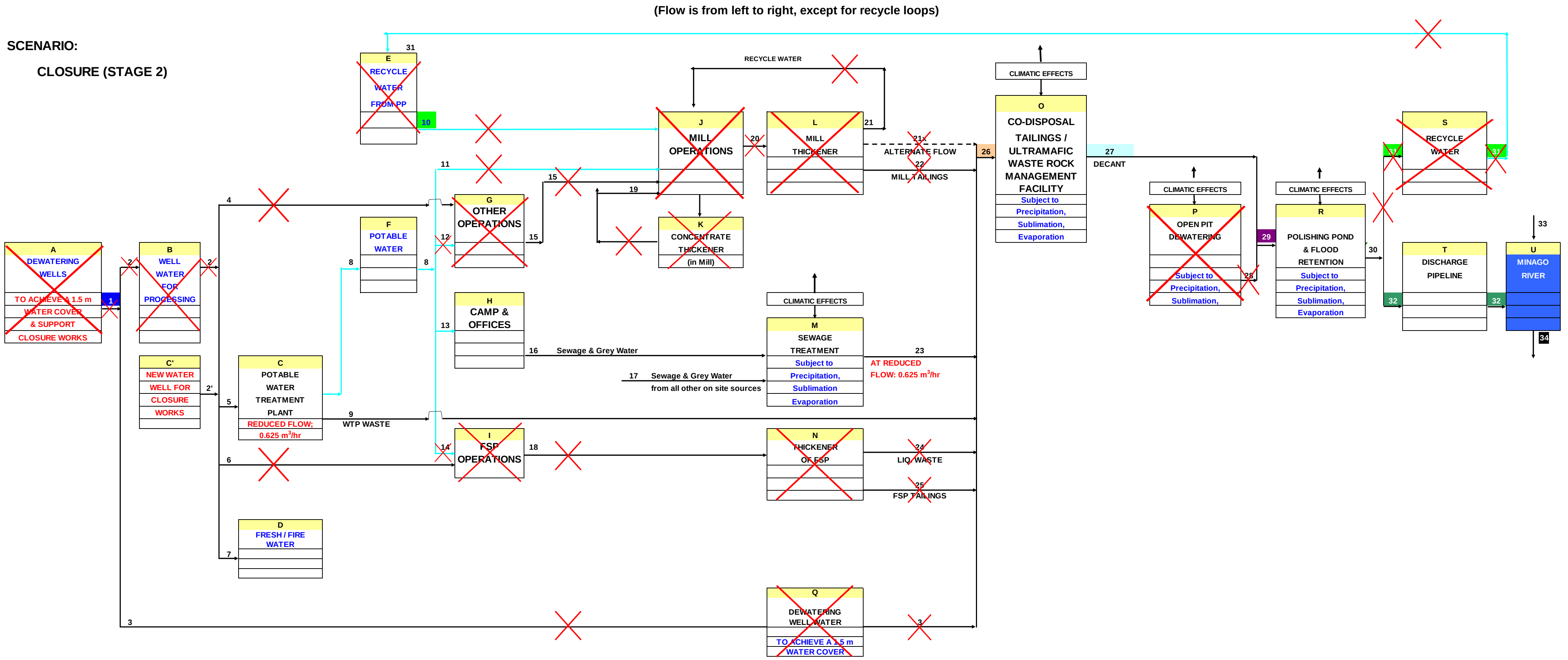
In the post closure phase, the TWRMF will have been decommissioned and reclaimed as much as possible.



SYSTEM OF LINEAR EQUATIONS (FOR FLOWS)

DEWATERING WELLS	Q1 = Q2+Q3
PROCESS WATER	Q2 = Q4 + Q5 + Q6 + Q7
RECYCLED WATER FROM FINAL POLISHING POND	Q10 = Q31
TMF INFLOW	Q26 = Q3+Q9+Q21x+Q22+Q23+Q24+Q25
TMF DECANT	Q27
POLISHING POND INFLOW	Q29 = Q27+Q28
DISCHARGED WATER	Q32
MINAGO RIVER DOWNSTREAM	Q34 = Q32+Q33

Figure 2.14-3 Water Management System during First Stage of Closure

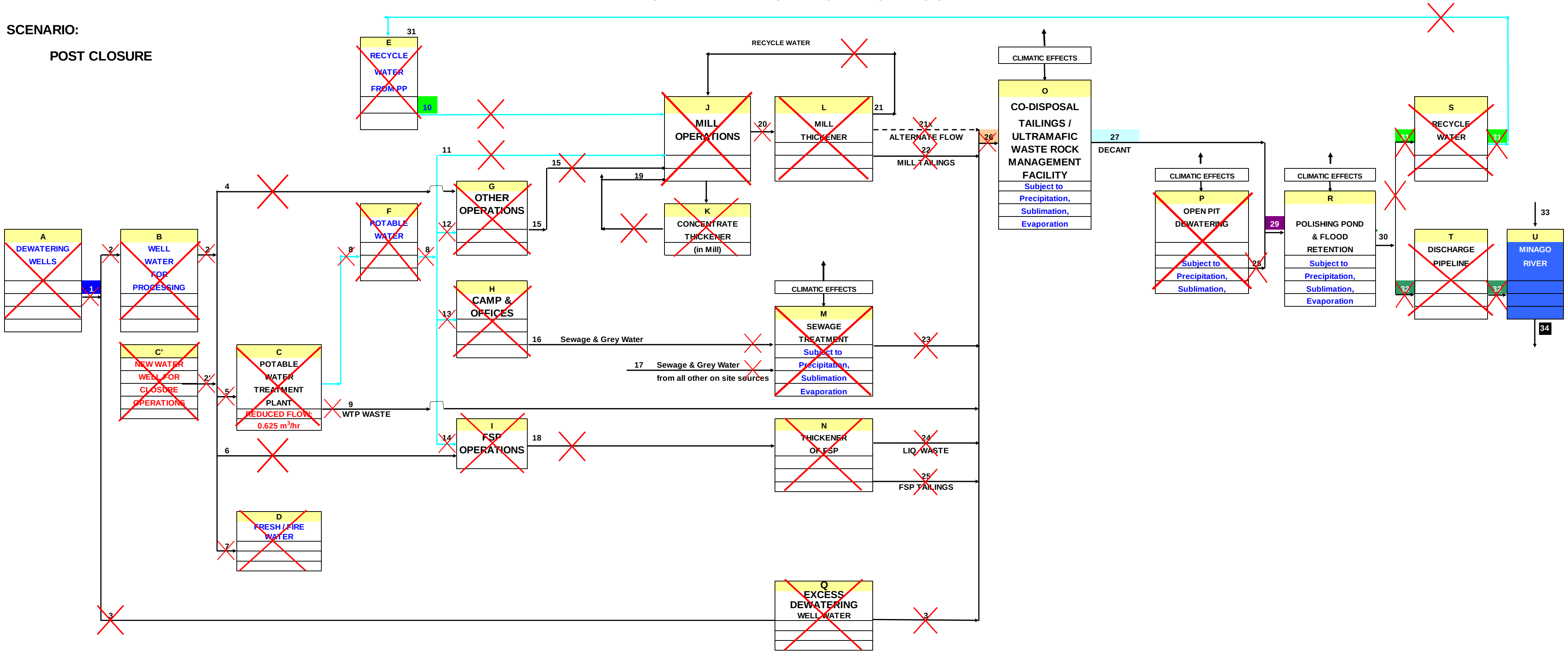


SYSTEM OF LINEAR EQUATIONS (FOR FLOWS)

DEWATERING WELLS	Q1 = Q2+Q3
PROCESS WATER	Q2 = Q4 + Q5 + Q6 + Q7
RECYCLED WATER FROM FINAL POLISHING POND	Q10 = Q31
TMF INFLOW	Q26 = Q3+Q9+Q21x+Q22+Q23+Q24+Q25
TMF DECANT	Q27
POLISHING POND INFLOW	Q29 = Q27+Q28
DISCHARGED WATER	Q32
MINAGO RIVER DOWNSTREAM	Q34 = Q32+Q33

Figure 2.14-4 Water Management System during Second Stage of Closure

(Flow is from left to right, except for recycle loops)



SYSTEM OF LINEAR EQUATIONS (FOR FLOWS)

DEWATERING WELLS	Q1 = Q2+Q3
PROCESS WATER	Q2 = Q4 + Q5 + Q6 + Q7
RECYCLED WATER FROM FINAL POLISHING POND	Q10 = Q31
TMF INFLOW	Q26 = Q3+Q9+Q21x+Q22+Q23+Q24+Q25
TMF DECANT	Q27
POLISHING POND INFLOW	Q29 = Q27+Q28
DISCHARGED WATER	Q32
MINAGO RIVER DOWNSTREAM	Q34 = Q32+Q33

Figure 2.14-5 Post Closure Water Management System

2.14.1.4 Water Management System during Temporary Suspension

A schematic of the site water management system during the temporary suspension (TS) of operations is given in Figure 2.14-6. As the name implies, the state of Temporary Suspension is typically temporary in nature. Temporary suspension does not occur under normal operating conditions. Due to the temporary nature of the state of Temporary Suspension, only production related facilities at the site will be suspended, which include the mill complex (mill operations, mill thickener, concentrate thickener in the mill), Frac Sand Plant, the thickener of the Frac Sand Plant, and Other Operations. During Temporary Suspension, recycling of water from the Polishing Pond will also cease, but the mine site and open pit will still be dewatered as was done during site operations.

Continued dewatering of the site will permit a timely start-up after the temporary suspension of site operations is lifted and normal operations resume.

All other components of the water management system that will not be shut down will be as was described previously for the Year 1 to Year 10 operational period.

In the water balance model, it was assumed that the state of Temporary Suspension will occur at the end of Year 5.

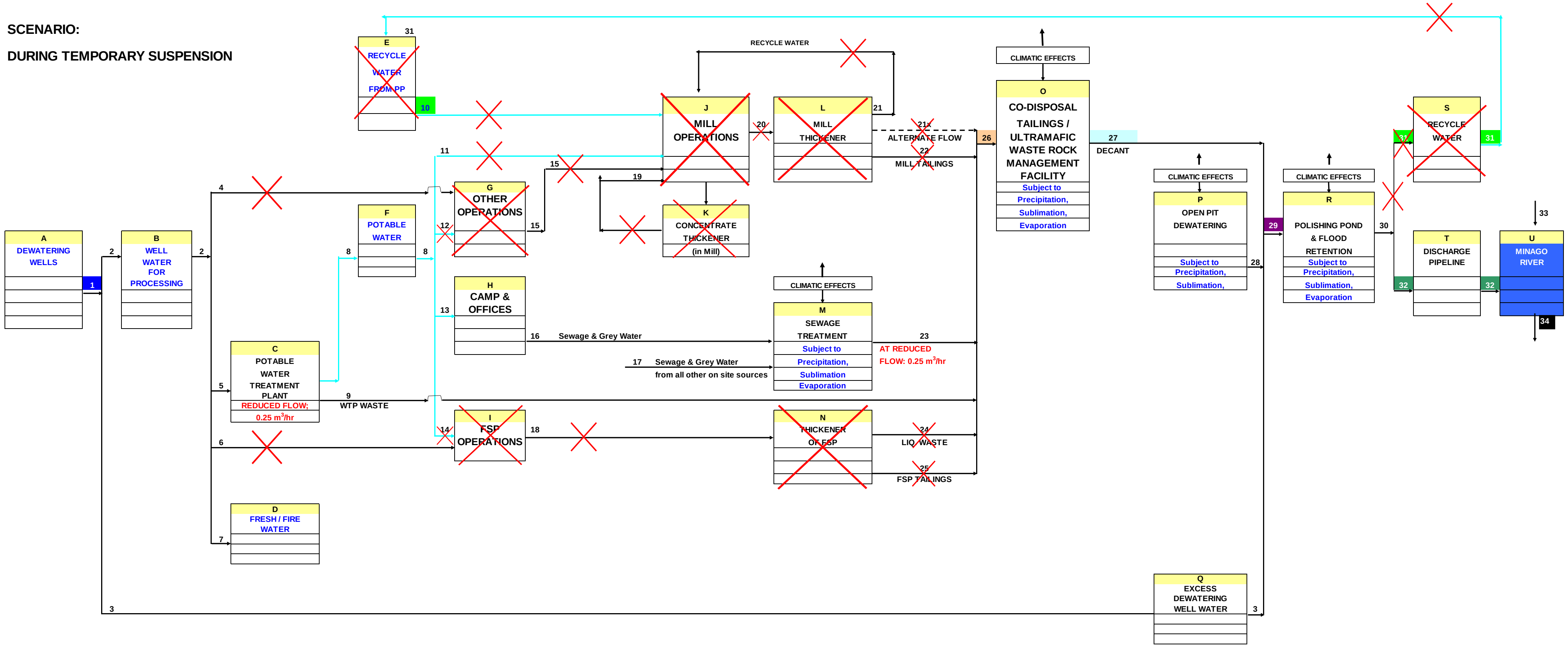
2.14.1.5 Water Management System during a State of Inactivity

A schematic of the site water management system during a State of Inactivity (SI) is given in Figure 2.14-7. The State of Inactivity does not occur under normal operating conditions. During the State of Inactivity, all process related operations will cease and the mill complex (mill operations, mill thickener, concentrate thickener in the mill), Frac Sand Plant, the thickener of the Frac Sand Plant, and Other Operations will be shut down. Recycling of water from the Polishing Pond to the mill and dewatering of the open pit will also cease. As illustrated in Figure 2.14-7, only one out of the twelve dewatering wells will be operating to supply water for the remaining activities at Minago.

All other components of the water management system that will not be shut down will be as was described for the Year 1 to Year 10 operational period.

In the Minago water balance model, the State of Inactivity was assumed to have occurred after one year of Temporary Suspension at the end of Year 6.

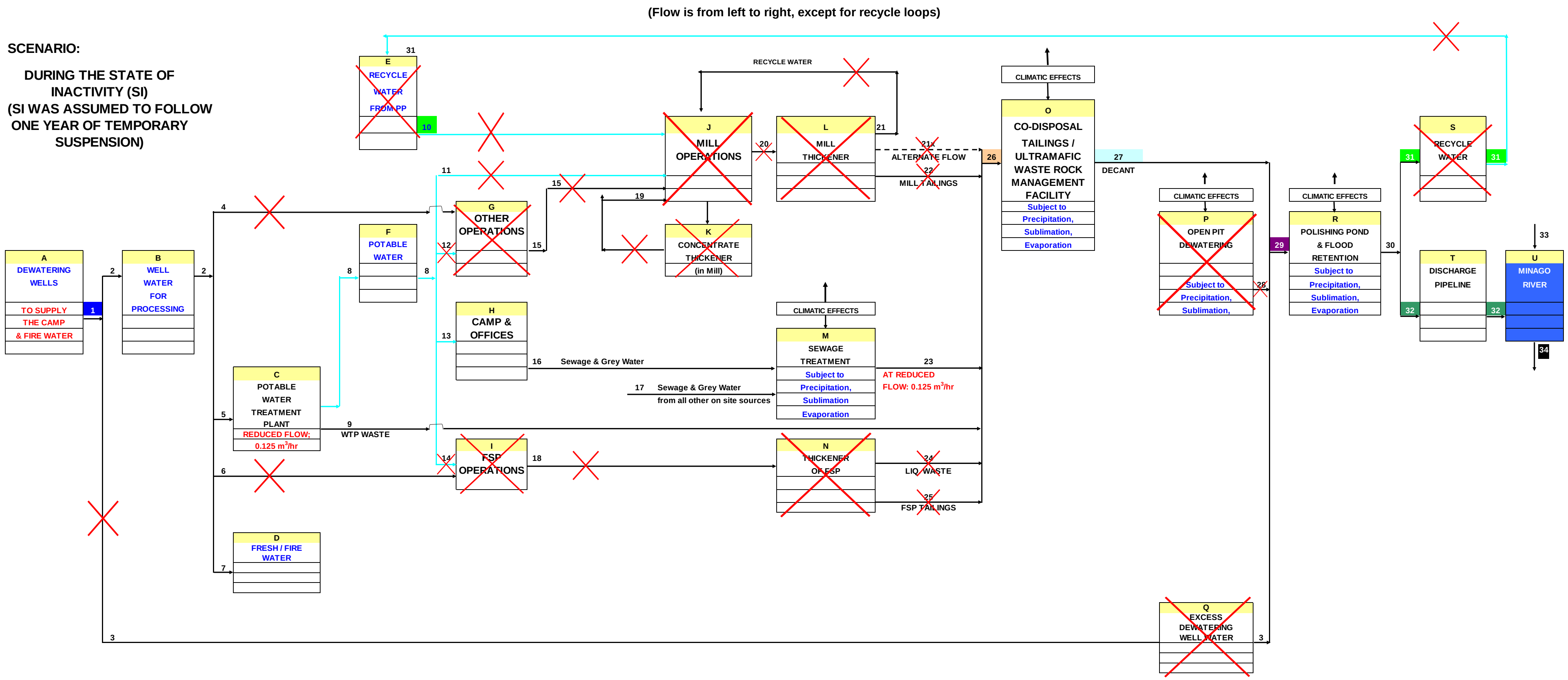
(Flow is from left to right, except for recycle loops)



SYSTEM OF LINEAR EQUATIONS (FOR FLOWS)

DEWATERING WELLS	Q1 = Q2+Q3
PROCESS WATER	Q2 = Q4 + Q5 + Q6 + Q7
RECYCLED WATER FROM FINAL POLISHING POND	Q10 = Q31
TMF INFLOW	Q26 = Q9+Q21x+Q22+Q23+Q24+Q25
TMF DECANT	Q27
POLISHING POND INFLOW	Q29 = Q3+Q27+Q28
DISCHARGED WATER	Q32
MINAGO RIVER DOWNSTREAM	Q34 = Q32+Q33

Figure 2.14-6 Water Management System During Temporary Suspension



SYSTEM OF LINEAR EQUATIONS (FOR FLOWS)

DEWATERING WELLS	Q1 = Q2+Q3
PROCESS WATER	Q2 = Q4 + Q5 + Q6 + Q7
RECYCLED WATER FROM FINAL POLISHING POND	Q10 = Q31
TMF INFLOW	Q26 = Q9+Q21x+Q22+Q23+Q24+Q25
TMF DECANT	Q27
POLISHING POND INFLOW	Q29 = Q3+Q27+Q28
DISCHARGED WATER	Q32
MINAGO RIVER DOWNSTREAM	Q34 = Q32+Q33

Figure 2.14-7 Water Management System during a State of Inactivity

2.14.2 Minago Water Balance Model

A Water Balance Model (WBM) was developed to estimate average elemental concentrations in flows that will be part of the working mine. The water balance was developed based on expected baseline inputs and outputs. Inputs and outputs are related to three main aspects including dewatering well water and its uses and discharges (chemistry and flow); mining and milling processes to produce concentrate and saleable products out of the ore (chemistry and flow); and climatic conditions (rainfall, snowfall, sublimation, and evaporation). Key input parameters and considerations of the water balance model are summarized below, first in general terms and then in detail.

As for the general description of the water management system, the water balance model is described for the following seven scenarios in this document:

- water balance during Nickel and Frac Sand Plants Operations (in Years 1 through 10) (illustrated in Figure 2.14-2);
- water balance during Closure (illustrated in Figure 2.14-3 and Figure 2.14-4);
- water balance during Post Closure (illustrated in Figure 2.14-5)
- water balance during Temporary Suspension (illustrated in Figure 2.14-6); and
- water balance during the State of Inactivity (illustrated in Figure 2.14-7).

2.14.2.1 General Description of Inputs and Outputs of the Water Balance Model

The primary water inputs of the water balance model are due to dewatering wells that enable mining in the open pit by lowering the water Table. In the water balance model, it was assumed that approximately 32,000 m^3/day will be pumped from 12 dewatering wells that surround the open pit and 8,000 m^3/day will be pumped from the Open Pit (Golder Associates, 2008b). Dewatering well water will be used for processing in the mill and Frac Sand Plant and to create potable water. However, the vast majority (approximately 84%) of the dewatering well water will be discharged unused to the Polishing Pond for subsequent discharge to the receiving environment (Minago River) during the mine operations as well as during the State of Inactivity and Temporary Suspension, should they occur.

Another major input into the water balance model are precipitation and associated climatic effects (evaporation, sublimation, etc). All large storage areas (including the waste rock dumps, the Tailings and Ultramafic Waste Rock Management Facility (TWRMF), the Open pit, the Polishing Pond, and the sewage treatment system) will be subject to climatic effects.

Input parameters and considerations used to characterize climatic effects for the Minago Project are as follows:

- **Precipitation**

  The precipitation at Minago was assumed to be 510 mm consisting of 369 mm (72%) of rain and 141 mm (28%) of snow (Golder Associates, 2009). It was assumed that 40 mm (10.8%) of the rain falls in the month of May and 329 mm (89.2%) in the period of June to October (Golder Associates, 2009).

- **Snow Storage**

  Snow sublimation and redistribution has a notable impact on the amount of water in the snowpack and therefore affects the water balance of site facilities and related watersheds. Sublimation can occur directly from snowpack surfaces or during blowing snow events with overall rates dependent on humidity and wind speed (Essery et al., 1999; Déry and Yau, 2002). Snow sublimation is highly dependent on the thermal balance of the snowpack. Golder Associates (2009) projected an average snow sublimation rate of 39% of the average annual snowfall for the Minago Project.

- **Snowmelt**

  In the water balance model, snowmelt was assumed to occur in the month of May.

- **Lake Evaporation and Evapotranspiration**

  Evaporation is the process by which water is transferred from land and water to the atmosphere. Transpiration is the evaporation of water from the vascular system of plants to the atmosphere. The combination of both processes is termed evapotranspiration and is a function of the type of surface (open water, leaf or leaf canopy, bare soil, etc.), the availability of water, and the net energy input into the system.

  The seasonal distribution of evaporation is affected primarily by solar radiation and vegetation cover (or lack of it). During the snowmelt period, evaporation is relatively small compared with the large supply of melt water within a thinly thawed active layer (Woo and Steer, 1983). Typically, evaporation is greatest following snowmelt and decreases through the summer period. Evaporation decreases as the latitude increases. Evaporation losses from lakes are greater than evapotranspiration losses from an equivalent terrestrial area.

  Lake evaporation in the vicinity of the proposed project site is expected to be 500 mm or more (EMRC, 1995), while evapotranspiration is estimated to range between 350 and 400 mm (EMRC, 1995). The majority of the water balance components at Minago will not be subjected to transpirational effects as they will be bare “brown” fields.

In the Minago water balance model, it was assumed that the evaporation from the Tailings and Ultramafic Waste Rock Management Facility (TWRMF), the Polishing Pond, and the sewage treatment system will be 50% of the lake evaporation estimated for large lakes in the vicinity of the Minago Project. Evaporation was assumed to be 56 mm in May, 218.35 mm in the period from June to October (over a period of 154 days), and 0 mm in the winter months (November to April). Evaporation losses were assumed to be negligible for the waste rock dumps (due to the coarseness of the material leading to negligible water storage on the surface) and the open pit due to the continuous removal (pumping) of water that infiltrates the open pit during operations.

- **Ice Regime**

The mean ice thickness in the vicinity of the Minago Project is expected to be between 0.75 and 1 m in lakes and rivers (Allen, 1977). The freeze-over window is expected to be early to mid November, while the ice-free date is typically in mid April (Allen, 1977).

Based on March, 2008, field measurements, Oakley Creek was found to be completely frozen near Highway #6 (at monitoring station OCW1) during the field monitoring program.

Outputs

Discharges to the Minago River watershed are the major "output" of the water balance model. All other clean, potable, grey, and processing waters will be managed internally at the Minago Project.

2.14.2.2 Detailed Input Parameters and Considerations of the Water Balance Model

Key input parameters and considerations of the Minago water balance model are presented below. These key input parameters and considerations include climatic conditions and the stages of Operations, Closure and Post Closure as well as Temporary Suspension and the State of Inactivity. Based on the stated input parameters and considerations, elemental concentrations and flowrates were estimated for combined flows that will have a bearing on the receiving environment.

- **Key Climatic Input Parameters and Considerations**

Key climatic parameters used for the water balance model are given in Table 2.14-1.

Table 2.14-1 Climatic Parameters and Considerations used for the Minago Water Balance Model

PRECIPITATION:		
Average annual precipitation:	**510 mm**	Source: Golder Associates (2009)
72% falls as rain:	369 mm	Source: Golder Associates (2009)
28% falls as snow:	141 mm	Source: Golder Associates (2009)
Snow Sublimation:		
39% of annual snow fall:	54.99 mm	Source: Golder Associates (2009)
Water equivalent remaining in the spring:	= 141-54.99 mm = 86.01 mm	Source: Golder Associates (2009)
Water Balance Model Assumptions:		
- It was assumed that 40 mm of rain falls in May (31 days).		Source: Golder Associates (2009)
- It was assumed that 141 mm of snow falls between November and April (180 days). It was assumed that 86.01 mm water equivalent remains of the snow precipitation in the spring.		Source: Golder Associates (2009)
- It was assumed that 329 mm of rain falls in June, July, August, September, October (2.1364 mm/day over 154 days)		Source: Golder Associates (2009)
LAKE EVAPORATION:		
Average annual lake evaporation:	566.0 mm	Source: Golder Associates (2009)
in April:	17.6 mm	Source: Golder Associates (2009)
in May:	112.0 mm	Source: Golder Associates (2009)
in period from June to October:	436.7 mm	Source: Golder Associates (2009)

Water Balance Model Assumptions:

It was assumed that water evaporates from the sewage treatment system, TWRMF, and Polishing Pond at 50% of the lake evaporation measured for big lakes in the vicinity of the Minago Project. For the 50% evaporation model, it was assumed that 56 mm evaporate in the month of May (1.80645 mm/day over 31 days) and 218.35 mm (1.4179 mm/day over 154 days) evaporate in June, July, August, September and October.

Key Input Parameters and Considerations for Nickel and Frac Sand Plant Operations (Year 1 through Year 10).

1. The Nickel Processing Plant and the Frac Sand Plant and related appurtenances will be operating.
2. All twelve dewatering wells will be running and the Open Pit will be dewatered.
3. Tailings and ultramafic waste rock will be concurrently disposed in a Tailings and Waste Rock Management Facility (TWRMF).
4. Only the deposited Ni tailings will leach at the maximum leaching rate measured during kinetic testing in the subaqueous leach column surface water.
5. Voids in freshly deposited tailings will represent 22% of the tailings stream. Voids remaining in the ultramafic waste rock after concurrent disposal with tailings were assumed to represent 6.9% of the total volume of the waste rock and its voids (Wardop, 2010). All voids were assumed to be filled with water of the same quality as the supernatant of the TWRMF. This porewater was assumed to be unavailable for discharge from the TWRMF.
6. On-site daily potable water consumption per person was assumed to be ~ 300 L.
7. The TWRMF will have a water cover with a nominal thickness of 0.5 m during the operational phase.
8. Excess groundwater from the dewatering wells will be discharged to the Polishing Pond all year round.
9. In the winter months (Nov. to Apr.), 65% of the Polishing Pond water will be discharged to the Minago River and 35% will be stored in the Polishing Pond. During the remainder of the year (May to October), 100% of the Polishing Pond water will be discharged to the Minago River.

- **Key Input Parameters and Considerations for Closure:**

  The closure period was broken down into two stages (first and second) for which the input parameters and considerations are summarized below.

  Considerations for the First Stage of Closure (Figure 2.14-3):

  1. All operations will have ceased at the Mill and Frac Sand Plant and related appurtenances.
  2. Open pit dewatering will have ceased.
  3. Water will be pumped from the dewatering wells to the TWRMF to provide a 1.5 m high water cover.
  4. Only the deposited Ni tailings will leach at the maximum leaching rate measured during kinetic testing in the subaqueous leach column surface water.

5. On-site potable water consumption was assumed to be 15 m^3/day (~ 300 L/person/day for 30 people).
6. Polishing Pond supernatant will be discharged to the Minago River via a discharge pipeline.

<u>Considerations for the Second Stage of Closure (Figure 2.14-4):</u>

All input parameters and considerations are as for first stage of closure except for the dewatering wells. The dewatering wells will be decommissioned, once a water cover of 1.5 m height will have been installed on top of the TWRMF.

- **Key Input Parameters and Considerations for Post Closure** (Figure 2.14-5):

1. All decommissioning activities of mining facilities and infrastructure will have been completed.
2. Only the deposited Ni tailings will leach at the maximum leaching rate measured during kinetic testing in the subaqueous leach column surface water.
3. TWRMF supernatant in excess of the 1.5 m water cover will be discharged to the Polishing Pond via a spillway.
4. Polishing Pond supernatant will be discharged to the Minago River basin via a spillway for ultimate discharge to the Minago River.

- **Key Input Parameters and Considerations for Temporary Suspension (TS) at the end of Year 5:**

1. All operations will have ceased at the Mill and Frac Sand Plant and related appurtenances at the end of Year 5. TS means that advanced exploration, mining or mine production activities have been suspended due to factors such as low metal prices, or mine related factors such as ground control problems and labour disputes.
2. No more tailings will be deposited into the TWRMF.
3. Only deposited Ni tailings will leach at the maximum leaching rate measured during kinetic testing in the subaqueous leach column surface water.
4. Dewatering wells will be running as usual during regular operations.
5. On-site potable water consumption was assumed to be 6 m^3/day (~ 300 L/person/day for 20 people).
6. Excess groundwater from the dewatering wells will be discharged to the Polishing Pond all year round.
7. TWRMF will have a water cover of a nominal thickness of 0.5 m. Excess supernatant from the TWRMF will be discharged to the Polishing Pond.

8. During the winter months (Nov. to Apr.), 65% of the Polishing Pond water will be discharged to the Minago River and 35% will be stored in the Polishing Pond. During the remainder of the year (May to October), 100% of the Polishing Pond water will be discharged to the Minago River.

- **Key Input Parameters and Considerations for The State of Inactivity (SI)**

1. State of Inactivity was assumed to have occurred after one year of Temporary Suspension at the end of Year 6. SI means that mine production and mining operations on site have been suspended indefinitely.
2. No tailings will be deposited into the TWRMF.
3. Only deposited Ni tailings will leach at the maximum leaching rate measured during kinetic testing in the subaqueous leach column surface water.
4. Operations will have ceased at the Nickel Processing Plant and Frac Sand Plant and related appurtenances.
5. One dewatering well will be running, but only to supply the camp and site activities with water.
6. On-site potable water consumption was assumed to be 3 m^3/day (~ 300 L/person/day for 10 people).

9. TWRMF will have a water cover of a nominal thickness of 0.5 m. Excess supernatant from the TWRMF will be discharged to the Polishing Pond.
10. During the winter months (Nov. to Apr.), none of the Polishing Pond water will be discharged. During the remainder of the year (May to October), 100% of the Polishing Pond water will be discharged to the Minago River.

- **Key Input Parameters and Considerations for the Calculation of Flowrates:**

Key input parameters and considerations for flowrate calculations are detailed in Table 2.14-2. Efforts were made to use flowrates that are representative of anticipated site conditions. All flowrates not detailed in Table 2.14-2were based on material flowsheets developed by Wardrop Engineering Inc. (Wardrop) and others and are presented as part of the presentation of modeling results.

- **Key Input Parameters and Considerations for the Calculation of Elemental Concentrations:**

Key input parameters and considerations for contaminant loadings and element concentrations in the water balance flows are summarized in Table 2.14-3. Efforts were made to use concentrations that are representative of anticipated site and geochemical conditions.

- **Key Input Parameters and Considerations for Flowrates in Minago River and Oakley Creek:**

  Key input parameters and considerations for flowrates in Minago River and Oakley Creek are summarized in Table 2.14-4.

- **Assumed Weekly Metal Leaching Rates for the Minago Tailings**

  The metal leaching rates assumed for Minago tailings are detailed in Table 2.14-5 and correspond to 10% of surface water loadings measured for the subaqueous column in kinetic tests that were run for 54 weeks (URS, 2009). Steady State was assumed after week 11 (URS, 2008i).

- **Assumed Areas of Site Facilities:**

  The areas of site facilities that were used in the water balance model are detailed in Table 2.14-6.

- **Input Data – Material Flow Rates and Conditions for the TWRMF:**

  Assumed material flow rates and conditions for the TWRMF are detailed in Table 2.14-7.

Table 2.14-2 Key Input Parameters and Considerations for Flowrate Calculations in the Minago Water Balance Model

Flowrates Qi (i = 1 to 34) | **Mathematical Formulae to determine Qi (i = 1 - 34)**

UNIT EVAPORATION (1 Unit = 1 ha)	UNIT LAKE EVAPORATION	= Q-Unit-Evapo
UNIT PRECIPITATION (1 Unit = 1 ha)		
Q1	FLOW FROM DEWATERING WELLS	
Q2	WELL WATER FOR PROCESSING	
Q3	EXCESS WATER FROM DEWATERING WELLS	
Q4	GROUNDWATER TO OTHER OPERATIONS	
Q5	GROUNDWATER TO WATER TREATMENT	as per Feasibility Study (Q1–Q9)
Q6	GROUNDWATER TO FRAC SAND PLANT	
Q7	GROUNDWATER FOR FIRE FIGHTING	
Q8	POTABLE WATER	
Q9	WATER TREATMENT PLANT WASTE	
Q10	RECYCLE WATER FROM POLISHING POND	= Q31
Q11	POTABLE WATER TO MILL	
Q12	POTABLE WATER TO OTHER OPERATIONS	
Q13	POTABLE WATER TO OFFICES & CAMP	
Q14	POTABLE WATER TO FRAC SAND PLANT	
Q15	FLOW FROM OPERATIONS TO MILL	
Q16	SEWAGE & GREY WATER FROM CAMP AND OFFICES	
Q17	SEWAGE & GREY WATER FROM ALL OTHER ON SITE SOURCES	as per Feasibility Study (Q11–Q25)
Q18	FLOW FROM FSP OPERATIONS TO FSP THICKENER	
Q19	FLOW FROM CONCENTRATE THICKENER IN MILL TO MILL	
Q20	FLOW FROM MILL TO MILL THICKENER	
Q21	RECYCLE WATER FROM MILL THICKENER	
Q21x	ATERNATE FLOW FOR RECYCLE WATER FROM MILL THICKENER	
Q22	MILL TAILINGS SLURRY	
Q23	SEWAGE TREATMENT OUTFLOW	
Q24	LIQ. WASTE FROM FSP	
Q25	SLURRY FROM FRAC SAND PLANT (FSP)	
Q26	TWRMF INFLOW	= Q9 + Q21x + Q22 + Q23 + Q24 + Q25
Q - Liquid Precipitation on TWRMF	Available Precipitation on TWRMF	= AREA*Q-Unit-PPT
Q - Evaporation from TWRMF	Evaporation from TWRMF	= AREA*(Q-Evapo from TWRMF)
Q - Retained Water in Tailings Voids	Retained Water in Tailings Voids	= 22% Retained Water in Voids; assumed tailings density = 1.5 tonnes/m3
Q - TWRMF Supernatant	TWRMF Supernatant	= Q26+(Q-Remaining Supernatant)+Q-PPT on TWRMF-(Q-Evapo from TWRMF) - (Q-Retained Water in Voids)
Q27	TWRMF DECANT	= TWRMF Supernatant minus 0.5 m water during Operations
Q - Pit Dewatering	OPEN PIT DEWATERING	= 8000 m3/day during Operations;= 0 m^3/day thereafter
Q - Precipitation on Pit	Precipitation minus Sublimation on Open Pit	= AREA*Q-Unit-PPT
Q28	TOTAL OPEN PIT DEWATERING	= (Q-Pit Dewatering)+(Q-PPT on Pit)
Q29	POLISHING POND INFLOW	= (Q3+Q27+Q28) during Operations
Q - Precipitation on Polising Pond	Precipitation minus Sublimation ON POLISHING POND	= AREA*Q-Unit-PPT
Q - Evaporation from Polishing Pond	EVAPORATION FROM POLISHING POND	= AREA*Q-Unit-Evapo
Q30	POLISHING POND OUTFLOW	= Q29 + (Q-PPT on Polishing Pond) - (Q-Evapo from Polishing Pond)
Q31	RECYCLE FROM FINAL POLISHING POND	as per Feasibility Study
Q32	FLOW TO DISCHARGE PIPELINE	as per Feasibility Study
Q32	DISCHARGE TO MINAGO	
Q33	MINAGO UPSTREAM	as outlined in Modeling Assumptions
Q34	MINAGO DOWNSTREAM	= Q32+Q33

Table 2.14-3 Key Input Parameters and Considerations for Calculations of Elemental Concentrations in the Minago Water Balance Model

Concentration Ci (in Flow Qi)	Mathematical Formulae to determine Ci (i = 1 to 34)
UNIT EVAPORATION	
UNIT PPT (U-PPT)	= CCME Mean Detection Limits
C1	= Aug-2008 Groundwater Quality (Dissolved Metals)
C2	= Aug-2008 Groundwater Quality (Dissolved Metals)
C3	= Aug-2008 Groundwater Quality (Dissolved Metals)
C4	= Aug-2008 Groundwater Quality (Dissolved Metals)
C5	= Aug-2008 Groundwater Quality (Dissolved Metals)
C6	= Aug-2008 Groundwater Quality (Dissolved Metals)
C7	= Aug-2008 Groundwater Quality (Dissolved Metals)
C8	= CCME Mean Detection Limits
C9	not assumed
C10	= C32
C11	= CCME Mean Detection Limits
C12	= CCME Mean Detection Limits
C13	= CCME Mean Detection Limits
C14	= CCME Mean Detection Limits
C15	Internal Nickel Processing Plant Water Quality
C16	not assumed
C17	not assumed
C18	Internal FSP Water Quality
C19	} Internal Mill Water Quality
C20	} Internal Mill Water Quality
C21	} Internal Mill Water Quality
C21x	} Internal Mill Water Quality
C22	= Measured Concentration SGS Lakefield Nov. 7, 2008 Results
C23	= CCME Mean Detection Limits
C24	= Measured Dissolved Concentration for FSP Overflow
C25	= Measured Dissolved Concentration for FSP Underflow
C26	= {Q9*C9 +Q21x*C21x + Q22*C22 + Q23*C23 + Q24*C24 + Q25*C25} / Q26
C - PPT on TWRMF	= CCME Mean Detection Limits
C - Evapo from TWRMF	
C - Tailings Leachate	= {Mass of Tailings [tonnes]* Leaching Rate of Tailings [mg/kg/period]} / Q-TWRMF Supernatant [m^3/period]
C-TWRMF Supernatant	= {Q26*C26 + (Q-TWRMF Supernatant Remaining)*(C-TWRMF Supernatant Remaining) + (Q-PPT on TWRMF)*(C-PPT on TWRMF) + (Q-Tailings Leachate)*(C-Tailings Leachate) } / Q-TWRMF Supernatant
C27	= C-TWRMF Supernatant
C-Pit Dewatering	= Aug-2008 Groundwater Quality (Dissolved Metals)
C-PPT on Pit	= CCME Mean Detection Limits
C28	= {(Q-Pit Dewatering)*(C-Pit Dewatering) + (Q-PPT on Pit)*(C-PPT on Pit)} / Q28
C29	= {Q3*C3 + Q27*C27 + Q28*C28} / Q29 during Operations
C-PPT on PP	= CCME Mean Detection Limits
C-Evapo from PP	
C30	= {Q29*C29 + (Q-PPT on Polishing Pond)*(C-PPT on Polishing Pond)} / Q30
C31	= C30
C32	= C30
C33	= AVERAGE 2006-2008 MINAGO RIVER WATER QUALITY (Dissolved Metals at MRW2)
C34	= {Q32*C32 + Q33*C33} / Q34

Table 2.14-4 Estimated Flowrates in Minago River

Time Period / Stream	May m^3/s	June to October m^3/s	November to April m^3/s
Minago River	10	1.9	0.8

Table 2.14-5 Weekly Metal Leaching Rates Assumed for Minago Tailings

10% of Subaqueous Leach Column Surface Water Loading as given in URS Geochemical Memo, dated March 4, 2010				
ELEMENT	Unit	Minimum	Average	Maximum
Aluminum (Al)	mg/kg/wk	2.000E-06	2.120E-05	1.440E-04
Antimony (Sb)	mg/kg/wk	6.080E-07	9.290E-07	1.180E-06
Arsenic (As)	mg/kg/wk	2.000E-07	1.304E-06	6.400E-06
Cadmium (Cd)	mg/kg/wk	1.600E-08	7.450E-08	7.680E-07
Chromium (Cr)	mg/kg/wk	3.200E-07	1.210E-06	2.000E-06
Cobalt (Co)	mg/kg/wk	6.400E-08	6.030E-07	1.240E-06
Copper (Cu)	mg/kg/wk	1.800E-06	8.010E-06	2.240E-05
Iron (Fe)	mg/kg/wk	3.200E-06	1.570E-05	6.200E-05
Lead (Pb)	mg/kg/wk	9.280E-08	1.621E-06	1.630E-05
Molybdenum (Mo)	mg/kg/wk	6.000E-06	1.180E-05	1.960E-05
Nickel (Ni)	mg/kg/wk	1.800E-05	4.020E-05	8.420E-05
Selenium (Se)	mg/kg/wk	4.000E-07	8.720E-07	2.180E-06
Zinc (Zn)	mg/kg/wk	4.160E-06	1.300E-05	7.680E-05

Table 2.14-6 Area of Site Facilities

Designated Area	Area (ha)
Pit Area	190
Tailings and Ultramafic Waste Rock Management Facility (TWRMF)	595
Polishing Pond	120

Table 2.14-7 Input Data - Material Flow Rates and Conditions for the Tailings and Ultramafic Waste Rock Management Facility (TWRMF)

			Ultramafic WR in TWRMF (kT)	Ni Tailings in TWRMF (kT)	Water Cover Height	Discharge to Minago River from Discharge Pipeline
Mill & Frac Sand Plant Operating	Year 1	Nov.-Apr.	6,215	889	0.5 m	65%
		May	6,215	889	0.5 m	100%
		Jun.-Oct.	6,215	889	0.5 m	100%
	Year 2	Nov.-Apr.	12,111	4,444	0.5 m	65%
		May	12,111	4,444	0.5 m	100%
		Jun.-Oct.	12,111	4,444	0.5 m	100%
	Year 3	Nov.-Apr.	17,056	7,999	0.5 m	65%
		May	17,056	7,999	0.5 m	100%
		Jun.-Oct.	17,056	7,999	0.5 m	100%
	Year 4	Nov.-Apr.	21,156	11,554	0.5 m	65%
		May	21,156	11,554	0.5 m	100%
		Jun.-Oct.	21,156	11,554	0.5 m	100%
	Year 5	Nov.-Apr.	25,379	15,109	0.5 m	65%
		May	25,379	15,109	0.5 m	100%
		Jun.-Oct.	25,379	15,109	0.5 m	100%
	Year 6	Nov.-Apr.	30,597	18,664	0.5 m	65%
		May	30,597	18,664	0.5 m	100%
		Jun.-Oct.	30,597	18,644	0.5 m	100%
	Year 7	Nov.-Apr.	35,046	22,219	0.5 m	65%
		May	35,046	22,219	0.5 m	100%
		Jun.-Oct.	35,046	22,219	0.5 m	100%
	Year 8	Nov.-Apr.	35,659	25,774	0.5 m	65%
		May	35,659	25,774	0.5 m	100%
		Jun.-Oct.	35,659	25,774	0.5 m	100%

Table 2.14-7 (Cont.'d) Input Data - Material Flow Rates and Conditions for the Tailings and Ultramafic Waste Rock Management Facility (TWRMF)

	Ultramafic WR in TWRMF (kT)	Ni Tailings in TWRMF (kT)	Water Cover Height	Discharge to Minago River from Discharge Pipeline	Comments

Table 2.14-7 (Cont.'d) Input Data - Material Flow Rates and Conditions for the Tailings and Ultramafic Waste Rock Management Facility (TWRMF)

			Ultramafic WR in TWRMF (kT)	Ni Tailings in TWRMF (kT)	Water Cover Height	Discharge to Minago River from Discharge Pipeline	Comments
Mill & Frac Sand Plant Operating	Year 9	Nov.-Apr.	35,659	29,329	0.5 m	65%	
		May	35,659	29,329	0.5 m	100%	
		Jun.-Oct.	35,659	29,329	0.5 m	100%	
	Year 10	Nov.-Apr.	35,659	30,567	0.5 m	65%	
Closure	Year 10	May	35,659	30,567	0.74 m	0%	1.5 m water cover will be installed
		Jun.-Oct.	35,659	30,567	1.5 m	0%	
	Year 11	Nov.-Apr.	35,659	30,567	1.5 m	0%	Excess water from the Polishing Pond will be discharged to the Minago River
		May	35,659	30,567	1.5 m	100%	
		Jun.-Oct.	35,659	30,567	1.5 m	100%	
Post Closure	Year 12+	Nov.-Apr.	35,659	30,567	1.5 m	0%	Excess water from the Polishing Pond will be discharged to the Minago River
		May	35,659	30,567	1.5 m	100%	
		Jun.-Oct.	35,659	30,567	1.5 m	100%	
Temporary Suspension (TS)	After Year 5	Nov.-Apr.	25,699.8	15,300	0.5 m	65%	Excess water will be discharged like during operations
		May	25,699.8	15,300	0.5 m	100%	
		Jun.-Oct.	25,699.8	15,300	0.5 m	100%	
State of Inactivity (SI)	After one year of TS	Nov.-Apr.	25,699.8	15,300	0.5 m	0%	No Discharge; Excess water will be stored in the Polishing Pond
		May	25,699.8	15,300	0.5 m	100%	Excess water will be discharged to the Minago River
		Jun.-Oct.	25,699.8	15,300	0.5 m	100%	

2.14.2.3 Results of the Minago Water Balance Model

Following are key results of the water balance model based on the assumptions outlined above. As for the general description of the water management, the water balance model results are presented for the following five mine development phases: Operations, Closure, Post Closure, Temporary Suspension, and the State of Inactivity. Following the presentation of results, Contaminants of Concern respective to the water quality of the discharged water will be summarized.

Water balance models for all mine development phases were developed for three periods of the year: May, June to October, and November to April. These periods were chosen to represent average conditions during the freshet, summer, and winter.

Contaminant loadings and estimated elemental concentrations in the various flows of the Minago water balance model, presented below, are listed against the Metal Mining Effluent Regulations (Environment Canada, 2002a) and the Canadian Guidelines for the Protection of Aquatic Life (CCME, 2011). They are also summarized against the Manitoba Water Quality Standards, Objectives and Guidelines (Tier II and Tier III Freshwater Quality) (Manitoba Water Stewardship, 2011). These guideline limits are presented in Table 2.14-8. Parametric concentrations were estimated for aluminum (Al), antimony (Sb), arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), molybdenum (Mo), nickel (Ni), selenium (Se), and zinc (Zn).

The Metal Mining Effluent Regulations (MMER) were registered on June 6, 2002 under subsections 34(2), 36(5), and 38(9) of the *Fisheries Act* (Environment Canada, 2002a; last amended in 2012), which replaced the MMLER and the associated *Metal Mining Liquid Effluent Guidelines*. The MMER prescribe authorized concentration limits for deleterious substances in mine effluents that discharge to waters frequented by fish. The MMER apply to all Canadian metal mines (except placer mines) that exceed an effluent flowrate of 50 m^3 per day. The MMER apply to effluent from all final discharge points (FDPs) at a mine site. A FDP is defined in the Regulations as a point beyond which the mine no longer exercises control over the quality of the effluent. The regulated MMER parameters are arsenic, copper, cyanide, lead, nickel, zinc, total suspended solids (TSS), Radium 226, and pH.

Canadian Water Quality Guidelines for the Protection of Aquatic Life define acceptable levels for substances or conditions that affect water quality such as toxic chemicals, temperature and acidity. Guideline values are meant to protect all forms of aquatic life and all aspects of the aquatic life cycles, including the most sensitive life stage of the most sensitive species over the long term.

Table 2.14-8 Guideline Limits used for Interpreting Water Balance Results

Water Quality Parameter		REGULATIONS					
		Metal Mining Liquid Effluent Regulations (2002, last amended in 2012)		Manitoba Water Quality Standards, Objectives, and Guidelines (Manitoba Water Stewardship, 2011)		Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2011)	
		Monthly Mean	Grab Sample	TIER II Water Quality Objectives assuming hardness = 150 mg/L $CaCO_3$	Freshwater	assuming hardness = 65 mg/L $CaCO_3$	assuming hardness = 150 mg/L $CaCO_3$
Aluminum	**Al**				0.005 - 0.1	0.005 - 0.1	0.005 - 0.1
Antimony	**Sb**						
Arsenic	**As**	0.5	1	0.15 mg/L (4-Day, 3-Year) [A]	Tier II	0.005	0.005
Cadmium	**Cd**			0.00033 [B]	Tier II	0.000023[a]	0.000047[a]
Chromium	**Cr**			0.10331 [C]	Tier II	0.0089	0.0089
Cobalt	**Co**						
Copper	**Cu**	0.3	0.6	0.01266 [D]	Tier II	0.002[b]	0.00334[b]
Iron	**Fe**				0.3	0.3	0.3
Lead	**Pb**	0.2	0.4	0.0039 [E]	Tier II	0.00184[c]	0.00533[c]
Molybdenum	**Mo**				0.073		
Nickel	**Ni**	0.5	1	0.07329 [F]	Tier II	0.06889[d]	0.13007[d]
Selenium	**Se**				0.001	0.001	0.001
Zinc	**Zn**	0.5	1	0.16657 [G]	Tier II	0.03	0.03

Notes:

A Arsenic limits: 0.15 mg/L for averaging duration 4 days (4-Day, 3-Year or 7Q10 Design Flow); 0.34 mg/L for averaging duration 1 hr (1-Day, 3-Year or 1Q10 Design Flow)

B Cadmium limits: [e{0.7409[ln(Hardness)]-4.719]×[1.101672-{ln(Hardness)(0.041838)}] for 4 days averaging duration.
[e{1.0166[ln(Hardness)]-3.924}]×[1.136672-{ln(Hardness)(0.041838)}] for 1 hour averaging duration.

C Chromium limits: Chromium III: [e{0.8190[ln(Hardness)]+0.6848}]×[0.860] for 4 days averaging duration.
Chromium III: [e{0.8190[ln(Hardness)]+3.7256}]×[0.316] for 1 hour averaging duration.
Chromium VI: 0.011 mg/L for averaging duration 4 days (4-Day, 3-Year or 7Q10 Design Flow);
Chromium VI: 0.016 mg/L for averaging duration 1 hr (1-Day, 3-Year or 1Q10 Design Flow)

D Copper limits: [e{0.8545[ln(Hardness)]-1.702}]×[0.960] for 4 Days hour averaging duration.
[e{0.9422[ln(Hardness)]-1.700}]×[0.960] for 1 hour averaging duration.

E Lead limits: [e{1.273[ln(Hardness)]-4,705}]×[1.46203 -{ln(Hardness)(0.145712)}] for 4 Days averaging duration.
[e{1.273[ln(Hardness)]-1.460}]×[1.46203 -{ln(Hardness)(0.145712)}] for 1 hour averaging duration.

F Nickel limits: [e{0.8460[ln(Hardness)]+0.0584}]×[0.997] for 4 Days averaging duration.
[e{0.8460[ln(Hardness)]+2.255}]×[0.998] for 1 hour averaging duration.

G Zinc limits: [e{0.8473[ln(Hardness)]+0.884}]×[0.986] for 4 Days averaging duration.
[e{0.8473[ln(Hardness)]+0.884}]×[0.978] for 1 hour averaging duration.

Canadian water quality guidelines for the protection of aquatic life (CCME, 2011)

a Cadmium limit: Cadmium concentration = $10^{0.86[\log10(\text{hardness})]-3.2}$ µg/L
b Copper limit: Copper concetration = $e^{0.8545[\ln(\text{hardness})]-1.465} * 0.2$ µg/L
c Lead limit: Lead concetration = $e^{1.273[\ln(\text{hardness})]-4.705}$ µg/L
d Nickel limit: Nickel concentration = $e^{0.76[\ln(\text{hardness})]+1.06}$ µg/L

The Manitoba Tier II Water Quality Objectives are defined for a limited number of common pollutants (such as dissolved metals and nutrients) that are routinely controlled through licensing under the Manitoba Environment Act. Manitoba Tier II Water Quality Objectives typically form the basis for the water quality base approach when additional restrictions need to be developed to protect important uses of ground or surface waters (Manitoba Water Stewardship, 2011).

It should be noted that water quality guideline limits for heavy metals (such as cadmium, chromium, copper, lead, nickel and zinc) depend on hardness. Therefore, results presented below are listed in terms of applicable equations to determine the guideline limits based on hardness as well as for a hardness of 150 mg/L $CaCO_3$. The hardness level of 150 mg/L $CaCO_3$ was chosen as comparison for results obtained with the Minago water balance model based on water quality results obtained to date. For these results, listed in Table 2.14-9, the average hardness was 192.2 mg/L $CaCO_3$, the median hardness was 193 mg/L $CaCO_3$, and the weighted average hardness was 173.1 mg/L $CaCO_3$.

Table 2.14-9 Hardness Levels Measured at Minago

	Number of Samples	Minimum (mg/L$CaCO_3$)	Average (mg/L$CaCO_3$)	Maximum (mg/L$CaCO_3$)
Frac Sand Plant Overflow	2		171.5	194
Frac Sand Plant Underflow	2		167	192
Sub-aqueous Col. Pore Water	53	145	232	358
Sub-aqueous Col. Surface Water	53	71.2	102.8	138
Groundwater Limestone	3	242	267	287
Groundwater Sandstone	3	165	196	257
Upstream Minago (MRW2)	7	169	192	213
Downstream Minago (MRW1)	14	87.2	149	256
Upstream Oakley Cr. (OCW2)	13	169	204.8	265
Process Water (Nov. 2008 SGS Lakefield Results)	1		240	
Total	151			
Minimum		**71.2**		
Average			**192.2**	
Maximum				**358.0**
Weighted Average			**173.1**	

2.14.2.3.1 Water Balance Modeling Results during Operations

Year 1 through Year 10 Operations

Estimated flowrates during Year 1 through Year 10 operations are listed in Table 2.14-10 and the corresponding water management plan is illustrated in Figure 2.14-3..

The Polishing Pond discharge to Minago River (Q32) in relation to the Minago River streamflow (Q33) will be 11-16% in May, 28-29% in the summer months (June to October) and 35-36% in the winter months (November to April). In absolute quantities, discharge to Minago River will range from 15,368 m^3/day to 139,507 m^3/day during Year 1 to Year 10 operations.

Table 2.14-11, Table 2.14-12 and Table 2.14-13 present projected parametric concentrations for the Polishing Pond outflow (Q30) and Minago downstream (Q34) for Year 1 through 4, Year 5 through 8, and Years 9 and 10, respectively. Additional results for Q26 (TWRMF Inflow), Q27 (TWRMF Decant), and Q29 (Polishing Pond Inflow) and detailed flow estimates are provided in Appendix 2.14. All Polishing Pond outflow concentrations are projected to meet the MMER levels and the projected water quality downstream of the mixing zones in the Minago River and the Oakley Creek meets the CCME (2011) and Manitoba Tier III Freshwater guidelines levels.

Table 2.14-10 Projected Flow Rates during Year 1 through 10 Operations

		Year 1			Year 2			…	Year 9			Year 10
		Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate		Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate
		NOVEMBER TO APRIL	MAY	JUNE TO OCTOBER	NOVEMBER TO APRIL	MAY	JUNE TO OCTOBER		NOVEMBER TO APRIL	MAY	JUNE TO OCTOBER	NOVEMBER TO APRIL
	FLOW	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day		m^3/day	m^3/day	m^3/day	m^3/day
UNIT EVAPORATION	UNIT LAKE EVAPORATION	0	18	14	0	18	14		0	18	14	0
UNIT PPT (U-PPT)	UNIT PRECIPITATION	0	41	21	0	41	21		0	41	21	0
Q1	FLOW FROM DEWATERING WELLS	31,999	31,999	31,999	31,999	31,999	31,999		31,999	31,999	31,999	31,999
Q2	WELL WATER FOR PROCESSING	5,724	5,724	5,724	5,724	5,724	5,724		5,724	5,724	5,724	5,724
Q3	EXCESS WATER FROM DEWATERING WELLS	26,276	26,276	26,276	26,276	26,276	26,276		26,276	26,276	26,276	26,276
Q4	GROUNDWATER TO OTHER OPERATIONS	1,440	1,440	1,440	1,440	1,440	1,440		1,440	1,440	1,440	1,440
Q5	GROUNDWATER TO WATER TREATMENT	96	96	96	96	96	96		96	96	96	96
Q6	GROUNDWATER TO FRAC SAND PLANT	4,188	4,188	4,188	4,188	4,188	4,188		4,188	4,188	4,188	4,188
Q7	GROUNDWATER FOR FIRE FIGHTING	0	0	0	0	0	0		0	0	0	0
Q8	POTABLE WATER	96	96	96	96	96	96		96	96	96	96
Q9	WATER TREATMENT PLANT WASTE	0	0	0	0	0	0		0	0	0	0
Q10	RECYCLE WATER FROM FPP	10,632	10,632	10,632	10,632	10,632	10,632		10,632	10,632	10,632	10,632
Q11	POTABLE WATER TO MILL	6	6	6	6	6	6		6	6	6	6
Q12	POTABLE WATER TO OTHER OPERATIONS	5	5	5	5	5	5		5	5	5	5
Q13	POTABLE WATER TO OFFICES & CAMP	72	72	72	72	72	72		72	72	72	72
Q14	POTABLE WATER TO FRAC SAND PLANT	12	12	12	12	12	12		12	12	12	12
Q15	FLOW FROM OPERATIONS TO MILL	1,440	1,440	1,440	1,440	1,440	1,440		1,440	1,440	1,440	1,440
Q16	SEWAGE & GREY WATER FROM CAMP AND OFFICES	72	72	72	72	72	72		72	72	72	72
Q17	SEWAGE & GREY WATER FROM ALL OTHER ON SITE SOURCES	24	24	24	24	24	24		24	24	24	24
Q19	FLOW FROM CONCENTRATE THICKENER IN MILL TO MILL	1,080	1,080	1,080	1,080	1,080	1,080		1,080	1,080	1,080	1,080
Q20	FLOW FROM MILL TO MILL THICKENER	32,928	32,928	32,928	32,928	32,928	32,928		32,928	32,928	32,928	32,928
Q21	RECYCLE WATER FROM MILL THICKENER	20,856	20,856	20,856	20,856	20,856	20,856		20,856	20,856	20,856	20,856
Q21x	ATERNATE FLOW FOR RECYCLE WATER FROM MILL THICKENER	0	0	0	0	0	0		0	0	0	0
Q22	MILL TAILINGS SLURRY	12,072	12,072	12,072	12,072	12,072	12,072		12,072	12,072	12,072	12,072
Q23	SEWAGE TREATMENT OUTFLOW	0	676	103	0	676	103		0	676	103	0
Q24	LIQ. WASTE FROM FSP	2,892	2,892	2,892	2,892	2,892	2,892		2,892	2,892	2,892	2,892
Q25	SLURRY FROM FSP	772	772	772	772	772	772		772	772	772	772
Q26	TWRMF INFLOW	15,736	16,412	15,839	15,736	16,412	15,839		15,736	16,412	15,839	15,736
Q - Liquid PPT on TWRMF	PPT on TWRMF	0	24,186	12,711	0	24,186	12,711		0	24,186	12,711	0
Q - Retained Water in Tailings Voids	Q - Retained Water in Tailings Voids	724	1,467	847	1,467	1,467	1,467		1,467	1,467	1,467	1,009
Q - TWRMF Supernatant	TWRMF Supernatant	14,422	111,531	37,996	30,237	123,790	37,406		30,797	124,350	37,965	31,255
Q27	TWRMF Decant	0	15,563	18,678	13,710	27,823	18,088		14,269	28,382	18,647	14,727
Q - Pit Dewatering	OPEN PIT DEWATERING	8,000	8,000	8,000	8,000	8,000	8,000		8,000	8,000	8,000	8,000
Q - Precipitation on Pit	Precipitation minus Sublimation on Open Pit	0	7,723	4,059	0	7,723	4,059		0	7,723	4,059	0
Q28	TOT. OPEN PIT DEWATERING	8,000	15,723	12,059	8,000	15,723	12,059		8,000	15,723	12,059	8,000
Q29	POLISHING POND INFLOW	34,276	105,612	57,012	47,985	145,733	56,423		48,545	147,429	56,982	49,003
Q - Precipitation on Polishing Pond	Precipitation minus Sublimation ON POLISHING POND	0	4,878	2,564	0	4,878	2,564		0	4,878	2,564	0
Q - Evaporation from Polishing Pond	EVAPORATION FROM POLISHING POND	0	2,168	1,701	0	2,168	1,701		0	2,168	1,701	0
Q30	POLISHING POND OUTFLOW	34,276	108,322	57,874	47,985	148,443	57,285		48,545	150,139	57,844	49,003
Q31	RECYCLE FROM FINAL POLISHING POND	10,632	10,632	10,632	10,632	10,632	10,632		10,632	10,632	10,632	10,632
Q32	DISCHARGE PIPELINE	15,368	97,690	47,242	24,280	137,811	46,653		24,643	139,507	47,212	24,941
Q32	DISCHARGE TO MINAGO	15,368	97,690	47,242	24,280	137,811	46,653		24,643	139,507	47,212	24,941
Q33	MINAGO UPSTREAM	69,120	864,000	164,160	69,120	864,000	164,160		69,120	864,000	164,160	69,120
Q34	MINAGO DOWNSTREAM	84,488	961,690	211,402	93,400	1,001,811	210,813		93,763	1,003,507	211,372	94,061

FLOW RATIOS:

Q32 / Q33	RATIO OF DISCHARGE TO MINAGO TO FLOW IN MINAGO	22%	11%	29%	35%	16%	28%		36%	16%	29%	36%

Note:

A complete listing of projected flowrates during the Year 1 to Year 10 Operations are given in Appendix 2.14.

Table 2.14-11 Projected Effluent Concentrations in Site Flows during Year 1 through Year 4 Operations

SCENARIO:			ESTIMATED AVERAGE CONCENTRATION												REGULATIONS					
			Year 1			Year 2			Year 3			Year 4			Metal Mining Liquid Effluent Regulations (2002, last amended in 2012)		Manitoba Water Quality Standards, Objectives, and Guidelines (Manitoba Water Stewardship, 2011)		Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2011)	
			Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate						
FLOW		WATER QUALITY PARAM.	NOVEMBER TO APRIL (mg/L)	MAY (mg/L)	JUNE TO OCTOBER (mg/L)	NOVEMBER TO APRIL (mg/L)	MAY (mg/L)	JUNE TO OCTOBER (mg/L)	NOVEMBER TO APRIL (mg/L)	MAY (mg/L)	JUNE TO OCTOBER (mg/L)	NOVEMBER TO APRIL (mg/L)	MAY (mg/L)	JUNE TO OCTOBER (mg/L)	Monthly Mean	Grab Sample	TIER II Water Quality Objectives assuming hardness = 150 mg/L $CaCO_3$	Freshwater	assuming hardness = 65 mg/L $CaCO_3$	assuming hardness = 150 mg/L $CaCO_3$
Q30	POLISHING POND OUTFLOW	Al	0.009	0.079	0.157	0.157	0.172	0.153	0.158	0.172	0.154	0.159	0.173	0.155				0.005 - 0.1	0.005 - 0.1	0.005 - 0.1
Q30	POLISHING POND OUTFLOW	Sb	0.00003	0.00067	0.00136	0.00127	0.00145	0.00134	0.00128	0.00146	0.00135	0.00129	0.00147	0.00136						
Q30	POLISHING POND OUTFLOW	As	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.5	1	0.15 mg/L (4-Day, 3-Year) [A]	Tier II	0.005	0.005
Q30	POLISHING POND OUTFLOW	Cd	0.00001	0.00012	0.00024	0.00024	0.00026	0.00024	0.00024	0.00027	0.00024	0.00025	0.00028	0.00025			0.00033 [B]	Tier II	0.000023[a]	0.000047[a]
Q30	POLISHING POND OUTFLOW	Cr	0.0010	0.0028	0.0049	0.0048	0.0052	0.0048	0.0048	0.0052	0.0048	0.0048	0.0053	0.0048			0.10331 [C]	Tier II	0.0089	0.0089
Q30	POLISHING POND OUTFLOW	Co	0.00008	0.00163	0.00334	0.00328	0.00363	0.00325	0.00328	0.00363	0.00325	0.00329	0.00363	0.00326						
Q30	POLISHING POND OUTFLOW	Cu	0.0005	0.0056	0.0113	0.0112	0.0124	0.0112	0.0114	0.01258	0.0113	0.0116	0.0128	0.0115	0.3	0.6	0.01266 [D]	Tier II	0.002[b]	0.00334[b]
Q30	POLISHING POND OUTFLOW	Fe	0.005	0.342	0.715	0.706	0.781	0.693	0.705	0.778	0.692	0.704	0.777	0.691				0.3	0.3	0.3
Q30	POLISHING POND OUTFLOW	Pb	0.00003	0.00096	0.00198	0.00195	0.00221	0.00204	0.00209	0.00236	0.00218	0.00223	0.00252	0.00233	0.2	0.4	0.0039 [E]	Tier II	0.00184[c]	0.00533[c]
Q30	POLISHING POND OUTFLOW	Mo	0.0007	0.0023	0.0042	0.0042	0.0046	0.0043	0.0043	0.0048	0.0044	0.0045	0.0050	0.0046				0.073		
Q30	POLISHING POND OUTFLOW	Ni	0.001	0.077	0.161	0.161	0.177	0.157	0.161	0.177	0.157	0.161	0.177	0.157	0.5	1	0.07329 [F]	Tier II	0.06889[d]	0.13007[d]
Q30	POLISHING POND OUTFLOW	Se	0.0002	0.0014	0.0026	0.0025	0.0028	0.0026	0.0025	0.0028	0.0026	0.0025	0.0029	0.0026				0.001	0.001	0.001
Q30	POLISHING POND OUTFLOW	Zn	0.005	0.009	0.014	0.014	0.015	0.014	0.014	0.016	0.015	0.015	0.016	0.016	0.5	1	0.16657 [G]	Tier II	0.03	0.03
Q34	MINAGO DOWNSTREAM	Al	0.011	0.019	0.044	0.050	0.034	0.043	0.050	0.034	0.044	0.050	0.034	0.044				0.005 - 0.1	0.005 - 0.1	0.005 - 0.1
Q34	MINAGO DOWNSTREAM	Sb	0.00004	0.00011	0.00034	0.00037	0.00024	0.00034	0.00037	0.00024	0.00034	0.00037	0.00025	0.00034						
Q34	MINAGO DOWNSTREAM	As	0.0006	0.0007	0.0008	0.0009	0.0008	0.0008	0.0009	0.0008	0.0008	0.0009	0.0008	0.0009	0.5	1	0.15 mg/L (4-Day, 3-Year) [A]	Tier II	0.005	0.005
Q34	MINAGO DOWNSTREAM	Cd	0.000015	0.000027	0.000066	0.000074	0.000051	0.000065	0.000076	0.000052	0.000067	0.000078	0.000053	0.000068			0.00033 [B]	Tier II	0.000023[a]	0.000047[a]
Q34	MINAGO DOWNSTREAM	Cr	0.00037	0.00049	0.00127	0.00142	0.00092	0.00124	0.00143	0.00092	0.00125	0.00143	0.00092	0.00125			0.10331 [C]	Tier II	0.0089	0.0089
Q34	MINAGO DOWNSTREAM	Co	0.00006	0.00021	0.00078	0.00089	0.00054	0.00076	0.00089	0.00054	0.00076	0.00089	0.00054	0.00076						
Q34	MINAGO DOWNSTREAM	Cu	0.001	0.001	0.003	0.003	0.002	0.003	0.003	0.002	0.003	0.003	0.002	0.003	0.3	0.6	0.01266 [D]	Tier II	0.002[b]	0.00334[b]
Q34	MINAGO DOWNSTREAM	Fe	0.058	0.097	0.214	0.235	0.167	0.207	0.235	0.167	0.207	0.235	0.167	0.207				0.3	0.3	0.3
Q34	MINAGO DOWNSTREAM	Pb	0.00005	0.00015	0.00049	0.00055	0.00035	0.00050	0.00059	0.00037	0.00053	0.00063	0.00040	0.00056	0.2	0.4	0.0039 [E]	Tier II	0.00184[c]	0.00533[c]
Q34	MINAGO DOWNSTREAM	Mo	0.00023	0.00035	0.00104	0.00118	0.00074	0.00104	0.00123	0.00077	0.00108	0.00127	0.00080	0.00112				0.073		
Q34	MINAGO DOWNSTREAM	Ni	0.001	0.009	0.037	0.043	0.025	0.035	0.043	0.025	0.036	0.043	0.025	0.036	0.5	1	0.07329 [F]	Tier II	0.06889[d]	0.13007[d]
Q34	MINAGO DOWNSTREAM	Se	0.00024	0.00036	0.00078	0.00082	0.00060	0.00077	0.00083	0.00060	0.00077	0.00084	0.00060	0.00078				0.001	0.001	0.001
Q34	MINAGO DOWNSTREAM	Zn	0.002	0.002	0.004	0.004	0.003	0.004	0.004	0.003	0.004	0.005	0.003	0.004	0.5	1	0.16657 [G]	Tier II	0.03	0.03

Notes: Footnotes A to G and a to d, pertaining to the regulations, are the same as given below in Table 2.14-8.

Table 2.14-12 Projected Effluent Concentrations in Site Flows during Year 5 through Year 8 Operations

SCENARIO:			ESTIMATED AVERAGE CONCENTRATION												REGULATIONS					
			Year 5			Year 6			Year 7			Year 8			Metal Mining Liquid Effluent Regulations (2002, last amended in 2012)		Manitoba Water Quality Standards, Objectives, and Guidelines (Manitoba Water Stewardship, 2011)		Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2011)	
			Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate						
FLOW		WATER QUALITY PARAM.	NOVEMBER TO APRIL (mg/L)	MAY (mg/L)	JUNE TO OCTOBER (mg/L)	NOVEMBER TO APRIL (mg/L)	MAY (mg/L)	JUNE TO OCTOBER (mg/L)	NOVEMBER TO APRIL (mg/L)	MAY (mg/L)	JUNE TO OCTOBER (mg/L)	NOVEMBER TO APRIL (mg/L)	MAY (mg/L)	JUNE TO OCTOBER (mg/L)	Monthly Mean	Grab Sample	TIER II Water Quality Objectives assuming hardness = 150 mg/L $CaCO_3$	Freshwater	assuming hardness = 65 mg/L $CaCO_3$	assuming hardness = 150 mg/L $CaCO_3$
Q30	POLISHING POND OUTFLOW	Al	0.160	0.175	0.156	0.161	0.176	0.158	0.162	0.178	0.159	0.165	0.179	0.160				0.005 - 0.1	0.005 - 0.1	0.005 - 0.1
Q30	POLISHING POND OUTFLOW	Sb	0.00130	0.00148	0.00137	0.00131	0.00149	0.00138	0.00132	0.00151	0.00139	0.00134	0.00152	0.00140						
Q30	POLISHING POND OUTFLOW	As	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.5	1	0.15 mg/L (4-Day, 3-Year) [A]	Tier II	0.005	0.005
Q30	POLISHING POND OUTFLOW	Cd	0.00026	0.00028	0.00026	0.00026	0.00029	0.00026	0.00027	0.00030	0.00027	0.00028	0.00031	0.00028			0.00033 [B]	Tier II	0.000023[a]	0.000047[a]
Q30	POLISHING POND OUTFLOW	Cr	0.0049	0.0053	0.0048	0.0049	0.0053	0.0049	0.0049	0.0053	0.0049	0.0049	0.0053	0.0049			0.10331 [C]	Tier II	0.0089	0.0089
Q30	POLISHING POND OUTFLOW	Co	0.00329	0.00364	0.00326	0.00329	0.00365	0.00328	0.00332	0.00367	0.00329	0.00335	0.00368	0.00329						
Q30	POLISHING POND OUTFLOW	Cu	0.0118	0.0130	0.0117	0.0120	0.0132	0.0119	0.0122	0.0134	0.0121	0.0125	0.0137	0.0123	0.3	0.6	0.01266 [D]	Tier II	0.002[b]	0.00334[b]
Q30	POLISHING POND OUTFLOW	Fe	0.703	0.776	0.691	0.702	0.776	0.692	0.705	0.778	0.693	0.709	0.778	0.691				0.3	0.3	0.3
Q30	POLISHING POND OUTFLOW	Pb	0.00238	0.00268	0.00247	0.00253	0.00284	0.00262	0.00269	0.00301	0.00277	0.00285	0.00318	0.00290	0.2	0.4	0.0039 [E]	Tier II	0.00184[c]	0.00533[c]
Q30	POLISHING POND OUTFLOW	Mo	0.0047	0.0052	0.0048	0.0049	0.0054	0.0050	0.0051	0.0056	0.0051	0.0053	0.0058	0.0053				0.073		
Q30	POLISHING POND OUTFLOW	Ni	0.162	0.178	0.158	0.162	0.179	0.159	0.163	0.180	0.160	0.165	0.180	0.160	0.5	1	0.07329 [F]	Tier II	0.06889[d]	0.13007[d]
Q30	POLISHING POND OUTFLOW	Se	0.0025	0.0029	0.0027	0.0026	0.0029	0.0027	0.0026	0.0029	0.0027	0.0026	0.0029	0.0027				0.001	0.001	0.001
Q30	POLISHING POND OUTFLOW	Zn	0.016	0.017	0.016	0.016	0.018	0.017	0.017	0.019	0.018	0.018	0.019	0.018	0.5	1	0.16657 [G]	Tier II	0.03	0.03
Q34	MINAGO DOWNSTREAM	Al	0.051	0.034	0.044	0.051	0.035	0.044	0.051	0.035	0.045	0.052	0.035	0.045				0.005 - 0.1	0.005 - 0.1	0.005 - 0.1
Q34	MINAGO DOWNSTREAM	Sb	0.00037	0.00025	0.00034	0.00038	0.00025	0.00034	0.00038	0.00025	0.00035	0.00039	0.00025	0.00035						
Q34	MINAGO DOWNSTREAM	As	0.0009	0.0008	0.0009	0.0009	0.0008	0.0009	0.0009	0.0008	0.0009	0.0010	0.0008	0.0009	0.5	1	0.15 mg/L (4-Day, 3-Year) [A]	Tier II	0.005	0.005
Q34	MINAGO DOWNSTREAM	Cd	0.000079	0.000054	0.000070	0.000081	0.000055	0.000071	0.000083	0.000056	0.000073	0.000086	0.000057	0.000074			0.00033 [B]	Tier II	0.000023[a]	0.000047[a]
Q34	MINAGO DOWNSTREAM	Cr	0.00143	0.00092	0.00125	0.00143	0.00092	0.00126	0.00144	0.00093	0.00126	0.00146	0.00094	0.00127			0.10331 [C]	Tier II	0.0089	0.0089
Q34	MINAGO DOWNSTREAM	Co	0.00089	0.00054	0.00076	0.00089	0.00055	0.00076	0.00090	0.00055	0.00077	0.00092	0.00055	0.00077						
Q34	MINAGO DOWNSTREAM	Cu	0.003	0.002	0.003	0.004	0.002	0.003	0.004	0.002	0.003	0.004	0.002	0.003	0.3	0.6	0.01266 [D]	Tier II	0.002[b]	0.00334[b]
Q34	MINAGO DOWNSTREAM	Fe	0.234	0.167	0.207	0.234	0.167	0.207	0.235	0.167	0.208	0.237	0.168	0.208				0.3	0.3	0.3
Q34	MINAGO DOWNSTREAM	Pb	0.00066	0.00042	0.00059	0.00070	0.00044	0.00062	0.00074	0.00047	0.00066	0.00079	0.00049	0.00069	0.2	0.4	0.0039 [E]	Tier II	0.00184[c]	0.00533[c]
Q34	MINAGO DOWNSTREAM	Mo	0.00132	0.00082	0.00116	0.00136	0.00085	0.00120	0.00141	0.00088	0.00124	0.00148	0.00091	0.00128				0.073		
Q34	MINAGO DOWNSTREAM	Ni	0.043	0.025	0.036	0.043	0.026	0.036	0.043	0.026	0.036	0.044	0.026	0.036	0.5	1	0.07329 [F]	Tier II	0.06889[d]	0.13007[d]
Q34	MINAGO DOWNSTREAM	Se	0.00084	0.00061	0.00078	0.00084	0.00061	0.00079	0.00085	0.00061	0.00079	0.00087	0.00062	0.00080				0.001	0.001	0.001
Q34	MINAGO DOWNSTREAM	Zn	0.005	0.003	0.004	0.005	0.003	0.005	0.005	0.003	0.005	0.005	0.004	0.005	0.5	1	0.16657 [G]	Tier II	0.03	0.03

Notes: Footnotes A to G and a to d, pertaining to the regulations, are the same as given below in Table 2.14-8.

Table 2.14-13 Projected Effluent Concentrations in Site Flows during Year 9 and Year 10 Operations

SCENARIO:		WATER QUALITY	ESTIMATED AVERAGE CONCENTRATION — Year 9: Tailings only; max.tailings leaching rate	Year 9: Tailings only; max.tailings leaching rate	Year 9: Tailings only; max.tailings leaching rate	Year 10: Tailings only; max.tailings leaching rate	REGULATIONS — Metal Mining Liquid Effluent Regulations (2002, last amended in 2012)		Manitoba Water Quality Standards, Objectives, and Guidelines (Manitoba Water Stewardship, 2011)		Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2011)	
FLOW		PARAM.	NOVEMBER TO APRIL (mg/L)	MAY (mg/L)	JUNE TO OCTOBER (mg/L)	NOVEMBER TO APRIL (mg/L)	Monthly Mean	Grab Sample	TIER II Water Quality Objectives assuming hardness = 150 mg/L $CaCO_3$	Freshwater	assuming hardness = 65 mg/L $CaCO_3$	assuming hardness = 150 mg/L $CaCO_3$
Q30	POLISHING POND OUTFLOW	Al	0.165	0.179	0.160	0.166				0.005 - 0.1	0.005 - 0.1	0.005 - 0.1
Q30	POLISHING POND OUTFLOW	Sb	0.00134	0.00152	0.00140	0.00135						
Q30	POLISHING POND OUTFLOW	As	0.002	0.002	0.002	0.002	0.5	1	0.15 mg/L (4-Day, 3-Year) [A]	Tier II	0.005	0.005
Q30	POLISHING POND OUTFLOW	Cd	0.00028	0.00031	0.00028	0.00029			0.00033 [B]	Tier II	0.000023[a]	0.000047[a]
Q30	POLISHING POND OUTFLOW	Cr	0.0049	0.0053	0.0049	0.005			0.10331 [C]	Tier II	0.0089	0.0089
Q30	POLISHING POND OUTFLOW	Co	0.00333	0.00366	0.00329	0.00336						
Q30	POLISHING POND OUTFLOW	Cu	0.0126	0.0138	0.0124	0.01278	0.3	0.6	0.01266 [D]	Tier II	0.002[b]	0.00334[b]
Q30	POLISHING POND OUTFLOW	Fe	0.705	0.773	0.688	0.708				0.3	0.3	0.3
Q30	POLISHING POND OUTFLOW	Pb	0.00298	0.00332	0.00304	0.00310	0.2	0.4	0.0039 [E]	Tier II	0.00184[c]	0.00533[c]
Q30	POLISHING POND OUTFLOW	Mo	0.0054	0.0059	0.0054	0.0055				0.073		
Q30	POLISHING POND OUTFLOW	Ni	0.165	0.180	0.160	0.166	0.5	1	0.07329 [F]	Tier II	0.06889[d]	0.13007[d]
Q30	POLISHING POND OUTFLOW	Se	0.0026	0.0029	0.0027	0.0026				0.001	0.001	0.001
Q30	POLISHING POND OUTFLOW	Zn	0.019	0.020	0.019	0.019	0.5	1	0.16657 [G]	Tier II	0.03	0.03
Q34	MINAGO DOWNSTREAM	Al	0.052	0.035	0.045	0.053				0.005 - 0.1	0.005 - 0.1	0.005 - 0.1
Q34	MINAGO DOWNSTREAM	Sb	0.00039	0.00025	0.00035	0.00040						
Q34	MINAGO DOWNSTREAM	As	0.0010	0.0008	0.0009	0.0010	0.5	1	0.15 mg/L (4-Day, 3-Year) [A]	Tier II	0.005	0.005
Q34	MINAGO DOWNSTREAM	Cd	0.000087	0.000058	0.000076	0.000089			0.00033 [B]	Tier II	0.000023[a]	0.000047[a]
Q34	MINAGO DOWNSTREAM	Cr	0.00146	0.00093	0.00127	0.00148			0.10331 [C]	Tier II	0.0089	0.0089
Q34	MINAGO DOWNSTREAM	Co	0.00091	0.00055	0.00077	0.00093						
Q34	MINAGO DOWNSTREAM	Cu	0.004	0.002	0.003	0.004	0.3	0.6	0.01266 [D]	Tier II	0.002[b]	0.00334[b]
Q34	MINAGO DOWNSTREAM	Fe	0.236	0.167	0.208	0.239				0.3	0.3	0.3
Q34	MINAGO DOWNSTREAM	Pb	0.00083	0.00051	0.00072	0.00086	0.2	0.4	0.0039 [E]	Tier II	0.00184[c]	0.00533[c]
Q34	MINAGO DOWNSTREAM	Mo	0.00152	0.00093	0.00132	0.00156				0.073		
Q34	MINAGO DOWNSTREAM	Ni	0.044	0.026	0.037	0.045	0.5	1	0.07329 [F]	Tier II	0.06889[d]	0.13007[d]
Q34	MINAGO DOWNSTREAM	Se	0.00087	0.00062	0.00080	0.00088				0.001	0.001	0.001
Q34	MINAGO DOWNSTREAM	Zn	0.00563	0.00366	0.00499	0.00580	0.5	1	0.16657 [G]	Tier II	0.03	0.03

Notes: Footnotes A to G and a to d, pertaining to the regulations, are the same as given below in Table 2.14-8..

The projected outflow from the Polishing Pond meets MMER requirements at all times. Projected results for the Polishing Pond outflow range from 0.001 to 0.002 mg/L for As, from 0.001 to 0.014 mg/L for Cu, from 0.000 to 0.003 mg/L for Pb, from 0.001 to 0.018 mg/L for Ni, and from 0.005 to 0.020 mg/L for Zn.

2.14.2.3.2 Water Balance Results during Closure

Estimated flowrates during the first and second stages of the closure period are listed in Table 2.14-14. The water balance during the first stage of Closure is illustrated in Table 2.14-14 and the second stage of Closure is illustrated in Table 2.14-14

During the first stage of Closure, a water cover will be installed on top of the TWRMF and no discharges to the receiving environment will occur from the TWRMF nor from the pipeline discharge system. During the second stage of Closure (after installation of the 1.5 m water cover on the top of the TWRMF), the Polishing Pond discharge to Minago River (Q32) in relation to the Minago River streamflow (Q33) will be 0-3%.

Table 2.14-15 presents projected parametric concentrations during the two stages of Closure for the Polishing Pond outflow (Q30) and Minago downstream (Q34). Additional results for Q26 (TWRMF Inflow), Q27 (TWRMF Decant), Q29 (Polishing Pond Inflow) are given in Appendix 2.14.

During the first and second stages of Closure, the projected outflow from the Polishing Pond will meet MMER requirements at all times. During both stages of Closure, the projected water quality in Minago River downstream of the mixing zones meets the Manitoba Freshwater guidelines for the protection of aquatic life for all parameters.

2.14.2.3.3 Water Balance Results during Post Closure

During the Post Closure period, the discharge pipeline system to Minago River will have been dismantled and excess water from the TWRMF (Q27 = TWRMF Decant) will be discharged via a spillway to the Polishing Pond for subsequent discharge to the receiving. The active and inactive water balance components during the Post Closure period are illustrated in Table 2.14-16.

Projected flowrates during the post closure period are listed in Table 2.14-14. Projected Polishing Pond outflow rates range from 0 m^3/day in the winter months (Nov. to Apr.) to 16,170 m^3/day in the period from June to October.

Table 2.14-14 Projected Flow Rates during Closure Stages

		Year 10		Year 11		
		Closure (Stage 1)		Closure (Stage 2)		
		Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate
		MAY	JUNE TO OCTOBER	NOVEMBER TO APRIL	MAY	JUNE TO OCTOBER
	FLOW	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day
UNIT EVAPORATION	UNIT LAKE EVAPORATION	18	14	0	18	14
UNIT PPT (U-PPT)	UNIT PRECIPITATION	41	21	0	41	21
Q1	FLOW FROM DEWATERING WELLS	31,999	25,104	15	15	15
Q2	WELL WATER FOR PROCESSING	15	15	15	15	15
Q3	EXCESS WATER FROM DEWATERING WELLS	31,984	25,089	0	0	0
Q4	GROUNDWATER TO OTHER OPERATIONS	0	0	0	0	0
Q5	GROUNDWATER TO WATER TREATMENT	15	15	15	15	15
Q6	GROUNDWATER TO FRAC SAND PLANT	0	0	0	0	0
Q7	GROUNDWATER FOR FIRE FIGHTING	0	0	0	0	0
Q8	POTABLE WATER	15	15	15	15	15
Q9	WATER TREATMENT PLANT WASTE	0	0	0	0	0
Q10	RECYCLE WATER FROM FPP	0	0	0	0	0
Q11	POTABLE WATER TO MILL	0	0	0	0	0
Q12	POTABLE WATER TO OTHER OPERATIONS	0	0	0	0	0
Q13	POTABLE WATER TO OFFICES & CAMP	15	15	15	15	15
Q14	POTABLE WATER TO FRAC SAND PLANT	0	0	0	0	0
Q15	FLOW FROM OPERATIONS TO MILL	0	0	0	0	0
Q16	SEWAGE & GREY WATER FROM CAMP AND OFFICES	15	15	15	15	15
Q17	SEWAGE & GREY WATER FROM ALL OTHER ON SITE SOURCES	0	0	0	0	0
Q19	FLOW FROM CONCENTRATE THICKENER IN MILL TO MILL	0	0	0	0	0
Q20	FLOW FROM MILL TO MILL THICKENER	0	0	0	0	0
Q21	RECYCLE WATER FROM MILL THICKENER	0	0	0	0	0
Q21x	ATERNATE FLOW FOR RECYCLE WATER FROM MILL THICKENER	0	0	0	0	0
Q22	MILL TAILINGS SLURRY	0	0	0	0	0
Q23	SEWAGE TREATMENT OUTFLOW	595	22	0	125	22
Q24	LIQ. WASTE FROM FSP	0	0	0	0	0
Q25	SLURRY FROM FSP	0	0	0	0	0
Q26	TWRMF INFLOW	32,579	25,111	0	125	22
Q - Liquid PPT on TWRMF	PPT on TWRMF	24,186	12,711	0	24,186	12,711
Q - Retained Water in Tailings Voids	Q - Retained Water in Tailings Voids	0	0	0	0	0
Q - TWRMF Supernatant	TWRMF Supernatant	141,984	57,967	49,583	301,465	62,252
Q27	TWRMF Decant	0	13	0	13,562	4,297
Q - Pit Dewatering	OPEN PIT DEWATERING	0	0	0	0	0
Q - Precipitation on Pit	Precipitation minus Sublimation on Open Pit	7,723	4,059	0	7,723	4,059
Q28	TOT. OPEN PIT DEWATERING	0	0	0	0	0
Q29	POLISHING POND INFLOW	77,979	13	0	13,562	4,297
Q - Precipitation on Polishing Pond	Precipitation minus Sublimation ON POLISHING POND	4,878	2,564	0	4,878	2,564
Q - Evaporation from Polishing Pond	EVAPORATION FROM POLISHING POND	2,168	1,701	0	2,168	1,701
Q30	POLISHING POND OUTFLOW	80,689	875	0	16,272	5,159
Q31	RECYCLE FROM FINAL POLISHING POND	0	0	0	0	0
Q32	DISCHARGE PIPELINE	80,689	875	0	16,272	5,159
Q32	DISCHARGE TO MINAGO	80,689	875	0	16,272	5,159
Q33	MINAGO UPSTREAM	864,000	164,160	69,120	864,000	164,160
Q34	MINAGO DOWNSTREAM	944,689	165,035	69,120	880,272	169,319

FLOW RATIOS:

Q32 / Q33	RATIO OF DISCHARGE TO MINAGO TO FLOW IN MINAGO	9%	1%	0%	2%	3%

Table 2.14-15 Projected Concentrations in Flows around the Minago Mine Site during Closure Stages

SCENARIO: FLOW		WATER QUALITY PARAM.	Closure (Stage 1) Tailings only; max.tailings leaching rate MAY (mg/L)	Closure (Stage 1) Tailings only; max.tailings leaching rate JUNE TO OCTOBER (mg/L)	Closure (Stage 2) Tailings only; max.tailings leaching rate NOVEMBER TO APRIL (mg/L)	Closure (Stage 2) Tailings only; max.tailings leaching rate MAY (mg/L)	Closure (Stage 2) Tailings only; max.tailings leaching rate JUNE TO OCTOBER (mg/L)	REGULATIONS: Metal Mining Liquid Effluent Regulations (2002, last amended in 2012) Monthly Mean	Metal Mining Liquid Effluent Regulations (2002, last amended in 2012) Grab Sample	Manitoba Water Quality Standards, Objectives, and Guidelines (Manitoba Water Stewardship, 2011): TIER II Water Quality Objectives assuming hardness = 150 mg/L $CaCO_3$	Manitoba Water Quality Standards, Objectives, and Guidelines (Manitoba Water Stewardship, 2011): Freshwater	Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2011): assuming hardness = 65 mg/L $CaCO_3$	Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2011): assuming hardness = 150 mg/L $CaCO_3$
Q30	POLISHING POND OUTFLOW	Al	0.161	0.018	0.000	0.170	0.169				0.005 - 0.1	0.005 - 0.1	0.005 - 0.1
Q30	POLISHING POND OUTFLOW	Sb	0.00134	0.00149	0.00000	0.00168	0.00182						
Q30	POLISHING POND OUTFLOW	As	0.002	0.002	0.000	0.003	0.003	0.5	1	0.15 mg/L (4-Day, 3-Year) [A]	Tier II	0.005	0.005
Q30	POLISHING POND OUTFLOW	Cd	0.00028	0.00006	0.00000	0.00038	0.00041			0.00033 [B]	Tier II	0.000023[a]	0.000047[a]
Q30	POLISHING POND OUTFLOW	Cr	0.0048	0.0030	0.000	0.005	0.005			0.10331 [C]	Tier II	0.0089	0.0089
Q30	POLISHING POND OUTFLOW	Co	0.00326	0.00094	0.00000	0.00332	0.00328						
Q30	POLISHING POND OUTFLOW	Cu	0.0124	0.0032	0.00000	0.01525	0.01588	0.3	0.6	0.01266 [D]	Tier II	0.002[b]	0.00334[b]
Q30	POLISHING POND OUTFLOW	Fe	0.686	0.100	0.000	0.652	0.622				0.3	0.3	0.3
Q30	POLISHING POND OUTFLOW	Pb	0.00302	0.00154	0.00000	0.00555	0.00631	0.2	0.4	0.0039 [E]	Tier II	0.00184[c]	0.00533[c]
Q30	POLISHING POND OUTFLOW	Mo	0.0054	0.0030	0.0000	0.0084	0.0094				0.073		
Q30	POLISHING POND OUTFLOW	Ni	0.160	0.006	0.000	0.160	0.154	0.5	1	0.07329 [F]	Tier II	0.06889[d]	0.13007[d]
Q30	POLISHING POND OUTFLOW	Se	0.0026	0.0030	0.0000	0.0032	0.0035				0.001	0.001	0.001
Q30	POLISHING POND OUTFLOW	Zn	0.019	0.015	0.000	0.031	0.035	0.5	1	0.16657 [G]	Tier II	0.03	0.03
Q34	MINAGO DOWNSTREAM	Al	0.025	0.012	0.012	0.015	0.017				0.005 - 0.1	0.005 - 0.1	0.005 - 0.1
Q34	MINAGO DOWNSTREAM	Sb	0.00016	0.00006	0.00005	0.00008	0.00010						
Q34	MINAGO DOWNSTREAM	As	0.0007	0.0006	0.0006	0.0006	0.0007	0.5	1	0.15 mg/L (4-Day, 3-Year) [A]	Tier II	0.005	0.005
Q34	MINAGO DOWNSTREAM	Cd	0.000039	0.000017	0.000017	0.000024	0.000029			0.00033 [B]	Tier II	0.000023[a]	0.000047[a]
Q34	MINAGO DOWNSTREAM	Cr	0.00062	0.00024	0.00023	0.00032	0.00038			0.10331 [C]	Tier II	0.0089	0.0089
Q34	MINAGO DOWNSTREAM	Co	0.00032	0.00005	0.00005	0.00011	0.00015						
Q34	MINAGO DOWNSTREAM	Cu	0.002	0.001	0.001	0.001	0.001	0.3	0.6	0.01266 [D]	Tier II	0.002[b]	0.00334[b]
Q34	MINAGO DOWNSTREAM	Fe	0.122	0.069	0.069	0.080	0.086				0.3	0.3	0.3
Q34	MINAGO DOWNSTREAM	Pb	0.00031	0.00007	0.00006	0.00016	0.00025	0.2	0.4	0.0039 [E]	Tier II	0.00184[c]	0.00533[c]
Q34	MINAGO DOWNSTREAM	Mo	0.00058	0.00014	0.00013	0.00028	0.00041				0.073		
Q34	MINAGO DOWNSTREAM	Ni	0.015	0.001	0.001	0.004	0.006	0.5	1	0.07329 [F]	Tier II	0.06889[d]	0.13007[d]
Q34	MINAGO DOWNSTREAM	Se	0.00045	0.00026	0.00024	0.00030	0.00034				0.001	0.001	0.001
Q34	MINAGO DOWNSTREAM	Zn	0.00252	0.00107	0.00100	0.00155	0.00204	0.5	1	0.16657 [G]	Tier II	0.03	0.03

Notes: Footnotes A to G and a to d, pertaining to the regulations, are the same as given in Table 2.14-8.

Table 2.14-16 Projected Flow Rates during Post Closure

FLOW		Year 12			Year 13			Year 14		
		Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate
		NOVEMBER TO APRIL	MAY	JUNE TO OCTOBER	NOVEMBER TO APRIL	MAY	JUNE TO OCTOBER	NOVEMBER TO APRIL	MAY	JUNE TO OCTOBER
		m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day
UNIT EVAPORATION	UNIT LAKE EVAPORATION	0	18	14	0	18	14	0	18	14
UNIT PPT (U-PPT)	UNIT PRECIPITATION	0	41	21	0	41	21	0	41	21
Q1	FLOW FROM DEWATERING WELLS	0	0	0	0	0	0	0	0	0
Q2	WELL WATER FOR PROCESSING	0	0	0	0	0	0	0	0	0
Q3	EXCESS WATER FROM DEWATERING WELLS	0	0	0	0	0	0	0	0	0
Q4	GROUNDWATER TO OTHER OPERATIONS	0	0	0	0	0	0	0	0	0
Q5	GROUNDWATER TO WATER TREATMENT	0	0	0	0	0	0	0	0	0
Q6	GROUNDWATER TO FRAC SAND PLANT	0	0	0	0	0	0	0	0	0
Q7	GROUNDWATER FOR FIRE FIGHTING	0	0	0	0	0	0	0	0	0
Q8	POTABLE WATER	0	0	0	0	0	0	0	0	0
Q9	WATER TREATMENT PLANT WASTE	0	0	0	0	0	0	0	0	0
Q10	RECYCLE WATER FROM FPP	0	0	0	0	0	0	0	0	0
Q11	POTABLE WATER TO MILL	0	0	0	0	0	0	0	0	0
Q12	POTABLE WATER TO OTHER OPERATIONS	0	0	0	0	0	0	0	0	0
Q13	POTABLE WATER TO OFFICES & CAMP	0	0	0	0	0	0	0	0	0
Q14	POTABLE WATER TO FRAC SAND PLANT	0	0	0	0	0	0	0	0	0
Q15	FLOW FROM OPERATIONS TO MILL	0	0	0	0	0	0	0	0	0
Q16	SEWAGE & GREY WATER FROM CAMP AND OFFICES	0	0	0	0	0	0	0	0	0
Q17	SEWAGE & GREY WATER FROM ALL OTHER ON SITE SOURCES	0	0	0	0	0	0	0	0	0
Q19	FLOW FROM CONCENTRATE THICKENER IN MILL TO MILL	0	0	0	0	0	0	0	0	0
Q20	FLOW FROM MILL TO MILL THICKENER	0	0	0	0	0	0	0	0	0
Q21	RECYCLE WATER FROM MILL THICKENER	0	0	0	0	0	0	0	0	0
Q21x	ATERNATE FLOW FOR RECYCLE WATER FROM MILL THICKENER	0	0	0	0	0	0	0	0	0
Q22	MILL TAILINGS SLURRY	0	0	0	0	0	0	0	0	0
Q23	SEWAGE TREATMENT OUTFLOW	0	23	7	0	23	7	0	23	7
Q24	LIQ. WASTE FROM FSP	0	0	0	0	0	0	0	0	0
Q25	SLURRY FROM FSP	0	0	0	0	0	0	0	0	0
Q26	TWRMF INFLOW	0	23	7	0	23	7	0	23	7
Q - Liquid PPT on TWRMF	PPT on TWRMF	0	24,186	12,711	0	24,186	12,711	0	24,186	12,711
Q - Retained Water in Tailings Voids	Q - Retained Water in Tailings Voids	0	0	0	0	0	0	0	0	0
Q - TWRMF Supernatant	TWRMF Supernatant	49,583	301,363	62,237	49,583	301,363	62,237	49,583	301,363	62,237
Q27	TWRMF Decant	0	13,460	4,282	0	13,460	4,282	0	13,460	4,282
Q - Pit Dewatering	OPEN PIT DEWATERING	0	0	0	0	0	0	0	0	0
Q - Precipitation on Pit	Precipitation minus Sublimation on Open Pit	0	7,723	4,059	0	7,723	4,059	0	7,723	4,059
Q28	TOT. OPEN PIT DEWATERING	0	0	0	0	0	0	0	0	0
Q29	POLISHING POND INFLOW	0	13,460	4,282	0	13,460	4,282	0	13,460	4,282
Q - Precipitation on Polishing Pond	Precipitation minus Sublimation ON POLISHING POND	0	4,878	2,564	0	4,878	2,564	0	4,878	2,564
Q - Evaporation from Polishing Pond	EVAPORATION FROM POLISHING POND	0	2,168	1,701	0	2,168	1,701	0	2,168	1,701
Q30	POLISHING POND OUTFLOW	0	16,170	5,144	0	16,170	5,144	0	16,170	5,144
Q31	RECYCLE FROM FINAL POLISHING POND	0	0	0	0	0	0	0	0	0
Q32	DISCHARGE TO MINAGO	0	16,170	5,144	0	16,170	5,144	0	16,170	5,144
Q33	MINAGO UPSTREAM	69,120	864,000	164,160	69,120	864,000	164,160	69,120	864,000	164,160
Q34	MINAGO DOWNSTREAM	69,120	880,170	169,304	69,120	880,170	169,304	69,120	880,170	169,304

FLOW RATIOS:

Q32 / Q33	RATIO OF DISCHARGE TO MINAGO TO FLOW IN MINAGO	0%	2%	3%	0%	2%	3%	0%	2%	3%

The projected parametric concentrations for the Polishing Pond outflow (Q30) and Minago downstream (Q34) are given in Figure 2.14-17. Additional results for Q26 (TWRMF Inflow), Q27 (TWRMF Decant), Q29 (Polishing Pond Inflow) are given in Appendix 2.14.

During the Post Closure, the projected outflow from the Polishing Pond will meet MMER requirements at all times and the projected water quality in Minago River downstream of the mixing zones will meet the Manitoba Freshwater guidelines for the protection of aquatic life for all parameters.

2.14.2.3.4 Water Balance Modeling Results during Temporary Suspension and a State of Inactivity

Estimated flowrates during Temporary Suspension and the State of Inactivity are listed Table 2.14-18 and the corresponding water management diagrams are shown in Figures 2.14-6 and Figure 2.14-7 respectively.

During the Temporary Suspension of operations, the Polishing Pond discharge to Minago River (Q32) in relation to the Minago River streamflow (Q33) will be 17% in May, 30% in the summer months (June to October) and 38% in the winter months (November to April). In absolute quantities, discharge to Minago River will range from approximately 26,000 m^3/day to 144,100 m^3/day during the Temporary Suspension of operations.

During the State of Inactivity, the projected Polishing Pond discharge to Minago River (Q32) in relation to the Minago River streamflow (Q32) will be 0% in the winter months (Nov. to Apr.), 2% in May, and 3% in the summer months (June to October). In absolute quantities, discharge to Minago River is projected to range from 0 m^3/day to 16,190 m^3/day during the State of Inactivity.

Table 2.14-19 presents projected parametric concentrations for the Polishing Pond outflow (Q30) and Minago downstream (Q34) during Temporary Suspension and the State of Inactivity. Additional results for Q26 (TWRMF Inflow), Q27 (TWRMF Decant), and Q29 (Polishing Pond Inflow) are given in Appendix 2.14.

During Temporary Suspension, the projected outflow from the Polishing Pond will meet MMER requirements at all times. During Temporary Suspension, the projected water quality in Minago

Table 2.14-17 Projected Concentrations in Flows around the Minago Site during Post Closure

SCENARIO:			ESTIMATED AVERAGE CONCENTRATION									REGULATIONS					
			Year 12 (Post Closure)			Year 13 (Post Closure)			Year 14 (Post Closure)			Metal Mining Liquid Effluent Regulations (2002, last amended in 2012)		Manitoba Water Quality Standards, Objectives, and Guidelines (Manitoba Water Stewardship, 2011)		Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2011)	
			Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate						
FLOW		WATER QUALITY PARAM.	NOVEMBER TO APRIL (mg/L)	MAY (mg/L)	JUNE TO OCTOBER (mg/L)	NOVEMBER TO APRIL (mg/L)	MAY (mg/L)	JUNE TO OCTOBER (mg/L)	NOVEMBER TO APRIL (mg/L)	MAY (mg/L)	JUNE TO OCTOBER (mg/L)	Monthly Mean	Grab Sample	TIER II Water Quality Objectives assuming hardness = 150 mg/L $CaCO_3$	Freshwater	assuming hardness = 65 mg/L $CaCO_3$	assuming hardness = 150 mg/L $CaCO_3$
Q30	POLISHING POND OUTFLOW	Al	0.000	0.173	0.171	0.000	0.175	0.173	0.000	0.177	0.175				0.005 - 0.1	0.005 - 0.1	0.005 - 0.1
Q30	POLISHING POND OUTFLOW	Sb	0.00000	0.00178	0.00192	0.00000	0.00188	0.00202	0.00000	0.00197	0.00210						
Q30	POLISHING POND OUTFLOW	As	0.000	0.004	0.004	0.000	0.004	0.005	0.000	0.005	0.005	0.5	1	0.15 mg/L (4-Day, 3-Year) [A]	Tier II	0.005	0.005
Q30	POLISHING POND OUTFLOW	Cd	0.00000	0.00045	0.00047	0.00000	0.00051	0.00053	0.00000	0.00057	0.00058			0.00033 [B]	Tier II	0.000023[a]	0.000047[a]
Q30	POLISHING POND OUTFLOW	Cr	0.0000	0.0051	0.0052	0.000	0.005	0.005	0.000	0.005	0.005			0.10331 [C]	Tier II	0.0089	0.0089
Q30	POLISHING POND OUTFLOW	Co	0.00000	0.00320	0.00317	0.00000	0.00310	0.00307	0.00000	0.00300	0.00299						
Q30	POLISHING POND OUTFLOW	Cu	0.0000	0.0169	0.0174	0.00000	0.01838	0.01881	0.00000	0.01971	0.02005	0.3	0.6	0.01266 [D]	Tier II	0.002[b]	0.00334[b]
Q30	POLISHING POND OUTFLOW	Fe	0.000	0.596	0.570	0.000	0.546	0.524	0.000	0.502	0.483				0.3	0.3	0.3
Q30	POLISHING POND OUTFLOW	Pb	0.00000	0.00731	0.00795	0.00000	0.00888	0.00941	0.00000	0.01028	0.01072	0.2	0.4	0.0039 [E]	Tier II	0.00184[c]	0.00533[c]
Q30	POLISHING POND OUTFLOW	Mo	0.0000	0.0104	0.0112	0.0000	0.0122	0.0129	0.0000	0.0139	0.0144				0.073		
Q30	POLISHING POND OUTFLOW	Ni	0.000	0.154	0.149	0.000	0.149	0.144	0.000	0.144	0.140	0.5	1	0.07329 [F]	Tier II	0.06889[d]	0.13007[d]
Q30	POLISHING POND OUTFLOW	Se	0.0000	0.0034	0.0037	0.0000	0.0036	0.0039	0.0000	0.0038	0.0040				0.001	0.001	0.001
Q30	POLISHING POND OUTFLOW	Zn	0.000	0.039	0.043	0.000	0.047	0.050	0.000	0.054	0.056	0.5	1	0.16657 [G]	Tier II	0.03	0.03
Q34	MINAGO DOWNSTREAM	Al	0.012	0.015	0.017	0.012	0.015	0.017	0.012	0.015	0.017				0.005 - 0.1	0.005 - 0.1	0.005 - 0.1
Q34	MINAGO DOWNSTREAM	Sb	0.00005	0.00008	0.00011	0.00005	0.00008	0.00011	0.00005	0.00008	0.00011						
Q34	MINAGO DOWNSTREAM	As	0.0006	0.0007	0.0007	0.0006	0.0007	0.0007	0.0006	0.0007	0.0007	0.5	1	0.15 mg/L (4-Day, 3-Year) [A]	Tier II	0.005	0.005
Q34	MINAGO DOWNSTREAM	Cd	0.000017	0.000025	0.000031	0.000017	0.000026	0.000032	0.000017	0.000027	0.000034			0.00033 [B]	Tier II	0.000023[a]	0.000047[a]
Q34	MINAGO DOWNSTREAM	Cr	0.00023	0.00032	0.00038	0.00023	0.00032	0.00038	0.00023	0.00032	0.00038			0.10331 [C]	Tier II	0.0089	0.0089
Q34	MINAGO DOWNSTREAM	Co	0.00005	0.00011	0.00014	0.00005	0.00011	0.00014	0.00005	0.00010	0.00014						
Q34	MINAGO DOWNSTREAM	Cu	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.3	0.6	0.01266 [D]	Tier II	0.002[b]	0.00334[b]
Q34	MINAGO DOWNSTREAM	Fe	0.069	0.079	0.084	0.069	0.078	0.083	0.069	0.077	0.082				0.3	0.3	0.3
Q34	MINAGO DOWNSTREAM	Pb	0.00006	0.00019	0.00030	0.00006	0.00022	0.00034	0.00006	0.00025	0.00038	0.2	0.4	0.0039 [E]	Tier II	0.00184[c]	0.00533[c]
Q34	MINAGO DOWNSTREAM	Mo	0.00013	0.00032	0.00047	0.00013	0.00035	0.00052	0.00013	0.00038	0.00056				0.073		
Q34	MINAGO DOWNSTREAM	Ni	0.001	0.004	0.006	0.001	0.004	0.005	0.001	0.004	0.005	0.5	1	0.07329 [F]	Tier II	0.06889[d]	0.13007[d]
Q34	MINAGO DOWNSTREAM	Se	0.00024	0.00030	0.00035	0.00024	0.00031	0.00036	0.00024	0.00031	0.00036				0.001	0.001	0.001
Q34	MINAGO DOWNSTREAM	Zn	0.00100	0.00170	0.00228	0.00100	0.00184	0.00249	0.00100	0.00197	0.00268	0.5	1	0.16657 [G]	Tier II	0.03	0.03

Notes: Footnotes A to G and a to d, pertaining to the regulations, are the same as given in Table 2.14-8

Table 2.14-18 Projected Flow Rates during Temporary Suspension and State of Inactivity

FLOW		Temporary Suspension (TS) assumed after Year 5			State of Inactivity (SI) assumed after one year of TS		
		Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate	Tailings only; max.tailings leaching rate
		NOVEMBER TO APRIL	MAY	JUNE TO OCTOBER	NOVEMBER TO APRIL	MAY	JUNE TO OCTOBER
		m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day
UNIT EVAPORATION	UNIT LAKE EVAPORATION	0	18	14	0	18	14
UNIT PPT (U-PPT)	UNIT PRECIPITATION	0	41	21	0	41	21
Q1	FLOW FROM DEWATERING WELLS	31,999	31,999	31,999	3	3	3
Q2	WELL WATER FOR PROCESSING	6	6	6	3	3	3
Q3	EXCESS WATER FROM DEWATERING WELLS	31,993	31,993	31,993	0	0	0
Q4	GROUNDWATER TO OTHER OPERATIONS	0	0	0	0	0	0
Q5	GROUNDWATER TO WATER TREATMENT	6	6	6	3	3	3
Q6	GROUNDWATER TO FRAC SAND PLANT	0	0	0	0	0	0
Q7	GROUNDWATER FOR FIRE FIGHTING	0	0	0	0	0	0
Q8	POTABLE WATER	6	6	6	3	3	3
Q9	WATER TREATMENT PLANT WASTE	0	0	0	0	0	0
Q10	RECYCLE WATER FROM FPP	0	0	0	0	0	0
Q11	POTABLE WATER TO MILL	0	0	0	0	0	0
Q12	POTABLE WATER TO OTHER OPERATIONS	0	0	0	0	0	0
Q13	POTABLE WATER TO OFFICES & CAMP	6	6	6	3	3	3
Q14	POTABLE WATER TO FRAC SAND PLANT	0	0	0	0	0	0
Q15	FLOW FROM OPERATIONS TO MILL	0	0	0	0	0	0
Q16	SEWAGE & GREY WATER FROM CAMP AND OFFICES	6	6	6	3	3	3
Q17	SEWAGE & GREY WATER FROM ALL OTHER ON SITE SOURCES	0	0	0	0	0	0
Q19	FLOW FROM CONCENTRATE THICKENER IN MILL TO MILL	0	0	0	0	0	0
Q20	FLOW FROM MILL TO MILL THICKENER	0	0	0	0	0	0
Q21	RECYCLE WATER FROM MILL THICKENER	0	0	0	0	0	0
Q21x	ATERNATE FLOW FOR RECYCLE WATER FROM MILL THICKENER	0	0	0	0	0	0
Q22	MILL TAILINGS SLURRY	0	0	0	0	0	0
Q23	SEWAGE TREATMENT OUTFLOW	0	63	13	0	43	10
Q24	LIQ. WASTE FROM FSP	0	0	0	0	0	0
Q25	SLURRY FROM FSP	0	0	0	0	0	0
Q26	TWRMF INFLOW	0	63	13	0	43	10
Q - Liquid PPT on TWRMF	PPT on TWRMF	0	24,186	12,711	0	24,186	12,711
Q - Retained Water in Tailings Voids	Q - Retained Water in Tailings Voids	156	0	0	0	0	0
Q - TWRMF Supernatant	TWRMF Supernatant	16,342	108,388	23,606	16,528	109,448	23,603
Q27	TWRMF Decant	0	12,420	4,288	0	13,480	4,285
Q - Pit Dewatering	OPEN PIT DEWATERING	8,000	8,000	8,000	0	0	0
Q - Precipitation on Pit	Precipitation minus Sublimation on Open Pit	0	7,723	4,059	0	7,723	4,059
Q28	TOT. OPEN PIT DEWATERING	8,000	15,723	12,059	0	0	0
Q29	POLISHING POND INFLOW	39,993	141,413	48,341	0	13,480	4,285
Q - Precipitation on Polishing Pond	Precipitation minus Sublimation ON POLISHING POND	0	4,878	2,564	0	4,878	2,564
Q - Evaporation from Polishing Pond	EVAPORATION FROM POLISHING POND	0	2,168	1,701	0	2,168	1,701
Q30	POLISHING POND OUTFLOW	39,993	144,123	49,203	0	16,190	5,147
Q31	RECYCLE FROM FINAL POLISHING POND	0	0	0	0	0	0
Q32	DISCHARGE PIPELINE	25,996	144,123	49,203	0	16,190	5,147
Q32	DISCHARGE TO MINAGO	25,996	144,123	49,203	0	16,190	5,147
Q33	MINAGO UPSTREAM	69,120	864,000	164,160	69,120	864,000	164,160
Q34	MINAGO DOWNSTREAM	95,116	1,008,123	213,363	69,120	880,190	169,307

FLOW RATIOS:

Q32 / Q33	RATIO OF DISCHARGE TO MINAGO TO FLOW IN MINAGO	38%	17%	30%	0%	2%	3%

Table 2.14-19 Projected Effluent Concentrations in Flows during Temporary Suspension and the State of Inactivity

SCENARIO: FLOW		WATER QUALITY PARAM.	ESTIMATED AVERAGE CONCENTRATION: TS after Year 5: Tailings only; max.tailings leaching rate NOVEMBER TO APRIL (mg/L)	ESTIMATED AVERAGE CONCENTRATION: TS after Year 5: Tailings only; max.tailings leaching rate MAY (mg/L)	ESTIMATED AVERAGE CONCENTRATION: TS after Year 5: Tailings only; max.tailings leaching rate JUNE TO OCTOBER (mg/L)	ESTIMATED AVERAGE CONCENTRATION: SI after one year TS: Tailings only; max.tailings leaching rate NOVEMBER TO APRIL (mg/L)	ESTIMATED AVERAGE CONCENTRATION: SI after one year TS: Tailings only; max.tailings leaching rate MAY (mg/L)	ESTIMATED AVERAGE CONCENTRATION: SI after one year TS: Tailings only; max.tailings leaching rate JUNE TO OCTOBER (mg/L)	REGULATIONS: Metal Mining Liquid Effluent Regulations (2002, last amended in 2012) Monthly Mean	REGULATIONS: Metal Mining Liquid Effluent Regulations (2002, last amended in 2012) Grab Sample	REGULATIONS: Manitoba Water Quality Standards, Objectives, and Guidelines (Manitoba Water Stewardship, 2011): TIER II Water Quality Objectives assuming hardness = 150 mg/L $CaCO_3$	REGULATIONS: Manitoba Water Quality Standards, Objectives, and Guidelines (Manitoba Water Stewardship, 2011): Freshwater	REGULATIONS: Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2011): assuming hardness = 65 mg/L $CaCO_3$	REGULATIONS: Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2011): assuming hardness = 150 mg/L $CaCO_3$
Q30	POLISHING POND OUTFLOW	Al	0.009	0.046	0.041	0.000	0.293	0.255				0.005 - 0.1	0.005 - 0.1	0.005 - 0.1
Q30	POLISHING POND OUTFLOW	Sb	0.00003	0.00040	0.00040	0.00000	0.00298	0.00288						
Q30	POLISHING POND OUTFLOW	As	0.001	0.001	0.001	0.000	0.004	0.004	0.5	1	0.15 mg/L (4-Day, 3-Year) [A]	Tier II	0.005	0.005
Q30	POLISHING POND OUTFLOW	Cd	0.00001	0.00008	0.00007	0.00000	0.00064	0.00059			0.00033 [B]	Tier II	0.000023[a]	0.000047[a]
Q30	POLISHING POND OUTFLOW	Cr	0.0010	0.0020	0.0019	0.000	0.008	0.008			0.10331 [C]	Tier II	0.0089	0.0089
Q30	POLISHING POND OUTFLOW	Co	0.00008	0.00088	0.00078	0.00000	0.00592	0.00515						
Q30	POLISHING POND OUTFLOW	Cu	0.0005	0.0035	0.0033	0.00000	0.02567	0.02343	0.3	0.6	0.01266 [D]	Tier II	0.002[b]	0.00334[b]
Q30	POLISHING POND OUTFLOW	Fe	0.005	0.173	0.147	0.000	1.186	0.997				0.3	0.3	0.3
Q30	POLISHING POND OUTFLOW	Pb	0.00003	0.00085	0.00089	0.00000	0.00878	0.00879	0.2	0.4	0.0039 [E]	Tier II	0.00184[c]	0.00533[c]
Q30	POLISHING POND OUTFLOW	Mo	0.0007	0.0019	0.0019	0.0000	0.0133	0.0131				0.073		
Q30	POLISHING POND OUTFLOW	Ni	0.001	0.040	0.034	0.000	0.285	0.240	0.5	1	0.07329 [F]	Tier II	0.06889[d]	0.13007[d]
Q30	POLISHING POND OUTFLOW	Se	0.0002	0.0009	0.0009	0.0000	0.0056	0.0055				0.001	0.001	0.001
Q30	POLISHING POND OUTFLOW	Zn	0.005	0.008	0.009	0.000	0.047	0.048	0.5	1	0.16657 [G]	Tier II	0.03	0.03
Q34	MINAGO DOWNSTREAM	Al	0.011	0.017	0.019	0.012	0.017	0.019				0.005 - 0.1	0.005 - 0.1	0.005 - 0.1
Q34	MINAGO DOWNSTREAM	Sb	0.00004	0.00010	0.00013	0.00005	0.00010	0.00014						
Q34	MINAGO DOWNSTREAM	As	0.0007	0.0007	0.0007	0.0006	0.0007	0.0007	0.5	1	0.15 mg/L (4-Day, 3-Year) [A]	Tier II	0.005	0.005
Q34	MINAGO DOWNSTREAM	Cd	0.000014	0.000025	0.000029	0.000017	0.000028	0.000034			0.00033 [B]	Tier II	0.000023[a]	0.000047[a]
Q34	MINAGO DOWNSTREAM	Cr	0.00044	0.00048	0.00061	0.00023	0.00038	0.00046			0.10331 [C]	Tier II	0.0089	0.0089
Q34	MINAGO DOWNSTREAM	Co	0.00006	0.00017	0.00022	0.00005	0.00016	0.00021						
Q34	MINAGO DOWNSTREAM	Cu	0.001	0.001	0.001	0.001	0.001	0.001	0.3	0.6	0.01266 [D]	Tier II	0.002[b]	0.00334[b]
Q34	MINAGO DOWNSTREAM	Fe	0.052	0.084	0.087	0.069	0.090	0.097				0.3	0.3	0.3
Q34	MINAGO DOWNSTREAM	Pb	0.00005	0.00017	0.00025	0.00006	0.00022	0.00032	0.2	0.4	0.0039 [E]	Tier II	0.00184[c]	0.00533[c]
Q34	MINAGO DOWNSTREAM	Mo	0.00028	0.00038	0.00055	0.00013	0.00037	0.00052				0.073		
Q34	MINAGO DOWNSTREAM	Ni	0.001	0.007	0.009	0.001	0.006	0.008	0.5	1	0.07329 [F]	Tier II	0.06889[d]	0.13007[d]
Q34	MINAGO DOWNSTREAM	Se	0.00023	0.00034	0.00039	0.00024	0.00034	0.00040				0.001	0.001	0.001
Q34	MINAGO DOWNSTREAM	Zn	0.00199	0.00206	0.00277	0.00100	0.00184	0.00242	0.5	1	0.16657 [G]	Tier II	0.03	0.03

Notes: footnotes a to g and a to d, pertaining to the regulations, are the same as given in table 2.14-8.

River downstream of the mixing zone will meet the Manitoba Tier III Freshwater guidelines for all parameters.

During the State of Inactivity, projected outflow from the Polishing Pond meets MMER requirements at all times. During the State of Inactivity, the projected water quality in Minago River downstream of the mixing zone meets the Manitoba Tier III Freshwater guidelines for all parameters.

Projected water quality of Polishing Pond discharges for the operational phase (Year 1-10), Stage 1 Closure (Year 10), Stage 2 closure (Year II), Post Closure

2.14.2.4 Storm Water Management

The site storm water management at the Minago Project is designed to accommodate a 1-in-20 year storm event over a 5-day period (120 mm) (Wardrop, 2009b).

Site water will be pumped to designated area settling ponds and sumps, or discharged to the local watersheds via runoff. Surface runoff from the industrial area, Overburden Disposal Facility, Dolomite Waste Rock Dump (WRD) and Country Rock WRD will be benign and is not expected to require treatment. The storm water falling on no-process areas including the Dolomite WRD and the Country Rock WRD will report to the natural environment. Settling ponds will nonetheless be built to control major events in the Overburden Disposal Facility areas. Seepage from the Tailings and Ultramafic Waste Rock Management Facility (TWRMF) will be collected in a perimeter ditch around the exterior of the facility and will be pumped back into TWRMF. The Polishing Pond and flood retention area will contain the storm water from the TWRMF, mine dewatering and site runoff. During operations, this water will be pumped to the Minago River watershed, and a portion will be diverted back to the process water tank (Wardrop, 2009b). Storm water release from the Polishing Pond will be staged over several days as needed to condition the Minago River.

2.14.2.5 Contaminants of Concern (CoC)

All discharges to the receiving environment are expected to meet the MMER guidelines during all stages of the mine development, closure and post closure periods.

summarizes the projected Polishing Pond water quality for the different mine development and closure stages against the MMER guideline limits (Environment Canada, 2002a; last amended in 2012). On the basis of the projected discharge water quantity for all phases of operation, there will be no contaminant of concern (CoC) for this project as all contaminants meet MMER guidelines.

2.14.3 Seepage Control

Seepage from the TWRMF will be collected with interceptor ditches surrounding the TWRMF. To ensure good capture of seepage from the tailings dam, the interceptor channel will be deep

Table 2.14-20 Water Quality of Polishing Pond Discharges

SCENARIO:			ESTIMATED AVERAGE CONCENTRATION																REGULATION	
			Operation (Year 1-10)	Year 10 (Closure Stage 1)		Year 11 (Closure Stage 2)			Year 12 (Post Closure)			Year 13 (Post Closure)			Year 14 (Post Closure)				Metal Mining Liquid Effluent Regulations (2002, last amended in 2012)	
		WATER QUALITY	MAXIMUM	MAY	JUNE TO OCTOBER	NOVEMBER TO APRIL	MAY	JUNE TO OCTOBER	NOVEMBER TO APRIL	MAY	JUNE TO OCTOBER	NOVEMBER TO APRIL	MAY	JUNE TO OCTOBER	NOVEMBER TO APRIL	MAY	JUNE TO OCTOBER	OVERALL MAXIMUM	Monthly Mean	Grab Sample
FLOW		PARAM.	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Q30	POLISHING POND OUTFLOW	As	0.002	0.002	0.002	0.000	0.003	0.003	0.000	0.004	0.004	0.000	0.004	0.005	0.000	0.005	0.005	0.005	0.5	1
Q30	POLISHING POND OUTFLOW	Cu	0.01379	0.01241	0.00317	0.00000	0.01525	0.01588	0.00000	0.01690	0.01743	0.00000	0.01838	0.01881	0.00000	0.01971	0.02005	0.020	0.3	0.6
Q30	POLISHING POND OUTFLOW	Pb	0.00332	0.00302	0.00154	0.00000	0.00555	0.00631	0.00000	0.00731	0.00795	0.00000	0.00888	0.00941	0.00000	0.01028	0.01072	0.011	0.2	0.4
Q30	POLISHING POND OUTFLOW	Ni	0.180	0.160	0.006	0.000	0.160	0.154	0.000	0.154	0.149	0.000	0.149	0.144	0.000	0.144	0.140	0.160	0.5	1
Q30	POLISHING POND OUTFLOW	Zn	0.020	0.019	0.015	0.000	0.031	0.035	0.000	0.039	0.043	0.000	0.047	0.050	0.000	0.054	0.056	0.056	0.5	1

enough to drain the local groundwater around it and to capture the seepage from the TWRMF. A good level of maintenance of this channel will be provided as any sustained channel blockage, local infilling or pump malfunction will reduce the effectiveness of the channel.

Horizontal seepage through the deposited tailings will be captured by a filter drain system to be constructed within the perimeter embankment of the TWRMF. The filter drain system will discharge to the interceptor channel close to the base of the embankment. The collected water in the interceptor channel will be pumped back into the TWRMF**.**

2.14.4 Control Systems

Automatic gauging stations will be installed upstream and downstream on Minago River and Oakley Creek. These gauging stations will provide a continuous record of water levels and flows in Minago River and Oakley Creek. Telemetry systems have been installed to monitor water levels, temperature, barometric pressure in the Minago Rover, Oakley Creek, and William River both upstream and downstream of the discharge points.

2.14.5 Effluent Monitoring

Monitoring programs will be implemented to assess project effects. Potential project effects on water quality in local watersheds during the operational and closure phases may be caused by the following:

- discharge from the Polishing Pond into the Minago River; and
- introduction of sediments (total suspended solids) to receiving waters due to runoff from areas disturbed during the mine activities.

Baseline and proposed monitoring programs during operations and closure are summarized below.

2.14.5.1 Baseline Monitoring Program

Surface water quality in watercourses surrounding the Minago Project was assessed by Wardrop (2007) from May to October 2006, URS (2008g) from May to August 2007, and KR Design Inc. from September 2007 to May 2008. Wardrop (2007) monitored water quality in Oakley Creek and Minago Project River while URS (2008g) and KR Design Inc. regularly monitored water quality in Oakley Creek, Minago River, William River, and Hargrave River. One-time assessments of surface water quality were also completed for William Lake, Little Limestone Lake, Russell Lake, and two locations near the confluence of William River and Limestone Bay on Lake Winnipeg. The selected locations for surface water sampling stations were based on:

- a review of topographic maps, orthophoto and drainage features at and surrounding the Minago site;

- consideration of the simultaneous collection of hydrological data, stream sediment and benthic samples during one or more of the surface water sampling events;
- consideration of the selection of representative stations both upstream and downstream of the Project site for the development of long-term sampling stations to monitor long-term trends in surface water quality during the exploration, development, operation and post-closure phases of the Project's mine life.

Water samples were analyzed for field parameters (pH, temperature, conductivity, oxidation-reduction potential (ORP), and dissolved oxygen (DO)), nutrients, major ions, metals, Radium-226, and other physicochemical parameters. Collection methods conformed to the guidelines outlined in the federal Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring (MMER-EEM; Environment Canada, 2002b). Details are provided in Section 7.5: Surface Water Quality.

2.14.5.2 Chemical Monitoring

Chemical monitoring will be undertaken during the operational and closure phases, in accordance with permit and MMER requirements. An application for amendment setting out a revised program for approval will be submitted to the respective agency. In addition to meeting permit requirements of the day, monitoring will be limited in scope to those parameters given in Schedule 4 of the MMER. In accordance with MMER, monitoring will continue as per the proposed program for three additional years. During the closure phase, chemical monitoring data will be reviewed for continual improvement.

2.14.5.3 Biological Monitoring

Biological monitoring will be undertaken to meet permit and MMER related requirements. Toxicity testing will be part of the biological monitoring program and will continue as required. In accordance with MMER, monitoring will continue as per the proposed program for seven additional years.

2.14.5.4 Physical Monitoring

Monitoring programs to assess physical parameters will be undertaken during the operational, closure, and post closure phases. In the event of any significant improvement or deficiency during the post closure monitoring phase (expected to last 4-6 years after closure), Victory Nickel will apply for an amendment setting out a revised program for approval.

2.14.5.5 Operational and Closure Water Quality Monitoring Programs

Victory Nickel intends to design its environmental protection programs in an environmentally sensitive manner to ensure that the above effects do not occur. However, in order to assess impacts, Victory Nickel will undertake a regional study during the operations and after closure.

This regional study area will include water bodies and watersheds beyond the local project area that reflect the general region to be considered for cumulative effects and that provide suitable reference areas for sampling. The regional study will encompass water sampling in:

- Minago River downstream and upstream of the Polishing Pond discharge;
- Hargrave River;
- upstream and downstream of the Oakley Creek and William River confluence;
- William River;
- Limestone Bay; and
- Cross Lake.

Monitoring sites have already been established as outlined in Table 2.14-22 and in Figure 2.14-8. These sampling sites will also be used during the operations, TS, SI and closure stages.

2.14.5.6 Proposed Water Quality Characterization

The proposed water quality monitoring parameters and associated minimum detection limits are given in Table 2.14-22. The respective QA/QC criteria and procedures for closure will be similar to the ones used during operations.

A water quality monitoring program was established as part of the environmental baseline studies. These streams will continue to be sampled during the operational and closure phases to determine potential impact(s) over time. The stations that will be sampled during the closure phase are provided in Table 2.14-23.

Table 2.14-21 Sampling Locations

Victory Nickel Sample Location (as of Sept. 15, 2007)	UTM (NAD 83)		UTM (NAD 83)		Description
	Northing	Easting	Latitude	Longitude	
HRW1	6028072	495606	54°24.041' N	99°04.051' W	Hargrave River immediately west of Highway 6
MRW1	6005277	488671	54°11.721' N	99°10.420' W	Minago Project River immediately west of Highway 6
MRW2x	6001166	472571	54°09.470' N	99°25.206' W	Minago Project River near Habiluk Lake (~ 100 m downstream of MRW2)
MRW3	6007895	494274			Minago Project River downstream of Highway 6 near powerline cut
OCW1	5990510	489322	54°03.762' N	99°09.786' W	Oakley Creek immediately east of Highway 6
OCW2	5990961	487463	54°04.002' N	99°11.492' W	Oakley Creek immediately downstream of north tributary
OCW3	5990892	487230	54°03.965' N	99°11.707' W	Oakley Creek immediately upstream of north tributary
WRW2x	5987162	495416	54°01.963' N	99°04.199' W	William River approx. 6 km upstream of the Oakley Creek confluence
WRW1x	5986554	498523	54°01.637' N	99°01.350' W	William River approx. 100 m downstream of the Oakley Creek confluence
WRAOC	5986647	498452	54°01.685' N	99°01.416' W	William River approx. 50 m upstream of the Oakley Creek
OCAWR	5986744	498457	54°01.738' N	99°01.414' W	Oakley Creek approx. 50 m above William River
WRALSB	5969206	503935	53°52.278' N	98°56.410' W	William River approx. 100 m above Limestone Bay
LSBBWR	5968889	504092	53°52.107' N	98°56.262' W	Limestone Bay approx. 250 m below William River
Little Limestone Lake	5954922	478725			Little Limestone Lake (at end of road)
Russell Lake	5967117	482571			Russell Lake (at end of road)
William River (Winter)	5973774	485141	53°54.730' N	99°13.574' W	William River east of Highway 6
William River at Road	5973791	485078			William River west of Highway 6
William Lake	5973831	479083			William Lake at end of access road
Polishing Pond	TBA*	TBA*	TBA*	TBA*	Polishing Pond Outflow to Receiving Environment during Closure

Note: * TBA To Be Announced

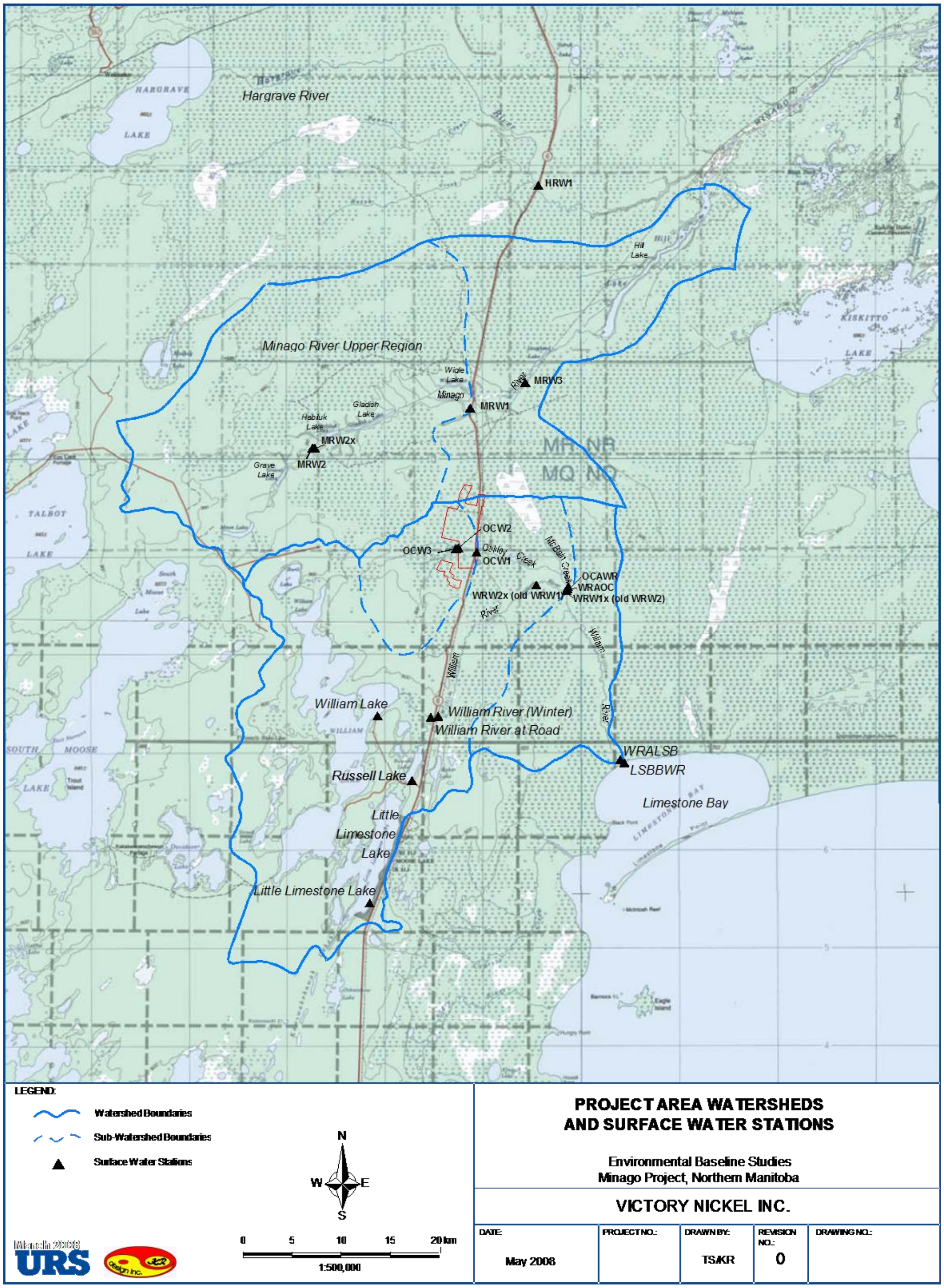


Figure 2.14-8 Minago Project – Surrounding Watersheds and WQ Sampling Locations

Table 2.14-22 Water Quality Monitoring Parameters and Detection Limits

Parameter		Detection limit (mg/L)	Analytical Method
Aluminum, total and dissolved	Al	0.001	ICP / ICP MS
Antimony, total and dissolved	Sb	0.00005	ICP / ICP MS
Arsenic, total and dissolved	As	0.00005	ICP / ICP MS
Barium, total and dissolved	Ba	0.00005	ICP / ICP MS
Beryllium, total and dissolved	Be	0.0005	ICP / ICP MS
Bismuth, total and dissolved	Bi	0.0005	ICP / ICP MS
Boron, total and dissolved	B	0.001	ICP / ICP MS
Cadmium, total and dissolved	Cd	0.00005 to 0.02	ICP / ICP MS
Calcium, total and dissolved	Ca	0.05	ICP / ICP MS
Chromium, total and dissolved	Cr	0.0001	ICP / ICP MS
Cobalt, total and dissolved	Co	0.0001	ICP / ICP MS
Copper, total and dissolved	Cu	0.0001	ICP / ICP MS
Iron, total and dissolved	Fe	0.01	ICP / ICP MS
Lead, total and dissolved	Pb	0.00005	ICP / ICP MS
Lithium, total and dissolved	Li	0.001	ICP / ICP MS
Magnesium, total and dissolved	Mg	0.05	ICP / ICP MS
Manganese, total and dissolved	Mn	0.00005	ICP / ICP MS
Mercury (total) , total and dissolved	Hg	0.00005	Cold Oxidation (CVAAS)
Molybdenum, total and dissolved	Mo	0.00005	ICP / ICP MS
Nickel, total and dissolved	Ni	0.0001	ICP / ICP MS
Phosphorus, total and dissolved	P	0.05	ICP / ICP MS
Potassium, total and dissolved	K	0.2	ICP / ICP MS
Selenium, total and dissolved	Se	0.0005	ICP / ICP MS
Silicon, total and dissolved	Si	0.05	ICP / ICP MS
Silver, total and dissolved	Ag	0.00001	ICP / ICP MS
Sodium, total and dissolved	Na	2	ICP / ICP MS
Strontium, total and dissolved	Sr	0.0001	ICP / ICP MS
Thallium, total and dissolved	Tl	0.00005	ICP / ICP MS

Table 2.14-22 (Cont.'d) Water Quality Monitoring Parameters and Detection Limits

Parameter	Detection limit (mg/L)		Analytical Method
Tin, total and dissolved	Sn	0.0001	ICP / ICP MS
Titanium, total and dissolved	Ti	0.01	ICP / ICP MS
Vanadium, total and dissolved	V	0.001	ICP / ICP MS
Zinc, total and dissolved	Zn	0.001	ICP / ICP MS
Total alkalinity	$CaCO_3$	1	Titration to pH=4.5
Ammonia	N	0.005	Colorimetry
Nitrate	N	0.005	Ion Exchange Chromatography
Nitrite	N	0.001	Colorimetry
Nitrite + nitrate	N	0.005	Ion Exchange Chromatography
Sulphate	SO_4	0.03	Ion Exchange Chromatography
Total dissolved solids		1 to 5	Filtration/Gravimetric
Total suspended solids		1 to 5	Filtration/Gravimetric
Turbidity		1.0 (NTU)	Nephelometric
Conductivity		1.0 (µS)	Conductivity cell
pH (RelU)		0.1 (RelU)	Potentiometric
Cyanide (total)	CN	0.005	Distillation/UV Detection
Fluoride	F	0.02	Colorimetry
Chloride	Cl	0.5	Colorimetry

Table 2.14-23 Sediment and Surface Water Monitoring Stations

VICTORY NICKEL Water Quality Monitoring Stations	Description	Monitoring Frequency – Water Quality – during Operational Phase	Monitoring Frequency – Water Quality – during Closure and Post Closure Phases	Monitoring Frequency – Flow – during Operational Phase	Monitoring Frequency – Flow – during Closure and Post Closure Phases	Duration – No. of Years	Applicable Regulations
HRW1	Hargrave River immediately west of Highway 6	M	Q	Q	Q	6	IP
MRW1	Minago River immediately west of Highway 6	M	Q	M	Q	6	IP
MRW2	Minago River near Habiluk Lake	SA	A	SA	A	6	IP
MRW2X	Minago River near Habiluk Lake (100 m downstream of MRW2)	Q	A	Q	A	6	IP
MRW3	Minago River downstream of Highway 6 near powerline cut	M	Q	M	Q	6	CCME / MB Tier II
OCW1	Oakley Creek immediately east of Highway 6	M	Q	M	Q	6	CCME / MB Tier II
OCW2	Oakley Creek immediately downstream of north tributary	M	A	M	A	6	IP
OCW3	Oakley Creek immediately upstream of north tributary	M	A	M	A	6	IP
WRW2X	William River approx. 6 km upstream of the Oakley Creek confluence	SA	A	SA	A	6	IP
WRW1X	William River approx. 100m downstream of the Oakley Creek confluence	M	A	M	A	6	IP
WRAOC	William River approx. 50 m upstream of the Oakley Creek	Q	Q	Q	Q	6	IP
OCAWR	Oakley Creek approx. 50 m above William River	Q	Q	Q	A	6	IP
WRALSB	William River approx. 100 m above Limestone Bay	Q	Q	Q	Q	3	IP
LSBBWR	Limestone Bay approx. 250 m below William River	Q	Q	Q	Q	1	IP
Little Limestone Lk	Little Limestone Lake (at end of road)	A	A	A	A	1	IP
Russell Lake	Russell Lake (at end of road)	A	A	A	A	1	IP
William River (Winter)	William River east of Highway 6	A	A	A	A	1	IP
William River at Road	William River east of Highway 6	A	Q	Q	Q	6	IP
William Lake	William Lake at end of access road	A	A	A	A	1	IP
Polishing Pond	Polishing Pond Outflow	M	M	M	Q	6	MMER

Note: A= Annually, Q= Quarterly, SA= Semi Annually; IP= Internal Programs; MMER= Metal Mines Effluent Regulation Monitoring Point (Polishing Point Outflow); CCME/MB Tier II Monitoring Station (OCW1 and MRW3).

2.15 Site Facilities and Infrastructure

The proposed project will be comprised of an open pit mine, an ore concentrating plant, a frac sand plant, and supporting infrastructure. The Ore Concentrating Plant will process 10,000 tonnes per day of ore through crushing, grinding, flotation, and gravity operations to produce nickel concentrate. The Frac Sand Plant will produce 1,500,000 t/a of various sand products including 20/40 and 40/70 frac sand, glass sand, and foundry sand products. The general site layout is illustrated in Figure 2.1-2.

The proposed infrastructure for the Project will include (adapted from Wardrop, 2009b):

- site haul and access roads and laydown areas;
- open pit (described in Section 2.9);
- Mill Process and Frac Sand Plant (described in Section 2.10);
- Crusher and Concentrator Facilities;
- a Tailings and Ultramafic Waste Rock Management Facility (TWRMF);
- waste rock and overburden disposal dumps;
- water and wastewater facilities, including an open pit dewatering system, site de-watering systems with associated pipelines and pumping stations, a sewage treatment system, a potable water treatment plant, a Polishing Pond and site infrastructure piping;
- a fuelling storage and dispensing facility for mobile equipment;
- equipment repair and maintenance facilities;
- miscellaneous service buildings including emergency services building, cold storage building, process and fresh water pump house, security guardhouse and scale house;
- an explosives storage;
- electrical power supply, transformation and distribution;
- modular facilities, including mine site staff dormitories, wash/laundry facilities, staff kitchen/cafeteria, mine dry, a modular office complex and a recreational facility;
- storm water management systems;
- life safety and security systems;
- data and communication systems; and
- other refuse disposal.

The modular camp, which is designed to accommodate 300 people, will form the basis of the accommodation for the construction workforce.

All infrastructure facilities will be located at least 300 m from Highway 6, to provide a visual tree-line barrier from traffic to the Minago operation. Only the guard house and scale house will initially be visible from Highway 6. Since the tailings dam will be of limited height and will be set back from the road, the tree lined barrier will limit visibility (Wardrop, 2009b).

The major infrastructure facilities such as the mill, crushing facility and truck garage will be located in the northwest corner of the site where the overburden thickness is minimal. This area has the highest site elevation therefore eliminates concerns on site drainage and flooding (Wardrop, 2009b).

The minimum distance requirements to separate the explosive plant operations from other operations and the necessary minimum clearances to the 230 kV and other electrical lines have been taken into account in the site layout.

2.15.1 Site Roads

Site roads will be located throughout the site to provide access to all operational areas of the mine (Wardrop, 2009b). Roads will vary in width and general cross section depending on the location, staging and ultimate use of the roadway. Initial road widths of 6 m, 8 m, 12 m, 20 m and 30 m will be used throughout the mine site and will be constructed so that the finished roadway surface is a minimum 0.8 m – 1.0 m above the surrounding ground elevation.

Haul roads will facilitate movement of the 218 tonne trucks with the required clearances. The roads carrying highway truck traffic for incoming supplies and materials and outgoing ore concentrate will be designed to accommodate a Super B-Train loading (GVW 62,500kg) and roads carrying mining ore will accommodate GVW 324,000kg haul trucks (Wardrop, 2009b).

A number of the roads will have elevated berm sections to accommodate utilities/pipelines. The elevated berms will prevent vehicles from wandering across the roadway and into the utilities themselves.

Parking areas will be illuminated and equipped with electrical plugs where necessary.

The intersection of the mine site access road with Highway 6 will require improvements to accommodate turning and slow moving truck traffic entering and exiting the site. The improvements will include pavement widening to create auxiliary acceleration/deceleration lanes.

2.15.2 Crushing and Concentrator Facilities

A crusher building was designed with a footprint of 19 m x 12 m. The crusher will be 51 m high and has a truck dumping area on one side of the building at a relative height of 30 m. The crusher will be contained in a fully enclosed building and has been designed to accommodate a 45 tonne bridge crane. The crusher foundation has been designed as a thick slab, assumed to be sitting on or near the bedrock layer.

The concentrator building is designed as a main building (27 m wide x 150 m long x 29 m high). This main area will house a ball mill, sag mill, pebble crusher, conditioner, and flotation units.

Four separate lean-to buildings are also included in the design of the concentrator. The first lean-to building will be 9 m wide x 22.5 m long x 9.5 m high and houses the switch rooms and motor control centers (MCCs). The second lean-to building will be a 5.5 m wide x 4.5 m long x 2.44 m high and is designed as an unloading area. The third lean-to building will be 16 m wide x 60 m long x 23 m high and houses the reagent area. The final lean-to building associated with the concentrator will be 14 m wide x 90 m long x 26 m high and houses the stock tank, concentrate thickener, and a storage area.

2.15.3 Tailings and Ultramafic Waste Rock Management Facility

The Tailings and Ultramafic Waste Rock Management Facility (TWRMF) will be a key component of the water and waste management system at Minago for liquid waste, nickel mill and Frac Sand Plant tailings, und ultramafic waste rock. Mine waste contained in the TWRMF will be stored subaqueously.

Submerging mine waste containing sulphide minerals, or "subaqueous disposal", is practiced at many metal mines to keep oxidative rates at a minimum and to minimize metal leaching. Based on geochemical work done to date, Minago's nickel tailings will contain low sulphide levels and were deemed to not become acid generating (URS, 2008a). Sulphide levels were less than or equal to 0.07 % in the Master tailings samples tested. However, Minago's ultramafic waste rock is potentially acid generating (URS, 2009i).

The TWRMF will receive water from the mill tailings thickener, sewage treatment plant, waste frac sand and the underflow from the frac sand clarifier. Typical tailings water inputs include 503 m^3/h from the process plant and 118 m^3/h from the waste receiving pump box. The waste receiving pump box will contain 100.4 m^3/h of waste frac sand, 12.4 m^3/h of underflow from the frac sand clarifier and 5 m^3/h from the sewage treatment plant (Wardrop, 2009b).

The following design considerations were taken into account for the TWRMF (Wardrop, 2009b):

- Ultramafic waste will be co-deposited with tailings in the TWRMF. This will contain all contaminants into a single area without contaminating other areas. The containment structure (21 m high) will be built initially followed by the construction of a perimeter ramp inside the TWRMF area. This will allow for co-depositing of tailings and ultramafic waste. The tailings will be deposited onto the ultramafic waste to fill in voids within the rock.
- To support the Tailings and Ultramafic Waste Rock Management Facility (TWRMF), a ring main pipe, a floating barge pumping station, and three perimeter ditch pumping stations will be provided. A ring main pipe with spigots will be located along the entire perimeter ramp and placement of tailings will be accomplished by opening and closing of valves along a ring main pipe to eliminate accumulations of solids in a particular area and allow for uniform discharge.
- The tailings deposition will create a decant pond sized for not less than five days of retention time. A minimum water depth of 1.5 m will be maintained in the pond at all times.

- Decant water from the tailings pond will be pumped to the Polishing Pond and flood retention area for subsequent water recycling or discharge to the receiving environment.
- Seepage ditches around the perimeter of the TWRMF will collect the seepage and runoff and transfer the water back into the facility.
- The TWRMF site will be located in permanently-flooded terrain. The construction of the TWRMF dam will be preceded by construction of roads surrounding the site.
- The pond in the TWRMF will be operated under average precipitation conditions, but with the barge pumps capable of pumping a 1-in-20 year, 5 day major rainfall event. The maximum discharge rate will be based on the expected requirements for a major rainfall event over a two week period. The nominal discharge rate will be increased and decant water will be pumped over a two week period during such an event.
- The TWRMF will provide adequate volume for containment of tailings, ultramafic waste and supernatant water. Ice formation over the tailings due to discharge in subfreezing temperatures during winter operations is envisaged, and contingency storage capacity has been provided in the design.

Seepage from the TWRMF will be collected in a perimeter ditch and pumped back into the facility by three 15 hp submersible pumps. Three pumping stations will be located along the low-elevation east-side ditch area. The tailings water from the TWRMF pond will be pumped to the Polishing Pond and flood retention area by three 60 hp vertical turbine pumps, each capable of pumping 530 m^3/h. These pumps will be mounted on a floating barge pump station (Wardrop, 2009b).

2.15.4 Waste Rock and Overburden Disposal Dumps

Ultramafic waste rock will be co-disposed with tailings in the Tailings and Ultramafic Waste Rock Management Facility (TWRMF). Non-reactive dolomite and country waste rock will be hauled to the designated dump areas. No water quality problems are anticipated from these dump areas since the rock is non-reactive and will not contain contaminants. The majority of the runoff will discharge directly to the environment while a minimal amount of rainfall will runoff to the roadway ditches and eventually to the overburden settling pond. There are no anticipated problems with TSS during a major event due to the nature of coarse waste rock (Wardrop, 2009b).

The overburden dump area will be surrounded by a containment berm. Weirs will allow for discharge of water to a settling pond. Due to restraints on total suspended solids (TSS), the settling pond will be used for settlement prior to discharge to the Oakley Creek watershed. Flocculent addition may be required to meet water quality standards. Placement of material in the overburden dump will be complete within the first two years of construction and re-vegetation of the surface will occur immediately after completion (Wardrop, 2009b).

During a 1-in-20 year, 5-day major rainfall event, the overburden settling ponds will be used for settlement and storage with the presence of an overflow line to discharge benign rainfall. Once the vegetation is established, it is anticipated that the runoff will be benign and will meet TSS water quality standards. The areal boundaries of the Overburden Disposal Facility dump will contain a permeable dyke/road, which will contain a filter cloth and sand bed to filter the water through the roadway. Due to the benign nature of the runoff, water will be discharged to the environment instead of the flood retention area (Wardrop, 2009b).

2.15.5 Water and Wastewater Facilities

The water and wastewater management components at Minago will include:

- dewatering wells to dewater the open pit area;
- a water treatment plant to produce potable water;
- a sewage treatment facility for on-site grey water and sewage;
- mill and Frac Sand Plant tailings and effluents that will be discharged into a Tailings and Ultramafic Waste Rock Management Facility (TWRMF);
- a Tailings and Ultramafic Waste Rock Management Facility (TWRMF) that will store tailings and ultramafic waste rock permanently and effluents from various site operations temporarily;
- waste rock dump seepages that will be discharged into the TWRMF or the receiving environment depending on their water quality;
- overburden dump runoff that will be discharged directly into the receiving environment (if it meets discharge requirements);
- an open pit dewatering system that will ensure safe working conditions in and around the open pit;
- a Polishing Pond and flood retention area to serve as holding pond for water that will either be recycled to site operations or discharged to the receiving environment (if it meets discharge water standards);
- a site drainage system to prevent flooding of site operations;
- site wide water management pumping systems; and
- discharge pipelines to Minago River and Oakley Creek to discharge excess water from the Polishing Pond / flood retention area and the country rock, dolomite rock, and overburden dumps to the receiving environment.

Due to the complexity of the water and wastewater management system, its components, flow volumes, seasonality and elemental concentrations are presented and discussed in a separate subsection (Section 2.14). However, the proposed sewage treatment, potable water treatment, site infrastructure piping and dewatering facilities are also outlined below.

2.15.5.1 Sewage Treatment Plant

The domestic sewage generated on the site will be collected by sanitary sewers and conveyed to an extended aeration mechanical sewage treatment plant. The sewage treatment plant will use an extended aeration system, supplied by CanWest Tanks and Ecological Systems Ltd. or equivalent (Wardrop, 2009b).

The proposed plant meets Manitoba Conservation requirements, and will meet 25/25 mg/L Five-day Biochemical Oxygen Demand (BOD_5) and Total Suspended Solids (TSS) targets. The plant design incorporates nitrification to reduce ammonia concentrations in the effluent to within Manitoba Conservation's winter and summer restrictions. Nitrogen or phosphorous removal is not expected to be required, since the discharge will flow into the catchment area of Lake Winnipeg (Wardrop, 2009b).

The sewage treatment plant will be located east of the maintenance building to allow all sewage to flow by gravity to the plant. A separate sewage pumping station with a fiberglass tank will be located at the modular complex facility to pump the raw sewage from the complex building to the sewage treatment plant.

The treatment plant will accommodate 450 people at 230 L/capita/day plus 10% for the water treatment plant backwash. The average daily flow will be 113,800 L/day (Wardrop, 2009b). The per capita BOD_5 contribution will be 0.091kg/capita/day. The daily BOD_5 loading will be 40.9 kg BOD_5/day (Wardrop, 2009b).

The tanks, which will be buried, will be constructed with fiberglass materials that meet CSA BL66 standards. The effluent will be disinfected using ultraviolet (UV) radiation (Wardrop, 2009b).

The treated effluent will be discharged to the waste receiving pump box, and then discharged to the TWRMF. The treatment plant will include an on-line lockable refrigerated composite sampler that will available to Manitoba Conservation for independent effluent sampling. Treated effluent sampling and analyses will be performed on a monthly basis to detect BOD_5, ammonia, TSS, and fecal coliforms (Wardrop, 2009b).

A grease trap will be installed at the discharge from the camp kitchen prior to the connection with the sewer system (Wardrop, 2009b).

The domestic wastewater sludge storage tank will be periodically de-sludged using three submersible pumps installed in the sludge storage tank. The sludge will be pumped into a tanker truck and hauled to the lagoon at Grand Rapids for disposal. The estimated sludge production is 0.15 to 0.23 m^3/h (Wardrop, 2009b).

An insulated pre-fabricated building will house the blowers, control panel, the lockable, refrigerated composite sampler and similar equipment. The building will be skid-mounted and installed on a crushed stone base. There will be no special electrical code requirements since none of the electrical equipment will be exposed to sewage or sludge (Wardrop, 2009b).

2.15.5.2 Potable Water Treatment Plant

The potable water supply will be drawn from the fresh/fire water storage tank and the ground water wells. Potable water will be used for the safety shower/eye wash stations, personal consumption, washrooms, canteen and dry. Potable water will not be used for fire water, process water or general plant distribution. Potable water will be pumped to the modular complex and the maintenance building, primary crusher building, crushed ore delivery tunnel, security building, and frac sand plant (Wardrop, 2009b).

Since raw water will be supplied from a confined aquifer, it is not considered Groundwater Under Direct Influence of Surface Water (GUDI). Accordingly, no special preventative precautions will be needed for giardia, cryptosporidium or similar parasites (Wardrop, 2009b).

Potable water treatment will consist of a bank of manganese greensand pressure filters to remove iron and manganese to less than 0.05 mg/L and 0.3 mg/L, respectively. These aesthetic limits are recommended by Manitoba Conservation as well as Health Canada's Canadian Guidelines for Drinking Water Quality. The filtration rate will be 6.1 m^3/hr per m^2 (Wardrop, 2009b).

Post-chlorination treatment will be performed by sodium hypochlorate (bleach) with an inline residual chlorine analyzer. If the chlorine residual exceeds the range of the high and low level set points, an alarm will alert the operator to review the problem and adjust the chlorine levels appropriately (Wardrop, 2009b).

The treatment plant will include enough treated water storage to accommodate an average day's consumption, expected to be 4.3 m^3/hr; peak demand flows are expected to reach up to 17.3 m^3/hr. The treatment plant will be located west of the modular complex building since the complex building requires the greatest amount of potable water (Wardrop, 2009b).

2.15.5.3 Site Infrastructure Piping

Water supply pipes and sewers will be High Density Polyethylene (HDPE) and will be buried on a benched part of the roadways to prevent freezing. In high density peat areas, concrete pipe weights may be required to secure the pipes and prevent flotation (Wardrop, 2009b).

The domestic sewers will be 50 to 200 mm diameter low pressure force mains in some areas. Gravity sewers will be utilized in areas with suitable ground conditions (Wardrop, 2009b).

2.15.5.4 Dewatering Facilities

Open pit dewatering will be accomplished by perimeter groundwater pumps as well as open-pit centrifugal and submersible pumps to properly dewater the pit (Wardrop, 2009b).

The groundwater pumps will consist of twelve 75 hp Grundfos groundwater pumps which will discharge approximately 35,000 m^3/d directly into the retention area while approximately 5,000 m^3/d will be diverted to the fresh water tank (Wardrop, 2009b).

The open-pit will be de-watered by the use of 11 centrifugal pumps and 6 submersible pumps. The dewatering pumps were sized to accommodate a 1-in-20 year, 5-day major rainfall event, and to eliminate down times within the pit due to flooding and will allow for the pit to be dewatered more rapidly. Pumping stations will be located on designated levels throughout the pit to optimize head loss and pipe lengths. The open pit dewatering will be performed by three separate pumping loops in series and will discharge to the Polishing Pond and flood retention area (Wardrop, 2009b).

2.15.6 Fuelling Storage and Dispensing Facility

A fuel storage facility will be centrally located within the industrial area. The diesel fuel storage capacity for the mining operation will be 380,000 L, which includes the fuel requirements for explosives (Wardrop, 2009b). The fueling system will consist of four 95,000 L above-ground double-walled diesel fuel tanks, a diesel fuel pumphouse, and a receiving station.

The fuel storage facility will be self-contained to ensure that inadvertent spills do not end up into the receiving environment. The facility will be equipped with a spill kit and will be inspected on a regular basis. Fuel will be supplied by a third party.

Bulk quantities of petroleum hydrocarbons will be stored and handled in accordance with Manitoba Regulation 188/2001 and any subsequent amendments.

Standard vehicles will be serviced using a dual-fuel dispensing unit and one 4,500 L double-walled diesel fuel tank and one 4,500 L double-walled gasoline tank (Wardrop, 2009b).

2.15.7 Miscellaneous Service Buildings

Miscellaneous service buildings will include an emergency services building, a process and fresh water pump house, a cold storage building, equipment repair and maintenance facilities, a fire protection water pump house, and a security guardhouse and scale house.

The emergency vehicle garage will be a pre-engineered building with an area of approximately 240 m^2. The garage will house an ambulance and a fire truck and will have one small office and storage space for emergency equipment (Wardrop, 2009b).

The process and freshwater pumphouse will be two pre-engineered buildings side by side with a combined area of approximately 170 m^2. The pumphouse complex will be located east of the ore processing facility. A monorail will be installed above each pump system to facilitate maintenance.

A 950 m^2 cold storage warehouse will be located south of the general maintenance building.

The general maintenance building will include (Wardrop, 2009b):

- seven heavy vehicle repair bays including four drive-through bays;
- a light vehicle repair bay, a tire bay, a welding bay, and a wash bay;

- a lube storage facility;
- a machine/hydraulic shop, a fabrication/welding shop, an electrical shop, and an instrumentation shop;
- a 1,290 m^2 storage warehouse;
- five offices, a lunch room and washroom facilities; and
- an upper level mezzanine with mechanical and compressor rooms.

A fire protection water pump house will be located directly beside the fresh water tank. In the event of a fire, the fire water pumps will discharge water from the fresh water tank to the appropriate area. Fire protection will be required at the modular complex building, frac sand plant, mill, maintenance building, fueling area, and primary crusher building.

The security guardhouse and scale house will be located at the entrance to the site, near Highway 6. The guardhouse and scale house will be a single-storey 3.6 m x 6 m modular trailer complete with a washroom facility (Wardrop, 2009b).

2.15.8 Explosive Storage

All explosives will be handled, transported and disposed of in compliance with the Explosive Act.

2.15.9 Power Supply

The primary source of electrical power will be the Manitoba Hydro 230 kV line along the east side of Highway 6. From the connection at Highway 6, a 6-km, 230 kV power transmission line will feed the main substation located to the west of the process plant in the northwest corner of the site. The connection from the Manitoba Hydro 230 kV line will be provided with gas-filled isolation switches (Wardrop, 2009b).

The main substation will consist of two main transformers rated at 50 MVA each capable of supplying the full load. The transformers will transform the power down from 230 kV to 13.8 kV to the main 13.8 kV switch room via metal clad switchgear (Wardrop, 2009b).

The electrical system will be sized and configured for full redundancy, allowing the transformers to operate in parallel or individually while maintaining full production. Each transformer will be able to accommodate the full operational loads in the event of a failure of the other. The main sub-station will be protected by a secure chain link fence surrounding a crushed stone bed for easy maintenance and to ensure effective drainage (Wardrop, 2009b).

Power from the main switchgear room will be distributed at 13.8 kV via overhead line to the various distribution centres around the site. Outdoor oil filled transformers will transform the primary 13.8 kV to 6,600 V, 4160 V and 600 V as required (Wardrop, 2009b).

2.15.9.1 Emergency Power

Two diesel generator sets rated at 1.5 MW, 13.8 kV with associated switchgear will be housed in a dedicated building located near the main electrical substation (Wardrop, 2009b). The system will be designed to provide power during the construction phase and emergency power during the operations phase for life sustaining and critical process equipment. The emergency power system will feed the entire plant grid with operators isolating non emergency switchgears to direct the standby power to the critical services. Most importantly, the emergency power would provide essential power to feed the dewatering pumps during a utility power failure. Diesel generators will provide redundancy as the 230 kV primary power feed from the main 230 kV Manitoba Hydro AC Line (Wardrop, 2009b).

2.15.9.2 Estimated Load

The peak connected load is estimated to be 42.4 MW (50 MVA), based upon the power requirements of operations and auxiliary equipment on the site and an average power factor of 0.85. The estimated operating load for the five cost centres including future growth is 30.0 MVA (Wardrop, 2009b).

2.15.10 Modular Building Complex including Accommodation

The following buildings will be part of the modular building complex (Wardrop, 2009b):

- mine site staff dormitories;
- mine staff kitchen/cafeteria;
- mine dry including male and female facilities and shift change rooms;
- mine office complex, and
- recreational facilities.

All modular facilities will have wheelchair access and will be connected with an enclosed walkway. The buildings will be designed for use in a heavy-duty industrial environment, with an expected life of approximately 20 years (Wardrop, 2009b).

The mine site staff dormitories will be sized to accommodate 300 personnel, including the construction crew. The dormitory complex will consist of 120 double sleeper units, 60 single sleeper units and 6 executive suites (Wardrop, 2009b).

The project will employ 422 staff members; however, workers will rotate on a 12-hour shift schedule, and each shift worker will vacate the site once for every 2-week shift period. In addition, some daytime workers that commute from Grand Rapids will not require accommodations. Accordingly, it is not necessary for the dormitories to accommodate all 422 workers.

The kitchen/cafeteria will be sized for 200 personnel and will house food storage and food preparation areas, the kitchen and cafeteria and a kitchen staff office. The kitchen/cafeteria area will be approximately 883 m^2 (9500 ft^2 (50' W x 190' L)).

The mine dry will accommodate 306 lockers (102 per mudroom area) with two male and one female facility.

The office complex will accommodate up to 60 personnel. The office complex will be approximately 790 m^2 (8,500 ft^2 (50' W x 170' L)) and will form part of the modular dormitory building. The office complex will be accessible from the exterior and interior of the building complex (Wardrop, 2009b).

2.15.11 Storm Water Management

The site storm water management at the Minago Project is designed to accommodate a 1-in-20 year storm event over a 5-day period (120 mm) (Wardrop, 2009b).

Site rainfall will be pumped to the Polishing Pond and retention area, contained in designated area settling ponds, or discharged to the local watershed via runoff. Rainfall onto the plant area, Overburden Disposal Facility, dolomite dump and country rock dump will be benign and is not expected to require treatment. Settling ponds will nonetheless be built to control major events in the Overburden Disposal Facility areas. Seepage from the Tailings and Ultramafic Waste Rock Management Facility (TWRMF) will be collected in a perimeter ditch around the exterior of the facility and will be pumped over the dyke back into it. A Polishing Pond and flood retention area will contain the storm water from the TWRMF, mine dewatering and site runoff. This water will be pumped to the Minago River watershed, and a portion will be diverted back to the process water tank (Wardrop, 2009b).

2.15.11.1 Ultramafic Waste Rock Dump

The ultramafic waste rock will be deposited directly into the TWRMF, limiting the potential contamination to a single area. The TWRMF is designed to accommodate a 1-in-20 year, 5-day major rainfall event. The nominal discharge from this area will be increased and pumped over a two week period during such an event (Wardrop, 2009b).

2.15.11.2 Overburden Disposal Facility

The Overburden Disposal Facility dump area will be surrounded by a containment berm. Weirs will allow water to discharge to the settlings pond, which will be used for storage of excess water and precipitation. Due to restraints on TSS, settling ponds will be used for settlement prior to discharging to the Oakley creek watershed. Flocculent addition may be required to meet water quality standards. Placement of material in the Overburden Disposal Facility will be complete within the first two years of construction and vegetation of the surface will commence immediately after completion (Wardrop, 2009b).

During a 1-in-20 year, 5-day major rainfall event, the settling ponds will be used for settlement and storage with the presence of an overflow line to discharge benign rainfall. Once the vegetation is established, it is anticipated that the rainfall will be benign and will meet TSS water quality standards. The area boundaries of the Overburden Disposal Facility dump will contain a permeable dyke/road which will contain a filter cloth and sand bed to filter water through the roadway. Due to the benign nature of the runoff, water will be discharged to the environment instead of the flood retention area (Wardrop, 2009b).

2.15.11.3 Plant Area

The plant area runoff including the frac sand plant and sand storage pile will be clean water and will be discharged directly to the environment. Since the plant area is located in the northwest corner of the site, benign rainfall will runoff through the roadway ditches to the Overburden Disposal Facility settling pond as well as runoff to the Oakley Creek watershed (Wardrop, 2009b).

2.15.11.4 Dolomite and Country Rock Dumps

The non-reactive dolomite and country rock will be hauled to designated dump areas (Figure 2.15.1). The majority of the runoff will discharge directly to the environment, while a minimal amount will runoff to the roadway ditches and eventually to the Overburden Disposal Facility settling pond. There are no anticipated problems with TSS during a major event due to the nature of coarse waste rock (Wardrop, 2009b).

2.15.11.5 Polishing Pond and Flood Retention Area

During a 1-in-20 year, 5-day major rainfall event (120 mm), the Polishing Pond and flood retention area will acquire approximately 550,000 m^3 of water over a surface area of 750,000 m^2, which will produce an average depth of approximately 0.75 m throughout the settling area. The roads surrounding the Polishing Pond and flood retention area will have a minimum height of 1 m (0.75 m depth and 0.25 m freeboard). This height will allow for sufficient water storage capacity for the effects of rainfall on the open pit and TWRMF during a major event (Wardrop, 2009b).

The majority of the site water accumulated in the Polishing Pond and flood retention area will be pumped to the Minago River watershed while 12,000 m^3/d will be diverted to the process water tank as reclaim water. Due to the high head and flow capacities, three 600 hp vertical turbine pumps will be used to generate the flow through an 800 mm (32") HDPE pipe to the Minago River watershed. In the summer months, the water will be discharged to the Minago River watershed by a distribution manifold, while in winter months the pipe outlet will discharge directly to an open ditch after the distribution manifold (Wardrop, 2009b).

2.15.12 Life Safety and Security Systems

The fire alarm and detection systems will be analog addressable systems from a single manufacturer with proven and reliable technology. The system will integrate all detection and annunciation devices with main annunciation panel located at the security station. The security system will employ proven and reliable technology to integrate door alarms and motion sensors for key areas into a central system monitored at the security station. The system will also provide monitored card access for offices, IT rooms and other secure areas (Wardrop, 2009b).

2.15.13 Data and Communication Systems

The telecommunications design will incorporate proven, reliable and state-of-the-art systems to ensure that personnel at the mine will have adequate data, voice and other communications channels available. The telecommunications system will be procured as a design-build package with the base system installed during the construction period then expanded to encompass the operating plant (Wardrop, 2009b).

The requirements for communications, particularly satellite bandwidth, are a function of the voice and data requirements of the active participants in the project. The expectation is that the need for satellite bandwidth will build to a peak during the plant construction phase, and then taper off slightly as the initial construction crew yields to plant operations (Wardrop, 2009b).

Closed Circuit TV (CCTV) cameras will be installed at various locations throughout the plant, including the primary crushing facility, the stockpile conveyor discharge point, the stockpile reclaim tunnel, the SAG and pebble crushing area, and the concentrate handling building. The cameras will be monitored from the plant control rooms (Wardrop, 2009b).

2.15.13.1 Site Wide Radio Communications System

The site radio communication system will operate in simplex and duplex modes. In simplex mode, only one user may communicate at a time. The system will also be capable of transmitting and receiving both voice and data. Site wide communications system will be comprised of the following (Wardrop, 2009b):

- fixed radios/repeaters,
- portable radios, and
- frequency assignment/approvals.

2.15.13.2 Site Wide Fibre Communications System

The site fibre communication system will be capable of operating in single and multimode depending on the length of fibre run. The fibre trunk will act as the main route of communication for the process LAN, business LAN, VoIP communication, and possibly security communication. The fibre trunk will connect all areas to the process mill and office complex (Wardrop, 2009b).

2.16 Transportation

2.16.1 Existing Access and Roads

The Minago Property is located directly adjacent to Manitoba Provincial Highway 6, a major north-south highway transportation route. The major transportation hubs closest to the Minago site are Winnipeg and Churchill, Manitoba (Figure 2.16-1). To date, the site has only been accessed via a winter road in the winter and by Argo or helicopter in the summer.

The Property may be served by the Hudson Bay Railway Company (HBR), with rail lines accessible from Ponton, MB, approximately 65 km north of the mine site.

Due to the Property's proximity to Provincial Highway 6, Wardrop assumed that all inbound freight for equipment and construction services will arrive by highway transportation. Operational inbound freight was also assumed to arrive via road transport.

2.16.2 Proposed Mine Access Road

The road network to be constructed on the Minago Property will be located in the VNI Mineral Lease Parcel.

In the proposed site layout, illustrated in Figure 2.1-2, roads will be located throughout the site to provide access to all operational areas of the mine. Roads will vary in width and general cross section depending on the location, staging and ultimate use of the roadway. Initial road widths of 6 m, 8 m, 12 m, 20 m and 30 m will be used throughout the mine site and will be constructed so that the finished roadway surface is a minimum 0.8 m – 1.0 m above the surrounding ground elevation (Wardrop, 2009b). Haul roads will facilitate movement of the 218 tonne trucks with the required clearances. The roads carrying highway truck traffic for incoming supplies and materials and outgoing ore concentrate will be designed to accommodate Super B-Train loading (GVW 62,500kg) and roads carrying mining ore will accommodate GVW 324,000kg haul trucks (Wardrop, 2009b).

All roads in-pit and around the waste rock dumps and tailings storage facility will be 30 metres in width. The 30 metre roads will allow the trafficking of the 218 tonne trucks. In-pit ramps are designed with an overall width of 30 m. The designed width includes an outside berm at 3.0 m wide and 1.8 m high; ditches at 2.5 m for two-lane traffic to accommodate a 218 tonne haul trucks. All of these 30 m roads will be decommissioned at the end of the mining operations.

The 8 m wide service road network will be for light equipment and not for ore trucks. These service roads include a 10 km road along the discharge pipeline to the Minago River and roads in and around the overburden storage area. All of the service roads will be decommissioned, except for the main access road into the center of the site.

All other 6-20 m wide service roads will be decommissioned, once these roads are not needed anymore.

Source: Wardrop, 2009b

Figure 2.16-1 Minago Shipping Routes

2.16.3 Concentrate Haulage Route

The saleable products of the Minago Mine will include nickel concentrate, two types of fracturing sand, and a flux sand product. It is anticipated that approximately 49,500 t/a of 22.3% nickel concentrate on an average year before transportation losses and 900,000 t/a of Frac Sand Plant products will be marketed annually.

Nickel concentrate may either be hauled by truck to Thompson, MB for smelting or the proposed Railway Siding along the OmniTrax Canada railway line near Ponton, MB or be trucked to Winnipeg for further transport to a suitable smelter for processing (Figure 2.16-2). Wardrop determined that shipping the concentrate by typical highway-type tractor trailer for 223 km (one way) to the smelter in Thompson, MB, is likely the most viable option (Wardrop, 2009b).

A separate study, entitled “Transportation Analysis for the Minago Sand Project” (Wardrop, 2008b), was completed for frac sand products to examine potential methods of bulk transportation from the Minago operation, such as railroad and highway-type haul trucks. It was assumed that the sand products produced at the Minago operation will either be trucked from the mine site directly to buyers, or trucked to a rail siding located at Ponton, MB, where it will be loaded into rail cars for onward shipment (Figure 2.16-2). This siding would be serviced by HBR, which has a working relationship with CN Rail. Alternatively, the sand may be trucked into Winnipeg where both CN Rail and CP Rail lines can be accessed. The Company will not own the facility at Ponton. OmniTrax will own the loadout facility.

2.16.4 Decommissioning Plans

Once the traffic around the site areas is reduced to a point where vehicle access is no longer required, most roads will be decommissioned. However, main access roads to the TWRMF and waste rock storage areas will only be partially decommissioned to permit vehicle access in case of emergency. Partial decommissioning will consist of narrowing the road width to 8 m, but leaving existing culverts in place. Regular decommissioning will consist of removing culverts and replacing them with cross-ditches and swales, ripping and scarifying road surfaces and revegetating them with the Minago custom revegetation mixture.

Access will remain for ATVs or similar transport for monitoring and inspections and with minimal effort vehicle access could be re-established.

Once the railway sidings will no longer be required, it will be decommissioned unless someone wants to take the facility over for further use. The two railside buildings will be removed with the exception of concrete foundations. Concrete foundations will be broken up to ground level and removed from the site. The dismantled materials will be sold to vendors as prevailing market conditions permit and remaining debris will be disposed of in an appropriate manner. Any diesel power gensets will be decommissioned and sold to vendors. Power distribution lines will be

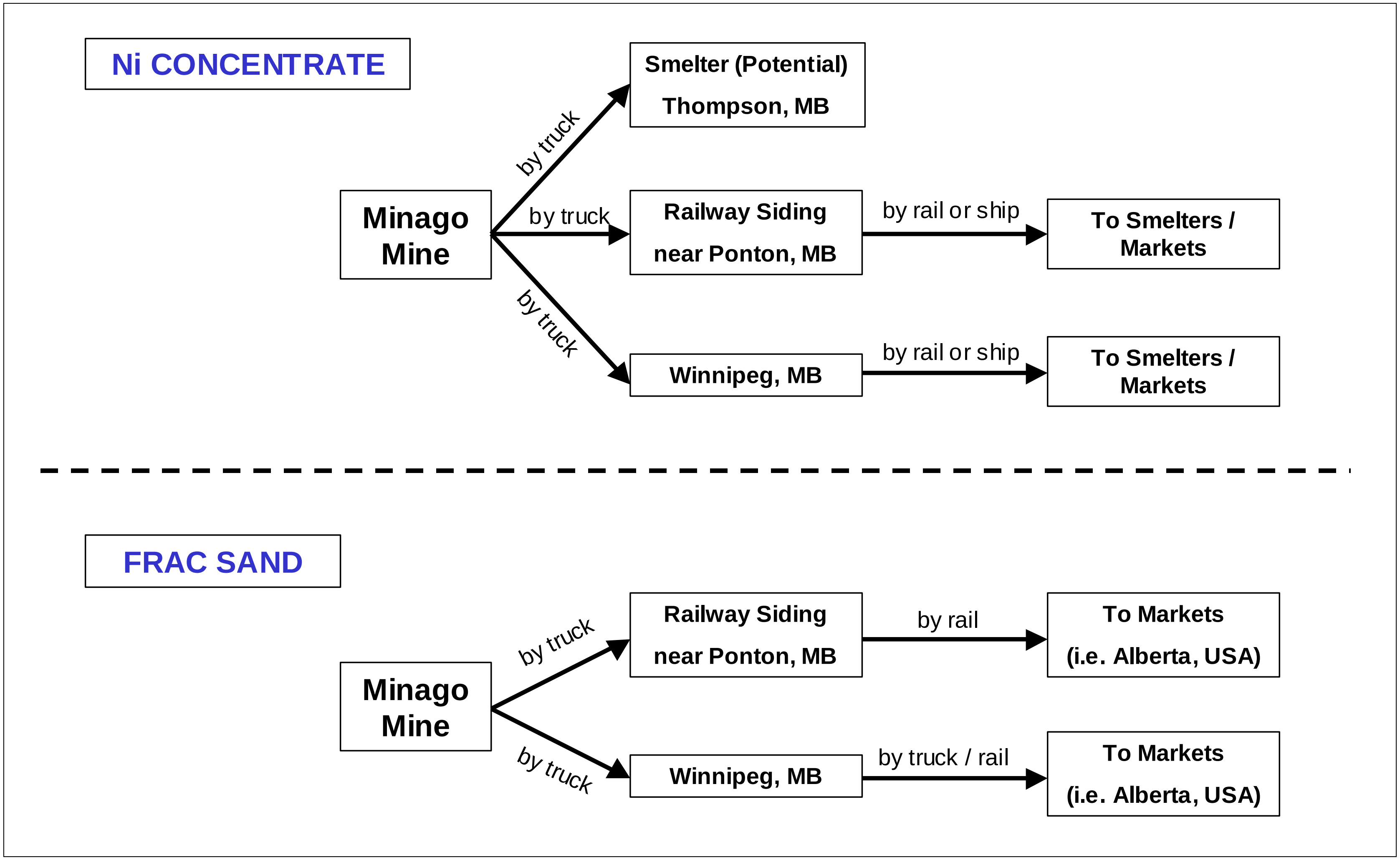


Figure 2.16-2 Concentrate and Frac Sand Haulage Routes

removed from the site and salvaged if possible. The disturbed areas will then be reclaimed using the Minago's revegetation shrubs.

2.16.5 Workforce Logistics

The Minago operation will be staffed by workers on a rotating 14-day basis. The majority of the operational workforce will be comprised of residents from surrounding local communities. Victory Nickel may provide bus service to and from the mine site through a contracted local bus company.

2.16.6 Environmental Impact

There will be no significant increase in environmental impact from these transportation decisions because current and well-established transportation routes and practices already exist on the Provincial Highway 6 corridor.