composed of diatoms, which made up more than 99% (numerically) of the sampled periphyton. The most common diatom species found in streams were *Diatoma tenue*, *Achnanthes minutissima*, and *Diatoma tenue elongatum*. Mean periphyton taxa richness ranged from 8 genera/sample at Windy Outflow to 13 genera/sample at Patch and P.O. outflows. Simpson's diversity indices for periphyton communities were relatively high at all sites (0.64 to 0.86) except Windy Outflow (0.32).

3.3.2 Benthic Invertebrates

Comprehensive lake and stream benthos baseline sampling programs were conducted in lakes/ponds and streams in the Madrid Area in 2009 (Rescan 2010f, 2011g). Additional baseline data are available for some lakes from 1995 to 1998, 2000, and 2006 to 2010, and for some streams from 1996, 1997, 2000, and 2006 to 2009 (Table 1.1-1; Figure 2.5-7).

Most lakes in the Madrid Area had benthos densities lower than 4,000 organisms/m^2, with densities ranging from 159 organisms/m^2 in Glenn Lake to 23,600 organisms/m^2 in Imniagut Lake in 2009. Lake benthic communities were generally dominated by dipterans (44 to 100% of organisms numerically), although pelecypods, ostracods, and oligochaetes were also common. Benthic communities in Wolverine and P.O. lakes differed slightly. In these lakes, dipterans comprised smaller fractions of the benthic communities (~15%, numerically) while pelecypods and ostracods were more numerous. Benthic genera richness and Simpson's diversity index were generally higher in the shallow depth zone compared to the mid and deep depth zones of lakes. Within the shallow depth zone, genera richness ranged from 2 genera/sample in Glenn Lake to 10 genera/sample in Wolverine Lake and Simpson's diversity ranged from 0.30 in Glenn Lake to 0.75 in Imniagut Lake.

Stream benthos density ranged from 3,160 organisms/m^2 in Patch Outflow to 12,300 organisms/m^2 in Ogama Outflow in 2009. Stream benthos assemblages were dominated by dipterans, which represented 43 to 88% of the stream benthic organisms. Nematodes, oligochaetes, and ostracods were also common in the study area, although they were not present at all sites. Benthic richness was consistent across streams in the Madrid Area, ranging from 14 to 16 genera/sample. Simpson's diversity was also similar across streams, ranging from 0.66 in Ogama Outflow to 0.83 in P.O. Outflow.

3.3.3 Fish Habitat and Fish Community Sampling

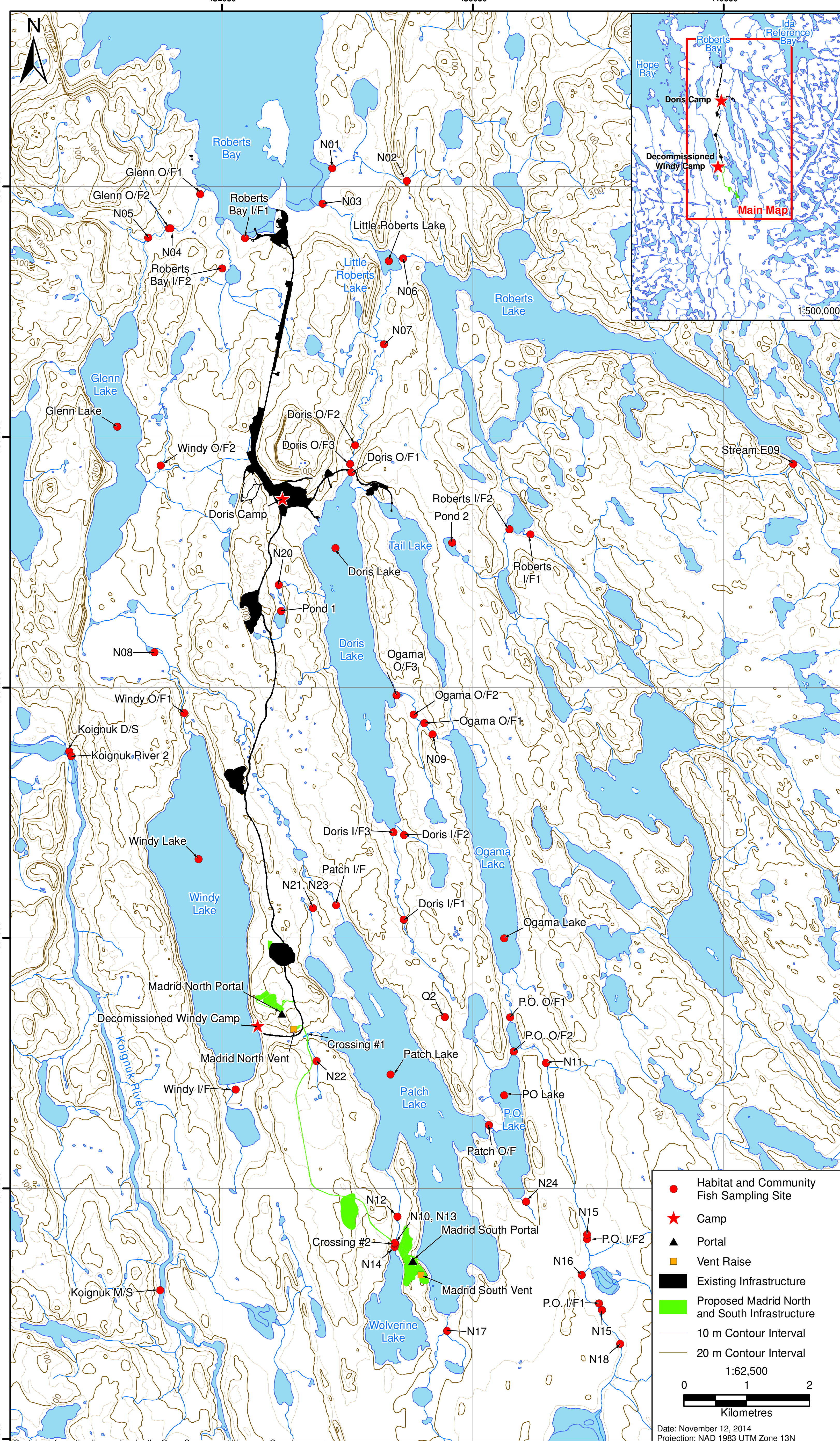
Baseline fish studies were conducted in the Belt from 1993 to 2009. Comprehensive baseline programs were also carried out in 2009 and 2010 within the Madrid Area (Rescan 2010f, 2011a). Baseline fish habitat and fish community information was collected for multiple waterbodies (i.e., lakes/ponds and streams) located adjacent to or at proposed infrastructure over these two years (Figure 3.3-1).

Fish habitat, defined as those environmental components that are required either directly or indirectly by fish to carry out their life processes, including spawning and rearing areas, food production areas, migration routes, and over-wintering areas, was assessed using a variety of methods. Lake and pond habitat was evaluated using hydroacoustics and/or visual observations, whereas streams were evaluated using either the detailed Fish Habitat Assessment Procedure (FHAP) or Sensitive Habitat Inventory Mapping (SHIM) survey methods depending on the site and potential infrastructure effects on the site.

Lakes were the predominant form of fish habitat in the Madrid Area and supplied the greatest amount of perennial fish habitat. A total of eight lakes from the Madrid Area were included in baseline studies, ranging in surface area from 83.1 ha (P.O. Lake) to 1,062.8 ha (Reference Lake B). Fines (e.g., silt clay or mud) were found to be the predominant substrate type in lakes. Reference lakes showed relatively higher percentages of hard substrates such as bedrock and boulder, while Patch Lake showed concentrations of fish associated with deepwater habitat over substrates of mud or fines. Ponds (maximum depth is <3 m) assessed in the Madrid Area were rated as having limited habitat.

Figure 3.3-1

Fish Habitat and Fish Community Sampling in the Madrid Area, 2009 to 2010



The SHIM method is used as a standard for watercourse and fish habitat mapping in British Columbia; methods were tailored and adapted for streams encountered in Nunavut (Mason and Knight 2001). This method attempts to ensure the collection and mapping of reliable, high quality, current and spatially accurate information about fish habitats and watercourses. It is particularly helpful for providing the necessary information when assessing the potential effects of specific infrastructure on fish and fish habitat.

Overall, channel and instream habitat characteristics were similar among streams and typical of slow moving streams flowing through tundra wetlands. Mean channel gradients ranged from 1 to 3.5 % and the dominant habitat unit was wetland. Instream vegetation was the dominant cover type. Deep pools were rarely observed. Organic material was the dominant substrate type in all streams. Hard rocky substrates were rarely observed. Ninespine Stickleback was the only fish species identified in the assessed streams. Overall, habitat quality was generally marginal except in N15 (upstream of Ogama Lake, in which overall habitat quality was classified as important.

Information collected through FHAP surveys indicated that streams in the Madrid Area were generally ephemeral and offered temporary habitat for fish during the spring and early summer months. Outflow streams from lake sources were relatively larger and permanent (e.g., Patch Outflow). These streams supplied relatively high quality habitat, especially for small-bodied fish species such as Ninespine Stickleback (*Pungitius pungitius*). Juvenile Lake Trout (*Salvelinus namaycush*) and Arctic Char (*Salvelinus alpinus alpinus*) were also observed utilizing these large streams for rearing habitat. High quality habitat was also found in P.O. Inflow, P.O. Outflow, Windy Inflow, and N15.

Large-bodied fish communities in lakes were assessed using RISC standard monofilament gillnets and with hydroacoustic gear at Patch Lake. The fish community of stream sites was primarily assessed using backpack electrofishing gear. Fish communities were defined in terms of total number and number-by-species at each sampling location, total Catch-Per-Unit-Effort (CPUE) and species-specific CPUE for each type of assessment gear. Biological features of fish such as length, weight, condition, age and diet were also measured as were tissue metal concentrations.

Specific information with regards to fish habitat and fish community sampling throughout the Madrid Area and pertinent adjacent areas is summarized in Section 4.

4. Fisheries

4. Fisheries

4.1 BACKGROUND

The Madrid Area bulk sample sites are located south of Doris North camp within the Windy-Glenn and Doris-Roberts watersheds (Figure 2.5-2). The Windy-Glenn Watershed originates just south of Windy Lake; it drains north through Windy Lake and then Glenn Lake before discharging into the ocean at Roberts Bay. In the Doris-Roberts Watershed, Wolverine Lake drains into Patch Lake in the upper reaches of the watershed. The watershed then drains through a series of lakes, including P.O., Ogama, and Doris Lake. Downstream of Doris Lake, Doris Creek flows over a 4 m high waterfall, and then joins the Roberts Watershed in Little Roberts Lake (downstream of Roberts Lake). Roberts Creek flows from Little Roberts Lake northwest for approximately 1.5 km where it enters Roberts Bay. The EIS for the Doris North Mine (Miramar 2005) was approved in 2006; this document described the environmental setting for the Doris Watershed adjacent and downstream of the mine, including Doris Lake and Little Roberts Lake. These two lakes will not be addressed further in this application as the EIS (Miramar 2005) provided a comprehensive review.

The proposed Madrid South bulk sample site is located on a narrow section of land between Patch Lake (to the east) and Wolverine Lake (to the west). This site falls completely within the Doris-Glenn Watershed. A new access road 5 km in length would extend south from the existing Windy - Doris Camp road. The proposed access road would primarily be located within the Doris-Roberts Watershed; a section less than 1 km in length would be in the Koignuk Watershed (Figure 2.5-2). The section of road in the Koignuk Watershed is located on top of a ridge far from any Koignuk Watershed waterbody. This section of road will not directly or indirectly impact the Koignuk Watershed, so this watershed will not be assessed further in this application.

This road extension would require two crossings (Figure 2.5-2). The most northern crossing (Crossing #1) is located slightly upstream of an inflow to Patch Lake, whereas the more southern crossing (Crossing #2) is situated at one of the outflows (most southern end) of Wolverine Lake (inflow to Patch Lake). Only Crossing #2 is fish-bearing (with confirmed ninespine stickleback). It is currently anticipated that closed-bottom culverts will be installed at these two locations since neither crossing location contains fish that are part of a recreational, commercial or Aboriginal fisheries, or that support such a fishery, as per the *Fisheries Act* (1985).

The Madrid North bulk sample site is located adjacent to the existing Windy Lake Camp between Patch Lake and Windy Lake (Figure 2.5-2), straddling the divide between the Windy and Doris Watersheds. Access to this site would utilize the existing Windy - Doris Camp road.

Extensive fish and fish habitat studies have been completed in waterbodies around the Madrid Area bulk sample sites between 1995 and 2013 (Table 4.1-1). The following section summarizes historical sampling for lakes and streams in the Doris-Roberts and Windy-Glenn watersheds downstream of the Madrid Area. Waterbodies are organized by watershed; within watersheds they are ordered from upstream to downstream.

Table 4.1-1. Historical Sampling of Freshwater Fish Habitats and Fish Communities in Waterbodies Adjacent to the Madrid Advanced Exploration Program Area, 1995 to 2013

Watershed	Waterbody or Site	Environment	Species	Sampling Years
Doris-Roberts	Wolverine Lake	Lake	CS, NSB	2006, 2007, 2008
	Imniagut Lake	Lake	N/A	Not sampled; to be sampled in 2014
	Patch Lake	Lake	CL, LT, LW, NSB, CS	1995 to 1999, 2006 to 2009
	P.O. Lake	Lake	CL, LT, LW, NSB	2006, 2007, 2009
	Ogama Lake	Lake	CL, LT, LW, NSB	1996, 2006, 2007, 2009
	Wolverine Outflow	Stream	NSB	1997, 2010
	Imniagut Outflow	Stream	N/A	Not sampled; to be sampled in 2014
	Patch Outflow	Stream	N/A	2006, 2009
	P.O. Outflow	Stream	NSB	2006, 2007, 2009
	Ogama Outflow	Stream	LT, LW, CL, NSB	1995, 1997, 2005 to 2007, 2009, 2010
Windy-Glenn	Nakhaktok Lake	Lake	N/A	Not sampled; to be sampled in 2014
	Windy Lake	Lake	LT, LW, CL, NSB	1996, 1997, 1999, 2008, 2009, 2012, 2013
	Glenn Lake	Lake	AC, LT, LW, CL	1997, 2000, 2006, 2007, 2009
	Nakhaktok Outflow	Stream	N/A	Not sampled; to be sampled in 2014
	Windy Outflow	Stream	LT, NSB, AC	1996, 1997, 2003, 2009, 2010
	Glenn Outflow	Stream	AC, LT, NSB, CCG, SFL	1997, 2000, 2003, 2009, 2010

Fish Species Codes: CS = Least Cisco, NSB = Ninespine Stickleback, CL = Lake Cisco*, LT = Lake Trout, LW = Lake Whitefish, AC = Arctic Char, CCG = Slimy Sculpin, SFL = Starry Flounder, N/A = fish community not sampled*
** It is difficult to identify Cisco to the species level, so these identifications should be interpreted with caution.*

4.2 DORIS-ROBERTS WATERSHED

4.2.1 Wolverine Lake and Outflow

Fish community baseline data were collected from Wolverine Lake in 2006, 2007, and 2008 (Golder 2008a, 2008b, 2009e). Over 4,000 fish were sampled using a range techniques and only two species were caught; Least Cisco (Coregonus sardinella) and Ninespine Stickleback (Table 4.1-1). The Least Ciscoes in Wolverine Lake were significantly smaller than in other local lakes, possibly due to the small, isolated size of the lake and the lack of a predatory fish species (Golder 2009b). No habitat data exists for Wolverine Lake.

Wolverine Lake has two outflows that connect this lake to Patch Lake; one flows to the north (Crossing #2) and one to the east. Both channels were sampled once for fish community in 1997 and once for habitat in 2010. Habitat assessments found that neither outflow has a clearly defined channel, as water seeps through vegetation over a broad area. Both channels are ephemeral, typically containing flowing water only during snow melt in spring. Water depth is minimal even during spring snowmelt (maximum water depth was 20 cm during 2010 spring surveys), there are no pools, and habitat is generally of poor quality (Rescan 2011b).

During 1997 spring freshet sampling, Ninespine Stickleback were caught in both outflows immediately upstream of Patch Lake (includes Crossing #2). The sample sites were described as flooded wetlands, reflecting the ephemeral nature of the channels. Both outflows of Wolverine Lake provide limited seasonal rearing habitat for juvenile and small-bodied fish during spring freshet. However, the connectivity between Patch Lake and Wolverine Lake appears to be limited.

4.2.2 Imniagut Lake and Outflow

The fish community and habitat quality of Imniagut Lake and Outflow have not previously been sampled; however, sampling of these waterbodies is scheduled for 2014.

A Sensitive Habitat Inventory and Mapping (SHIM) survey was completed on an inflow to Imniagut Lake in 2010 (Rescan 2011b). A section of creek 1,873 m in length was assessed, ending at the confluence with Imniagut Lake. Channel morphology was primarily a mixture of riffles and flooded wetlands. This inflow does not provide overwintering habitat due to its shallow depth and limited pool habitat. The overall habitat in this tributary was rated as marginal.

An assessment of the outflow of Imniagut Lake has not been completed, but aerial photographs indicate that it discharges into Patch Lake through a short outflow channel (approximately 50 m in length). Connectivity for fish movement between Patch Lake and Imniagut Lake has not been assessed.

4.2.3 Patch Lake, Outflow and Inflow

Fish community studies were conducted at Patch Lake from 1995 to 1999 and from 2006 to 2009, including an extensive Lake Trout population estimation study in 2007. Based on these studies, the fish community is composed of Lake Trout, Lake Whitefish (*Coregonus clupeaformis*), Least Cisco, Lake Cisco (*Coregonus artedii*) and Ninespine Stickleback (Table 4.1-1). CPUE for each fish species was highly variable between years due to various gillnet mesh sizes used for each study. The abundance of the three large-bodied species were relatively similar, regardless of gillnet mesh size. Mean fork length for Lake Trout and Lake Whitefish ranged from 433 to 702 mm and 372 to 475 mm, respectively. Lake Cisco fork length showed consistency between studies, ranging from 225 to 267 mm. Lake Whitefish showed the highest mean condition with values ranging from 1.20 to 1.33 g/mm^3 among studies. Ranges in mean condition for Lake Trout and Lake Cisco were considerably lower, ranging from 0.94 to 1.03 g/mm^3 and 0.77 to 1.09 g/mm^3, respectively. Stomach contents, sampled from Lake Trout and Lake Whitefish in 2008, indicated that Lake Trout fed predominantly on fish at time of sampling, while Lake Whitefish fed on isopods, gammarids and chironomids. Samples of muscle and liver were taken from Lake Trout and Lake Whikefish between 1995 and 1998 for baseline metals analyses.

Patch Lake Outflow is a short section of stream (less than 200 m) that connects Patch Lake to P.O. Lake. Beach seining in the outflow did not catch fish in 2006, but Lake Trout and Ninespine Stickleback were observed in the outflow during habitat assessments in 2009 (Table 4.1-1). The outflow appears to provide good connectivity between Patch and P.O. Lake, and the lower section (closer to P.O. Lake) provides the best quality fish habitat.

An eastern-flowing water source flows into Patch Lake at its northwestern end. The proposed road crossing (Crossing #1) is located along the drier and mostly underground headwater portion of this inflow; however, to the west and slightly upstream, the inflow consists of ephemerally-connected ponds. The most downstream reach situated just upstream of the lake is relatively steep (measured 8% near the mouth). The inflow is considered non-fish bearing; no fish were captured during fishing surveys conducted in 2010 (either through electrofishing along the inflow or minnow traps set in the ponds situated upstream).

4.2.4 P.O. Lake and Outflow

Fish community studies were conducted on P.O. Lake in 2006, 2007 and 2009. Lake Trout, Lake Whitefish, Lake Cisco and Ninespine Stickleback were captured in all studies (Table 4.1-1). Relative abundance of fish species varied among years. In 2006 and 2007 the predominant species captured was Lake Whitefish, while the Lake Cisco were the predominant species in 2009. Mean length of all species was consistent among study years. The range in mean fork length for each species was: Lake Trout (494 to 597 mm); Lake Whitefish (365 to 408 mm); and Lake Cisco (209 to 227 mm). Mean fork length of Ninespine Stickleback was 47 mm. Mean condition of Lake Whitefish in P.O. Lake was high relative to other lakes in the Project area, with means ranging from 1.36 to 1.53 g/mm3. Lake Trout displayed lower condition, with means ranging from 0.84 to 1.10 g/mm^3. The predominant food items observed through stomach content analysis of Lake Trout conducted in 2009 included chironomids and fish, while amphipods were the main diet of Lake Whitefish at time of fishing. Muscle and liver tissues were also sampled from Lake Trout (n = 10) and Lake Whitefish (n = 4) in 2009 for the evaluation of baseline metals concentrations.

P.O. Lake Outflow flows through a small lake (sometimes referred to as P.O. Connector Lake) and connects P.O. Lake to Ogama Lake. Fish community and fish habitat studies were conducted in 2006, 2007 and 2009. Ninespine Stickleback were the only fish species captured using electrofishing and beach seining gear. The mean fork length of fish captured ranged from 36 to 48 mm, while the mean condition was 0.97 g/mm^3 reported in 2009. The habitat value was highly rated due to varied habitat types and abundant cover for fish.

4.2.5 Ogama Lake and Outflow

Fish community studies were conducted at Ogama Lake in 1996, 2006, 2007 and 2009. The fish community was consistent with other lakes in the Doris Watershed, and included Lake Trout, Lake Whitefish, Lake Cisco and Ninespine Stickleback (Table 4.1-1). Lake Cisco was the most abundant large-bodies species in the catch. Lake Trout were the largest species captured with mean fork lengths ranging from 291 to 646 mm, while Ninespine Stickleback were the smallest with a mean fork length of 58 mm. Lake Trout displayed relatively low condition with means ranging from 0.89 to 0.93 g/mm^3 among study years. Lake Whitefish had the highest mean condition, ranging from 1.24 to 1.29 g/mm^3. Diet and tissue metal concentration data are not available for Ogama Lake.

Ogama Outflow was studied for fish habitat and fish community in 1995, 1997, 2005, 2006, 2007, and 2009. The fish community was represented by four species: Lake Trout, Lake Whitefish, Lake Cisco and Ninespine Stickleback (Table 4.1-1). Lake Trout were the largest species captured, with mean fork lengths ranging from 389 to 535 mm. Ninespine stickle back were the smallest fish captured with mean fork lengths ranging from 43 to 56 mm. Lake Whitefish displayed the highest mean condition at 1.56 g/mm^3, while Lake Trout had the lowest mean condition at 1.08 g/mm^3. Additional fish community variables such as diet and tissue metals were not examined in past studies.

Ogama Outflow is characterized by long stretches (i.e., 100 m) of riffle and glide habitat, and short stretches (i.e., 10 m) of pool habitat. Stream gradient ranged from 1.2 to 4.0%. Stream channel dimensions ranged from 4.0 m to 12.2 m for bankfull width, and 1.5 m to 2.2 m for bankfull depth. While the primary bed material present was fines, there was a diverse mixture of substrates, at least relative to other streams within the Project area. The major source of cover for fish within Ogama Outflow was instream cover. Trace amounts of overhanging vegetation and large woody debris were also present. Overall habitat quality was rated as marginal.

4.3 WINDY-GLENN WATERSHED

4.3.1 Nakhaktok Lake and Outflow

Nakhaktok Lake is a small lake in the upper reaches of the Windy Watershed. The fish community and fish habitat of this lake have not been sampled.

The lake discharges into a wetland area that lacks a clearly defined channel. Field crews working in Windy Lake noted that discharge between Nakhaktok Lake and Windy Lake is braided and ephemeral, and there is likely poor connectivity for fish between these lakes.

4.3.2 Windy Lake and Outflow

Fish habitat and fish community studies were conducted on Windy Lake and Outflow in 1996, 1997, 1999, 2008, 2009, 2010, 2012, and 2013 (Table 1.1-1). The fish community consists of Lake Trout, Lake Whitefish, Lake Cisco, and Ninespine Stickleback (Table 4.1-1). Gillnet CPUE show that Lake Cisco were captured in the highest relative abundance in most studies. Compared to Lake Trout sampled from other lakes in the Project area, Lake Trout sampled from Windy Lake are relatively large. Mean fork length for Lake Trout from Windy Lake ranged from 434 to 910 mm. Lake Cisco were also relatively large with mean fork lengths ranging from 291 to 344 mm. The mean condition of Lake Trout and Lake Cisco ranged from 1.04 to 1.12 g/mm^3, and from 0.93 to 1.11 g/mm^3, respectively. Stomach contents of Lake Trout and Lake Cisco examined in 2008 and 2009 indicated that Lake Trout fed primarily on gammarids, amphipods and fish, while Lake Cisco fed predominantly on mysids. Muscle and liver tissues collected from Lake Trout in 1999 and 2009 showed similar levels of mercury.

Windy Lake was selected for an enhancement project to partly compensate for impacts to fish habitat caused by infrastructure construction. Compensation and reference sites were selected in 2010 and shoals were constructed in 2011 (Figure 4.3-1). Two years of monitoring (2012 and 2013) have tracked the development of periphyton, invertebrate, and fish communities at enhancement sites. Two compensation shoals and one natural shoal reference site are located adjacent to the shoreline immediately to the west of the proposed Madrid North bulk sample sites.

The fish community and habitat of Windy Lake Outflow was sampled in 1996, 1997, 2003, 2009, and 2010 (Table 1.1-1). Windy Outflow is composed of pool, riffle and glide habitat types. Stream gradient ranged from 0 to 1.3%, while the stream bank dimensions ranged from 4.5 m to 9.2 m, for bankfull width, and 0.8 m to 1.5 m, for bankfull depth. The stream bed material was predominantly composed of fines. The total amount of cover available for fish within the stream was abundant, ranging from 78 to 90%. Overall habitat quality was rated as marginal.

Lake Trout, Ninespine Stickleback and Arctic Char (a single juvenile) have been captured in Windy Outflow (Table 4.1-1). Anadromous Arctic Char overwinter in Glenn Lake, but have never been caught in Windy Lake despite extensive sampling. A section of the creek between Windy and Glenn Lake may restrict the ability of migrating Arctic Char to reach potential overwintering habitat in Windy Lake. During habitat surveys, this section was described as a “marshy area” and it was noted that the channel was poorly defined, creating a seasonal restriction when anadromous fish return in the fall.

4.3.3 Glenn Lake and Outflow

Studies of Glenn Lake fish habitat and fish community were conducted in 1997, 2000, 2006, 2007 and 2009. The fish community comprised Arctic Char, Lake Trout, Lake Whitefish and Lake Cisco (Table 4.1-1). Arctic Char were not captured during the 2009 study. Lake Trout have also been documented to migrate to and from Glenn Lake and Roberts Bay via the Glenn Lake outflow. Lake Cisco showed the highest relative abundance in gillnet catches. Lake Trout were the largest species captured, with mean fork lengths ranging from 439 to 527 mm. The mean fork length of Arctic Char was 223 mm, representing the smallest species captured by gillnets in 2006 and 2007. Condition for each species were relatively high throughout the study periods. Lake Whitefish displayed the highest mean condition at 1.45 g/mm^3, while Lake Trout showed the lowest mean condition at 0.85 g/mm^3. Fish tissue metal samples have not been collected from Glenn Lake.

The fish habitat and fish community of Glenn Outflow was sampled in 1997, 2000, 2003, 2009, and 2010. Fish habitat was composed of pool, riffle and glide habitat types. The stream gradient ranged from 0 to 3.2%. Stream bank dimensions ranged from 5.1 m to 8.0 m for bankfull width, and 1.1 m to 1.5 m for bankfull depth. Fines were the predominant substrate type present. Cover available for fish in the outflow ranged from 3.2 to 20%. Instream cover and undercut banks were the primary cover types present. Overall habitat quality was rated as important because Glenn Outflow is a migratory route for anadromous Lake Trout moving to and from Glenn Lake and Roberts Bay. Juvenile Arctic Char, Lake Trout, whitefish spp. and Lake Cisco have also been captured near Roberts Bay (Table 4.1-1).

The fish community of Glenn Outflow was represented by Arctic Char, Lake Trout, Ninespine Stickleback, Slimy Sculpin (*Cottus cognatus*) and Starry Flounder (*Platichths stellatus*). Starry Flounder was captured in 2009 (n = 1), while remaining species were captured in all study years. Mean fork lengths for Arctic Char ranged from 205 to 820 mm, while mean fork lengths for Lake Trout ranged from 142 to 390 mm. Mean fork lengths of Ninespine Stickleback and Slimy Sculpin were 45 mm and 58 mm, respectively. Condition for Arctic Char and Lake Trout were calculated in the 2003 study. Mean condition of Arctic Char and Lake Trout were 1.17 g/mm^3 and 1.01 g/mm^3, respectively.

4.4 ABORIGINAL, COMMERCIAL, AND RECREATIONAL SPECIES SUMMARIES

Baseline fish community sampling identified seven freshwater fish species in the Madrid Area (Table 4.4-1). Life history types and habitat preferences of fish of Aboriginal, commercial or recreational importance are summarized below. Information was summarized from McPhail and Lindsey (1970), Scott and Crossman (1973), Richardson et al. (2001), and references therein.

Table 4.4-1. Fish Species Captured in the Hope Bay Belt Project Area

Common Name	Scientific Name	Habitat	Spatial Distribution	Watershed
Lake Trout	*Salvelinus namaycush*	Freshwater	Benthopelagic	D,W
Arctic Char	*Salvelinus alpinus*	Anadromous	Benthopelagic	W
Lake Whitefish	*Coregonus clupeaformis*	Freshwater	Demersal	D,W
Lake Cisco	*Coregonus artedi*	Anadromous	Neritopelagic	D,W
Least Cisco	*Coregonus sardinella*	Freshwater	Neritopelagic	D
Slimy Sculpin	*Cottus cognatus*	Freshwater	Demersal	W
Ninespine Stickleback	*Pungitius pungitius*	Freshwater	Benthopelagic	D,W

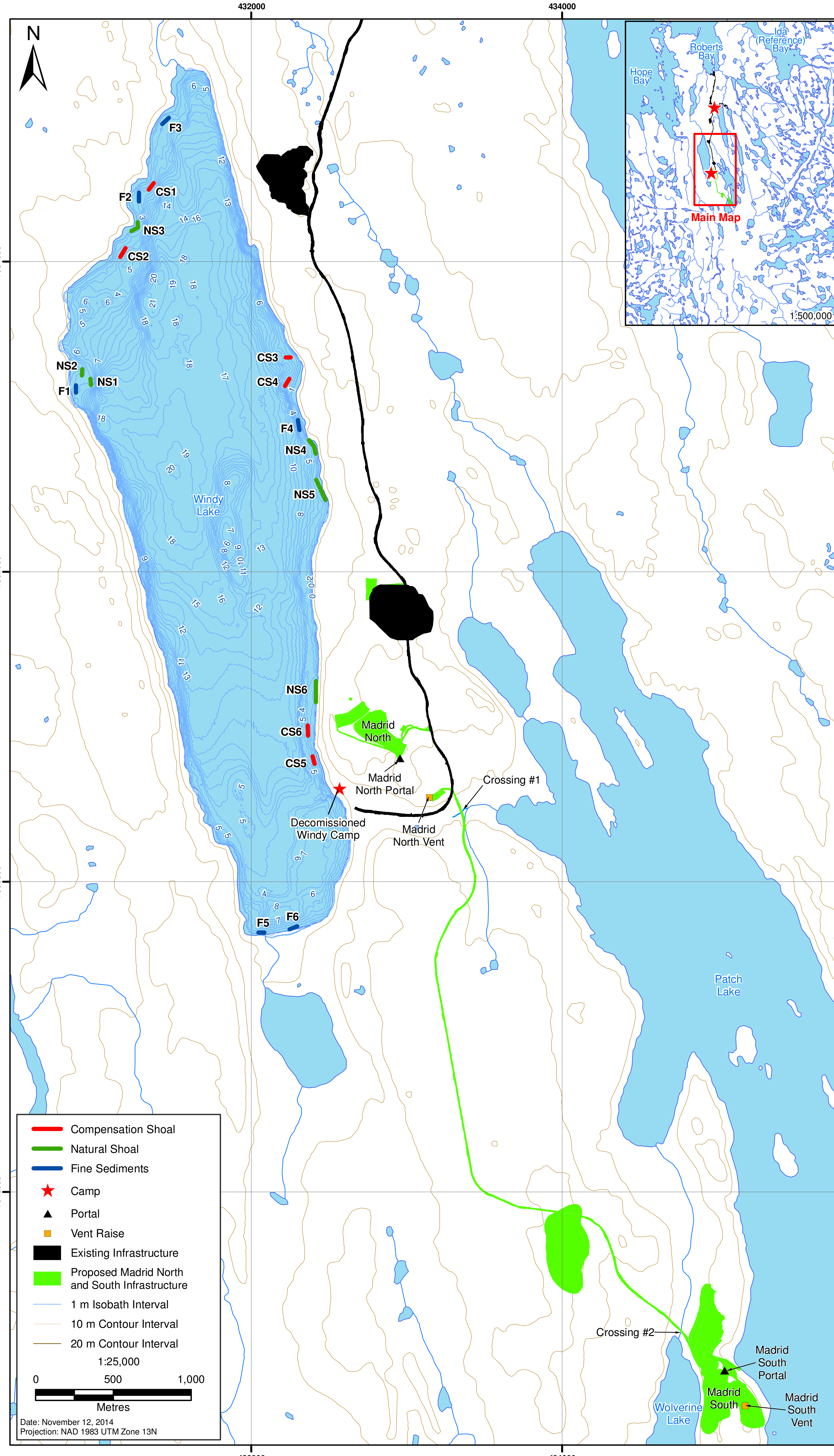
Watershed codes: D = Doris-Roberts, W = Windy-Glenn

4.4.1 Lake Trout

Lake Trout typically exhibit both lacustrine (lake resident) and adfluvial (river resident) life history types, but in the Hope Bay Belt there are unusual anadromous populations (migrate between freshwater and marine environs (Swanson et al. 2010)). Lake Trout spawn in fall, from September to October in northern regions. Spawning grounds are almost always associated with cobble, boulder and gravel substrates, where there is no vegetative cover, in depths less than 1 m to greater than 10 m. Eggs settle into cracks and crevices amongst the rocks, where they incubate for 4 to 5 months, with eggs usually hatching in March or April. Young-of-the-year remain in spawning areas from several weeks to several months, moving into deeper areas as water temperatures rise to greater than 15°C. Young-of-the-year and juveniles both prefer areas of cobble and boulder substrate for cover, and inhabit waters with a depth range of 2 to >10 m or alternatively inflows and outflows of the lake. Juveniles are often associated with large boulders, which they use for cover. Adult Lake Trout disperse into deeper water habitats, >10 m in depth, and are often found in the pelagic zone. Lake Trout feed on a wide variety of prey items including fish, molluscs, crustaceans, freshwater sponges and small mammals.

Figure 4.3-1

Fish Habitat Compensation and Reference Sites in Windy Lake



4.4.2 Arctic Char

Arctic Char occur in northern coastal regions in rivers, lakes, estuaries, and marine environments. They exhibit both anadromous and resident lacustrine life history types. Anadromous Arctic Char are found in several watersheds with a suitable set of habitats. Lakes must be of sufficient size to provide suitable overwintering habitat and these lakes need to be connected to the ocean by streams that can be navigated by adults, even during periods of low discharge in the fall. Freshwater populations feed on planktonic crustaceans, amphipods, molluscs, insects, and fishes, while marine populations are primarily piscivorous and feed almost exclusively on marine resources. Arctic Char require cold, highly oxygenated water and are extremely sensitive to water pollution. Arctic Char are the most economically important fish to the Inuit population of Nunavut. In the Melville Sound area, commercial fisheries operate during upstream runs in Elu Inlet and the Kulgayuk River (DFO 2004).

Arctic Char spawn in freshwater in the fall, usually September or October, over gravel and cobble shorelines of lakes and occasionally larger rivers. In the Belt area, and the central Canadian Arctic in general, spawning usually takes place in lakes because most streams and rivers freeze completely in winter. Males arrive first on the spawning grounds and establish and defend territories. Females are “courted” by males as they arrive later. The female digs a nest or redd in water typically 3 to 6 m deep, in which the eggs are deposited. The eggs incubate under ice for about six months. In most systems char are ready to take their first migration to sea at 4 to 5 years of age and a length of 150 to 250 mm (Johnson 1980). Young Arctic Char do not venture much past the brackish water of river estuaries, but as they grow, they develop a tolerance to higher salinity sea water. They feed in nearshore areas along the coast for the duration of the summer. More abundant food resources in marine waters allow anadromous Arctic Char to grow faster and larger than the freshwater form. At sea, char feed mainly upon invertebrates and fishes. In the fall, all char return to freshwater to overwinter (Johnson 1980).

4.4.3 Lake Whitefish

Lake Whitefish are found throughout Nunavut, predominantly in lakes, although they are also found in large rivers and brackish waters. Lake Whitefish may exhibit lacustrine, adfluvial and anadromous life history types. They spawn in both lakes and rivers over gravel, cobble and boulders at depths of less than 5 m. Eggs are released over the substrate and fall into interstices between rocks where they incubate for several months, hatching sometime from March to May. Young-of-the-year are commonly found in the spawning area in shallow water (<1 m) near the surface, and prefer substrates of boulder, cobble and sand with abundant emergent vegetation and woody debris. Adults are usually found in the open water at depths >10 m and do not show a preference for substrate. Adults are predominantly benthic, although they may be found in the pelagic zone. Lake Whitefish have been reported to make onshore movements into shallow water at night, possibly to feed.

5. Traditional Water and Land Use Areas

5. Traditional Water and Land Use Areas

5.1 BACKGROUND

The Hope Bay Belt Property is located in the Kitikmeot region of Nunavut, approximately 685 km northeast of Yellowknife. The closest settlements to the Madrid district are Umingmaktok (~70 km) and Kingaok (~150 km). The communities of Cambridge Bay (~130 km) and Kugluktuk (~350 km) are the closest major regional centres. Other communities within the region that are further removed from the project location, include Gjoa Haven (~445 km), Taloyoak (~550 km) and Kugaaruk (~690 km; Figure 5.1-1). Distances are approximate and direct (HBML 2011).

The Nunavut Planning Commission (NPC), as established under the Nunavut Land Claim Agreement, is currently developing a Nunavut Land Use Plan (NLUP) for all Nunavut regions that are outside of municipal boundaries. Once in place, the NLUP will be used to guide and direct resource use and development into the future. This Nunavut-wide planning approach was adopted to address inefficiencies in the previous regional approach. Until recently, land use planning in Nunavut had been approached regionally (HBML 2011; Rescan 2012c).

The Hope Bay Belt, including the Madrid North and South site, lies within the former West Kitikmeot Regional Land Use Plan (WKRLUP) boundary. The WKRLUP was in draft form before the regional planning process was halted and replaced with the Nunavut-wide approach. In the absence of an approved plan, the values and interests expressed by the WKRLUP from the original regional planning process are considered. The Hope Bay Belt also falls within the traditional "Areas of Influence" (as defined by the WKRLUP) of the communities of Bathurst Inlet, Umingmaktok, and Cambridge Bay. Areas of Influence encompass broad areas of land and sea that are included in traditional land use patterns by community members (HBML 2011; Rescan 2012c).

The Inuit people of the Kitikmeot have a longstanding relationship of reciprocity and respect with their region's wildlife and environment as a whole, as is manifested within Inuit Qaujimajatuqangit (Golder 2003b). In Inuit culture, the environment is valued as a whole: the value of one ecosystem component cannot be ranked or differentiated from the value of another. As such, the relative value of ecosystem components is not considered within Inuit Qaujimajatuqangit and traditional practices. Despite the ongoing Westernization of Inuit society, Inuit Qaujimajatuqangit, including ways of respecting wildlife and the environment as a whole, persist and continue to be passed from generation to generation (Golder 2003b). The values that guide traditional activities and subsistence harvests are reflected in the Inuit approach to historic and contemporary land and resource use activities in the Kitikmeot Region (Rescan 2012c).

5.2 INUIT QAUJIMAJATUQANGIT

As part of the Environmental Impact Statement (EIS) of the Doris North Project, *Inuit Qaujimajatuqangit* (IQ) provided assistance in obtaining baseline data for the Hope Bay Belt, which includes the Madrid North and South sites (Miramar Hope Bay Ltd. 2005). IQ for the Hope Bay Belt area was augmented with results from a three-day IQ Workshop in 2003 that was held in Iqaluktuuttiaq (Cambridge Bay; Golder 2003b).

Figure 5.1-1
Communities within the Kitikmeot Region of Nunavut

For generations, Nunavummiut have had to monitor water quality to ensure survival. For example, careful observation of variations in suspended sediment determines if water is fit for drinking. Both fish and animals are used as indicators when observing changes in water quality. Given this history, Inuit understand that changes to water quality can have far reaching effects on animals and fish, and the ecosystem as a whole. The record of documented IQ of environmental change includes observations of changes in water levels and water quality throughout the Kitikmeot region (Miramar Hope Bay Ltd. 2005). IQ has also shown that melting permafrost and the consequent increase in suspended sediments in major river bodies, such as in the Coppermine River, has had a profound influence on water quality (Miramar Hope Bay Ltd. 2005).

Lake Trout are important to local Inuit for food, while fishing is central to culture, identity and recreation. Arctic Char are considered most valuable for subsistence living by local communities, followed by Lake Trout and Lake Whitefish. The Hope Bay Belt in general has always been a popular region for fishing. Participants in the IQ Workshop commented that most of the lakes in the Project area were commonly fished. Although many traditional names for waterbodies in the Project area have not been recorded, there is still evidence of fishing camps throughout the region (Golder 2003b; Miramar Hope Bay Ltd. 2005).

In the Kitikmeot region, Caribou continue to be the most important subsistence mammal. Today, as in the past, Caribou are hunted for food, clothing, tools and other materials and the act of Caribou hunting is central to Inuit identity, culture and subsistence.IQ indicates that the region around the Hope Bay Belt is important Caribou habitat, particularly for calving (i.e., historical grounds for the Bathurst herd), and that Caribou are indicators of environmental change (Golder 2003b). There are three Caribou herds whose ranges may occur near the Project Area: the Bathurst, the Ahiak (meaning “berries” or “from where there are berries” [i.e., the mainland]) and the Dolphin-Union herds (Miramar Hope Bay Ltd. 2005). Historically the Hope Bay Belt area has been important for Bathurst Caribou migration and calving. According to IQ, the Bathurst herd has been calving on the west or south side of Bathurst Inlet for the last few years. Inuit expect that the Bathurst herd will return to the east side of the inlet, as it is common for the herd to alter calving ground location between areas of Bathurst Inlet, primarily as a function of annual climatic conditions and the associated state or quality of habitat (e.g., vegetation, ice). Locals report that other factors that influence the shifting of calving grounds include fidelity, human activity, escape from predators, and open spaces. Elders also reported that some mixing occurs between the Bathurst and Ahiak herds, and that the Dolphin-Union Caribou are starting to migrate to the treeline (which they have not done in the past), and are mixing with mainland herds (Golder 2003b).

Inuit have always held respect for Wolverines for their tenacious and often unpredictable behaviour. Wolverines have always been hunted, particularly for their fur. IQ indicates that the Wolverine is common in the Hope Bay Belt, due to the abundance of prey animals for scavenging (i.e., Caribou, Seals) and the presence of suitable habitat, such as eskers (Golder 2003b). Participants from the 2003 IQ Workshop also commented that Grizzly Bears are common in the Hope Bay Belt area, due to the abundance of prey animals (e.g. Caribou) and the presence of suitable habitat, such as eskers (Golder 2003b). Eskers are important for predators such as the Wolverine and the Grizzly Bear in that they provide habitat for denning, feeding and travel (Golder 2003b).

The participants of the 2003 IQ Workshop commented that the Hope Bay Belt area is known to be the home of many nesting bird species. Inuit have long observed that extensive cliff formations throughout Bathurst Inlet and the surrounding region provide important raptor habitat. Accordingly, the participants of the Workshop commented that Eagles and Gyrfalcons are common in the Hope Bay Belt and near the Project area (Golder 2003b). Participants mentioned that raptors nest in the highlands and that cliffs and mesas are important landscape features because they provide key nesting habitat. The workshop participants explained that eagles and Gyrfalcons feed on a variety of prey, including

Ground Squirrels, Arctic Hare and Canada Geese. Fluctuations in raptor populations have been observed, probably due to changes in prey abundance (Golder 2003b).

5.3 HISTORICAL LAND AND RESOURCES USE

Very little was known about the history and people of the central Arctic mainland until several scientific expeditions visited the region in the early 1900s. The local residents of this central Arctic coastline at the time of the early studies were identified as Copper Eskimo (or Inuit) due to their use of copper. Subsistence and settlement patterns of inhabitants of this region in the past were probably fairly similar throughout the period subsequent to the arrival of European explorers (i.e., after the passing of John Franklin's expedition along the coast), since they were dependent on the same types of resources. According to historic sources, from December to May, Copper Inuit people congregated at the coastline to conduct breathing-hole sealing. The period from May to November was spent travelling inland, hunting and fishing in small family groups. The focus was Caribou and people camped at good hunting localities, such as grass meadows or river narrow (Jenness 1922 as cited in HBML 2011).

Local residents reported numerous archaeological and traditional sites in the general region to the Nunavut Planning Commission Transition Team (NPCTT), stating that the Aimaokatalok Lake area was extensively used for Caribou hunting in the early 1900s or earlier (NPCTT 1996 as cited inHBML 2011). The Nunavut Atlas identifies the Koignuk River as an important resource gathering and camp location (Riewe 1992: 44, 167 as cited inHBML 2011). Elders were interviewed during the Doris North traditional knowledge study by Golder in 2003. One informant stated that archaeological sites could be found along any good sized river system, main Caribou migration routes and on islands. It was mentioned that archaeological sites could include sealing, hunting and fishing camps, food caches, burial sites and *inukhuit* or *taluit* (hunting blinds)(Golder 2003b).

5.4 TRADITIONAL LAND AND RESOURCES USE

Throughout Nunavut, traditional pursuits, such as hunting, trapping, and fishing, continue to be an important part of the economy and quality of life for Nunavummiut (Rescan 2012c). The importance of traditional activities and subsistence harvests is reflected in contemporary land and resource use activities and management in the Kitikmeot Region. This includes, most notably, renewable resource use, including hunting, trapping, fishing, and gathering of berries and other products (HBML 2011). Hunting, fishing, and the gathering of plants and berries provide dietary contributions to residents and their families (HBML 2011). Country foods are always available in Kitikmeot communities and, for many, continue to be eaten on a daily basis. This is particularly true for the smaller more traditional communities (Rescan 2012c). Trapping activities are also important, and primarily result in pelts for sale, personal use, and crafts (HBML 2011).

River and lake systems are integral to both fish and wildlife, and are also valued as a source of drinking water. In smaller communities where no public services are available, such as Bathurst Inlet and Umingmaktok, water is sourced from ice and river water (Rescan 2012c). Deep lakes and underground water are also valued highly for their water quality. Water used for drinking purposes possess several qualities that are desirable, including clarity, source, and ultimately taste and smell (Golder 2003b).

A large proportion of residents participate in harvesting activities. In 2006, the majority of Kitikmeot community members hunted, fished, trapped, or gathered wild plants and berries. This compares to data for all Aboriginal residents in Nunavut, in which 71% reported that they hunted, 76% fished, 79% gathered wild plants and berries, and 30% trapped (Statistics Canada 2008a, 2008b). Furthermore, statistics indicate that an increasing proportion of the Kitikmeot population is participating in traditional economic activities (HBML 2011).

Local Hunting and Trapping Organizations (HTOs) are recognized by the Nunavut Department of Environment to represent the interests of hunters and trappers at the local level. Government funding to HTOs depend on the number of general hunting licences within the community, fur returns and HTO work plans (Nunavut Department of Environment 2007 as cited in HBML 2011)). Kingaok, Umingmaktok and Cambridge Bay each have a local HTO. Primary information about current land use activities was obtained through interviews with HTO representatives in each Kitikmeot community, local hunters, and government land and resource managers. Additionally, in November 2011, a land use focus group session was held with people from Umingmaktok (Bay Chimo), the community closest to the Project. Travelling on the land, hunting, and fishing remain important cultural activities within the vicinity of the Hope Bay Belt and throughout the Kitikmeot Region. Subsistence land use in nearby areas is illustrated in Figure 5.4-1.

The results of interviews did not identify any specific locations that people visit for ceremonial and spiritual reasons. However, it was noted that an Elders group has recently started to go to old camp sites and places where relatives were born with the purpose of visiting the sites with family and friends. While prominent fishing areas were noted, fishing occurs throughout the region and is not limited to the specifically identified areas. During the land use focus group session, Roberts Lake was also highlighted as having abundant fish and as being especially important to the family who lived at an outpost camp there for many years (M. Avalak, pers. comm.; Figure 5.4-1). Larger lakes and rivers that connect to the ocean are important as they usually have an abundance of fish such as Char, Whitefish and Trout. Local land users stand up and pile rocks to mark good fishing spots. When travelling the land, people follow big lakes and rivers and look for fish markers. The big lakes, thus, have a long history of use (Land use focus group participants, pers. comm.).

While there are two regularly used camps located near the Madrid North and South sites (Figure 5.4-1), camping may take place anywhere as local land users camp in many places as they travel through the area hunting and fishing (J. Avalak, pers. comm.). In addition, as noted by Elders, camps have historically been located along the shores of Roberts Bay, around Hope Bay, and at river mouths and confluences (Golder 2003b).

Local travel patterns are seasonally-dependent as Kitikmeot residents travel to hunting, fishing, and camping areas. Although most people originally from Umingmaktok have moved to Cambridge Bay, they go back and forth to Umingmaktok. During the ice season (usually late November to early June), travel is predominantly by snowmobile and includes travel over ice and over land covered by ice and snow. During the ice-free period, travel over land is dominated by ATVs, though boats are also used during this period. Inland travel usually ends by mid-May, as snowmelt increases difficulties associated with travel, shifting to use of the coastal areas for travel (Anonymous, pers. comm.; Land use focus group participants, pers. comm.).

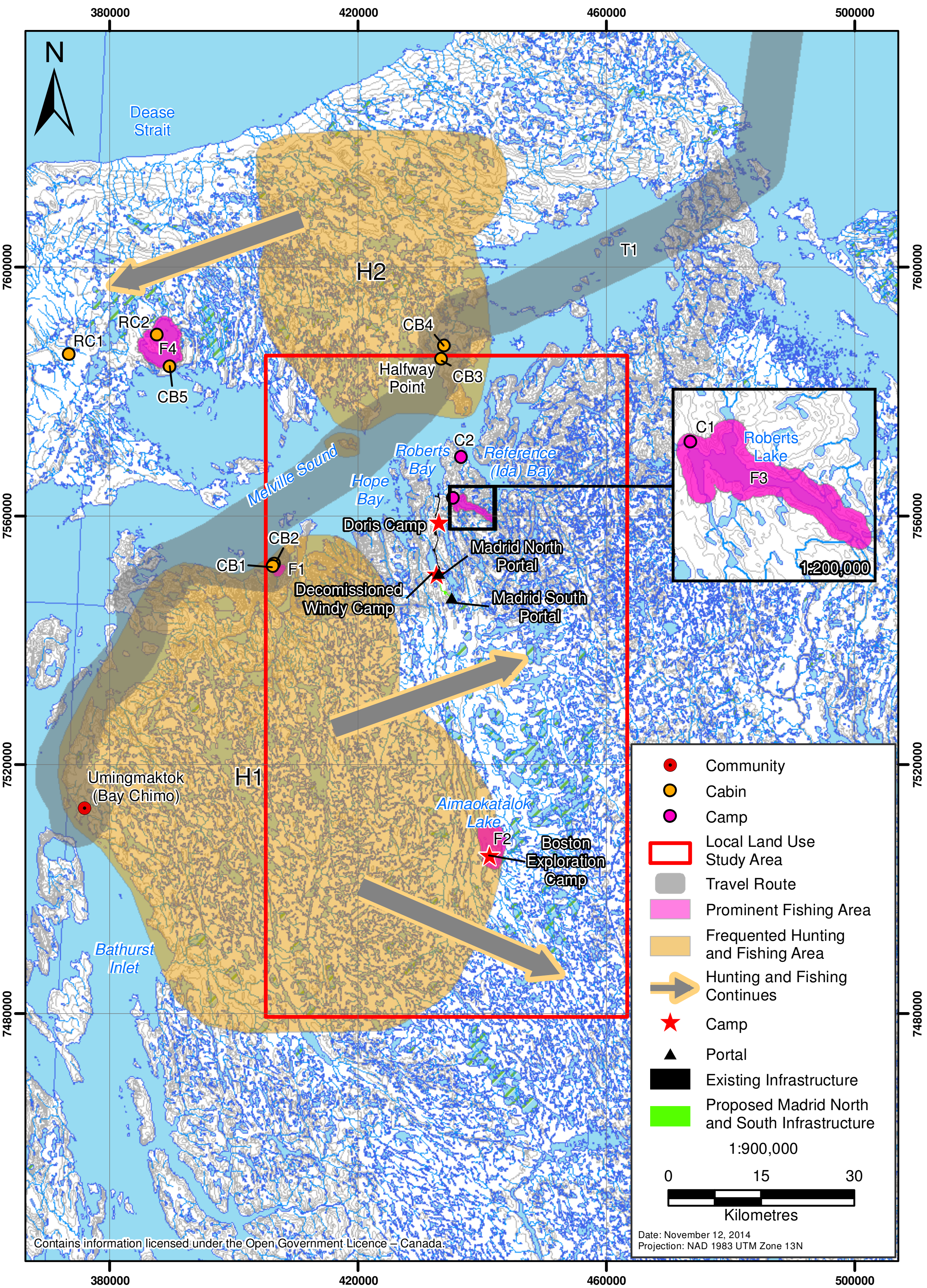
5.5 HARVEST ACTIVITIES

The Nunavut Wildlife Harvest Survey, conducted between 1996 and 2001, remains the most current and comprehensive information source on subsistence harvests in the Kitikmeot Region (NWMB 2004). The survey collected data on non-commercial hunting, trapping, gathering, and fishing of mammals, birds (and their eggs and feathers), fish, and shellfish.

Approximately 17 to 18 hunters were registered annually in Bathurst Inlet; three were classified as intensive land users, four as active, and the remainder reported occasional activity (NWMB 2004). Harvest data indicate that the majority of hunters harvested Caribou, with an annual mean harvest of 93 animals, while Arctic Ground Squirrel, Arctic Fox, Red Fox, Wolverine, Grey Wolf, Arctic Hare, and Seal were also common prey.

Figure 5.4-1

Local Traditional Land Use



Ptarmigan (Willow Ptarmigan and Rock Ptarmigan) were the most commonly hunted bird species, and Seagull eggs were also popular. Fishing activities were practiced by nearly all hunters, with catches including Arctic Char, Cod, Lake Trout, and Whitefish. It is noted that many hunters leave Bathurst Inlet for the winter to live in other centres (e.g., Cambridge Bay, Kugluktuk), returning to the community for the summer months.

In Umingmaktok, the number of hunters decreased from 31 in 1996/97 to only 11 in 2001, which likely reflects an overall decline in the population of the community (NWMB 2004). There were no intensive hunters in any year, while approximately three hunters were classified as active, although actual numbers varied greatly with changes in the population. Caribou was the most-hunted game, with an annual average of 176 kills, and Arctic Ground Squirrel, Grey Wolf, Arctic and Red Fox, Wolverine, and Seal were also common. Canada Goose, Eider Duck, and Ptarmigan were the most popular among birds, as were goose, duck, and seagull eggs. Similar to Bathurst Inlet, fishing activity focused on Arctic Char, Cod, and Lake Trout (Rescan 2012c).

Interview focus group results conducted for the 2012 baseline study confirmed that residents from Bathurst Inlet, Umingmaktok, and Cambridge Bay are known to hunt and fish in areas nearby the Hope Bay Belt area (Figures 5.1-1 and 5.4-1). Residents of Gjoa Haven, Taloyoak, and Kugaaruk do not hunt or fish as far west, typically remaining within an 80 to 100 km range of the community, often only going out on day-trips (Rescan 2012c). The results of interviews conducted for the 2012 baseline study have indicated that the current number of intensive and active hunters in Bathurst Inlet, Umingmaktok, and Cambridge Bay is approximately as reported in the NWMB (2004) survey. Approximately 20 to 25 hunters are reported to be active within and near the Hope Bay Belt area, 10 from Umingmaktok and Bathurst Inlet and 10 to 15 from Cambridge Bay (Rescan 2012c).

5.6 CONSULTATION

In September 2003, a three day Inuit Qaujimajatuqangit[2](IQ) workshop was held in Iqualuktuuttiaq (Cambridge Bay) in an effort to augment documented IQ and respond to the information gaps identified in a preceding literature review and gap analysis. Elders from each of the communities Umingmaktok (Bay Chimo), Kingauk (Bathurst Inlet), Kugluktuk, and Iqualuktuuttiaq nominated workshop participants according to their familiarity with the Hope Bay Belt. To complement the workshop, interviews were held with several IQ experts now living in Iqualuktuuttiaq but formerly of the Bathurst Inlet region and familiar with Hope Bay belt. The interviews were conducted on both an individual and group level in Iqaluktuuttiaq (Golder 2003b). The Kitikmeot Heritage society and Golder associates ltd. Interviewed seven elders from Iqaluktuuttiaq and Umingmaktok (Bay Chimo) to document their knowledge of traditional place names in the area surrounding the Hope Bay Belt (Golder 2003b).

Through the literature review, gap analysis, interviews, and workshop, a variety of IQ was collected that is pertinent to the Hope Bay Belt and Doris North Project. Definitions for IQ and an understanding of climate change, air quality, noise, landscape and terrain, hydrology and water quality, aquatic organisms and habitat, vegetation, terrestrial wildlife and habitats, archaeology, cumulative environmental effects and valued ecosystem components were documented (Golder 2003b).

Workshop participants and interviewees made several recommendations related to the Doris North Project. These included, but were not limited to, the inclusion of Innuinnaqtun place names for rivers, lakes and places (resulting in a traditional place names study), the reduction of noise levels, access to

[2] Inuit Qaujimajatuqangit (IQ) is Traditional Knowledge specific to Inuit.

environmental studies and dissemination of information, and overall respect for the environment (Golder 2003b).

Community-based research detailed in the Socio-Economic and Land Use Baseline Report completed by Rescan (2012c) consisted of site visits and the completion of interviews with key informants from each study community. A focus group session was also held with land users from Umingmaktok, the community closest to the Project location. Community visits to conduct interviews were also conducted in Cambridge Bay, Kugluktuk, Taloyoak, Gjoa Haven, and Kugaaruk, with a second visit to Cambridge Bay in November 2011 (Rescan 2012c).

Key informants included government representatives, service providers, business leaders, and other organization representatives. Representation was provided across a number of areas: local and regional governance, economic development, education and training, health and well-being, housing, safety and protection services, planning and resource management, hunting and trapping, and guide outfitting. The hunter focus group included some Elders (Rescan 2012c). Results of the interviews held with the hunter focus group are discussed in Section 1.5.3.

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Appendix 6

(for Chapter 6, Water Use)

No appendix for this chapter.

Appendix 7

(for Chapter 7, Waste Disposal)

7-A SRK, October 2014 Memo – Hope Bay Project: Madrid Advanced Exploration Bulk Sample: Underground Inflow Estimates

7-B SRK, December 2014 Memo – Hope Bay Project: Madrid Advanced Exploration Project: Water Quality Prediction

Appendix 7-A

SRK, October 2014 Memo – Hope Bay Project: Madrid Advanced Exploration Bulk Sample: Underground Inflow Estimates

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Memo

To:	John Roberts, TMAC	**Client:**	TMAC Resources Inc.
From:	Dan Mackie Gregory Fagerlund	**Project No:**	1CT022.001.410
Cc:	Tom Sharp, SRK Mark Liskowich, SRK	**Date:**	October 31, 2014
Subject:	Hope Bay Project: Madrid Advanced Exploration Project: Underground Inflow Estimates		

1 Introduction and Scope

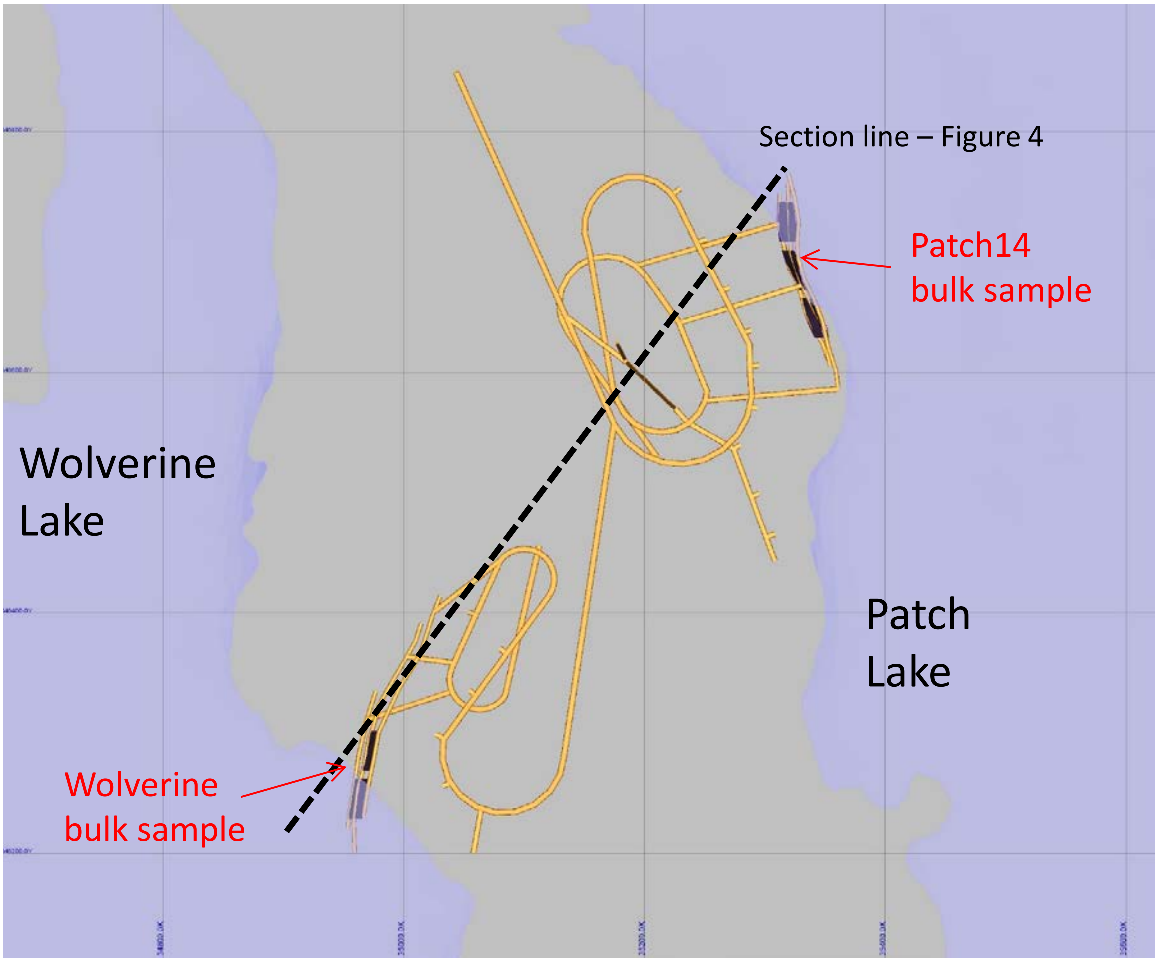
This memo summarizes updated inflow estimates and inflow water quality for the Madrid Advanced Exploration Project. The project consists of bulk samples at Madrid North and Madrid South.

The Madrid North underground bulk sample area is within the Naartok deposit. It has been determined this bulk sample will be within permafrost. As such, ground water inflows are not an issue and will not be discussed below.

The Madrid South underground bulk sample is within the Patch14 and Wolverine deposits. The mining areas are not expected to be completely within permafrost, thus groundwater inflows are possible. This memo presents estimates of groundwater inflow for use with overall mine water management planning, not engineering design.

The scope includes updating inflow estimates based on the current mine plans and existing data. No new data has been collected specifically for this work, but existing data from Madrid South (and across the entire Hope Bay belt) suggests that bedrock is generally competent and inflows to relatively small mine openings should not be excessive. The modeling approach does not attempt to provide rigorous calibration or incorporate a detailed mine plan; an approximation of the major mine openings are used to test the influence of different assumptions about bedrock hydraulic conductivity on inflow. The groundwater flow system around these mine openings is constrained by the more regional concepts for how groundwater moves in permafrost environments and results are sufficient for the purpose of water management planning.

Figure 1 shows the locations of the Madrid South bulk sample areas relative to Patch and Wolverine lakes.



Source: U:\1CT022.001_2014 Hope Bay Ongoing Support\410_Preparation of Submission (Patch 14, Wolverine & Madrid)\Madrid South GroundWater\figures for inflow memo_May222014.pptx

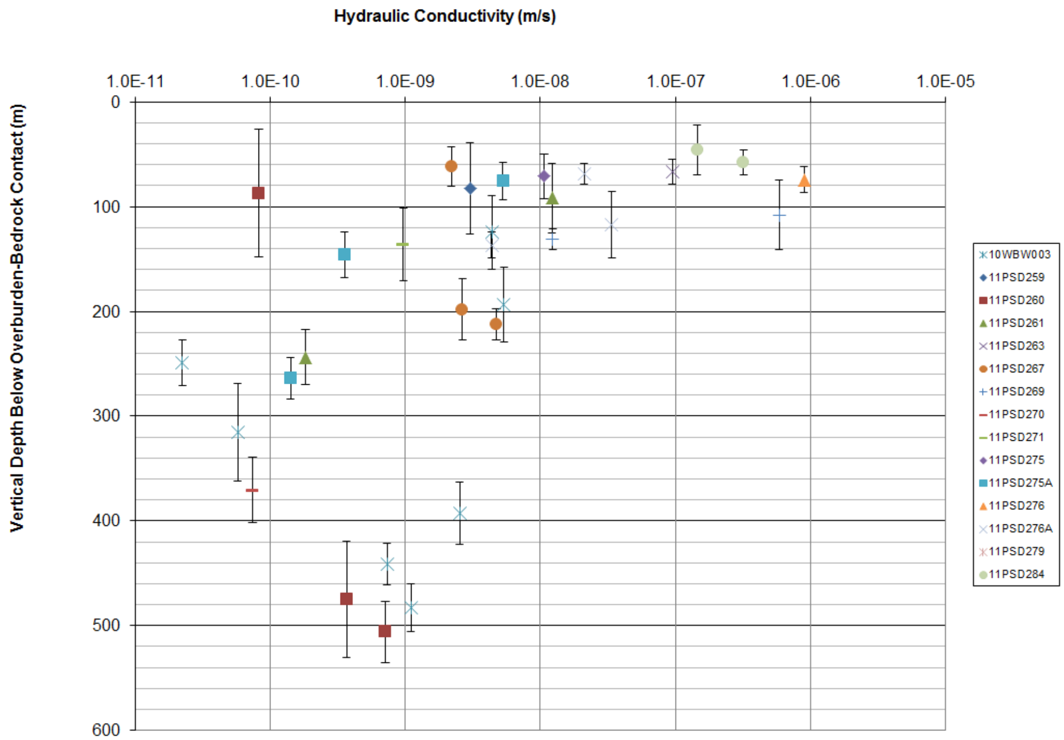
Figure 1: Map of Bulk Sample Locations Relative to Lakes

2 Available Data for Madrid South

2.1 Hydraulic Conductivity

Hydraulic conductivity (K) for the Madrid South area was collected during the 2010 and 2011 field seasons. The hydraulic conductivity (K) was measured through down-hole injection tests during drilling. Figure 3 shows all available data for Madrid South. Figure 4 presents average K by lithologic unit.

Arithmetic mean is provided for average K data because it is considered more appropriate than geometric mean for fractured rock environments. The wide range of K values for a given lithology is typical of the fractured rock environment at Hope Bay. K values are influenced by the presence or absence of discrete, relatively narrow fractures that have higher K than the unfractured bedrock. It is not apparent during drilling what fractures may control water flow (and K), and as a result, the “bulk K” determined by testing over even moderate scale testing intervals (e.g., 25 m) can vary by orders of magnitude.



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Notes:

1) Data presented by drill hole.
2) All PSD drill holes are from Madrid South area.
3) 10WBW003 is from the specific Patch 14 area.
4) Error bars indicate the test zone.

Figure 2. Hydraulic Conductivity vs Depth

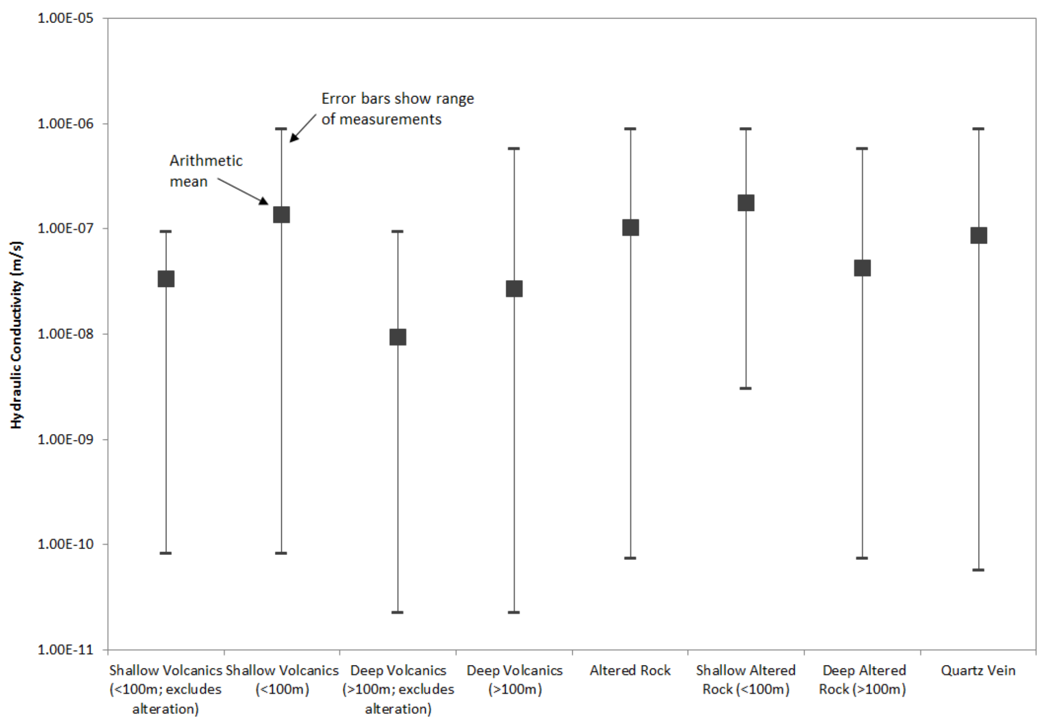

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Figure 3. Hydraulic Conductivity by Lithology

2.2 Permafrost

There are a number of deep thermistor strings in place across the Hope Bay belt that provide information on the likely depth of permafrost, including one string at Patch14 that was installed during the summer of 2014. Data from the Patch14 thermistor string was not available for this work. Estimates of the permafrost distribution were developed based on thermal data from the Doris, Madrid North and Boston areas of the Hope Bay Belt and the analytical model of Andersland and Ladanyi (2004).

Groundwater quality data from Hope Bay (and within the broader Canadian Shield in general) indicate elevated total dissolved solids (TDS) can occur at depth and at relatively shallow depths within taliks (refer to section 2.3). The elevated TDS can depress the temperature at which water actually freezes, creating “cryopegs” or areas where temperature is less than 0 degrees Celsius but water is not frozen. The influence of TDS distribution with depth, and the possibility of freezing point depression, has been considered as part of hydrogeological assessments for other mines in the north (e.g., Meliadine, Meadowbank, Diavik). At Hope Bay, potential freezing point depression was estimated based on water quality data collected from the Doris Central Westbay monitoring well using the following equation:

$$\Delta T = i \times K_f \times m$$

$\Delta T = change\ in\ freezing\ point\ from\ 0\ degrees\ Celsius$

i = numberof i) ions in a molecule or ii) molecular compounds

K_f = freezing point depression constant for water (-1.858 C kg/mol)

$m = molality$

Results suggest a freezing point between about -1 and -2 degree Celsius. Since the water quality at Madrid South is not well constrained, a -2 degree freezing point is assumed.

Figure 4 presents a cross section through the Madrid South Advanced Exploration Bulk Sample showing the -2 degree Celsius isotherm based on results of previous Patch14 thermal modeling (SRK 2010). Permafrost was assumed to start at the shoreline.

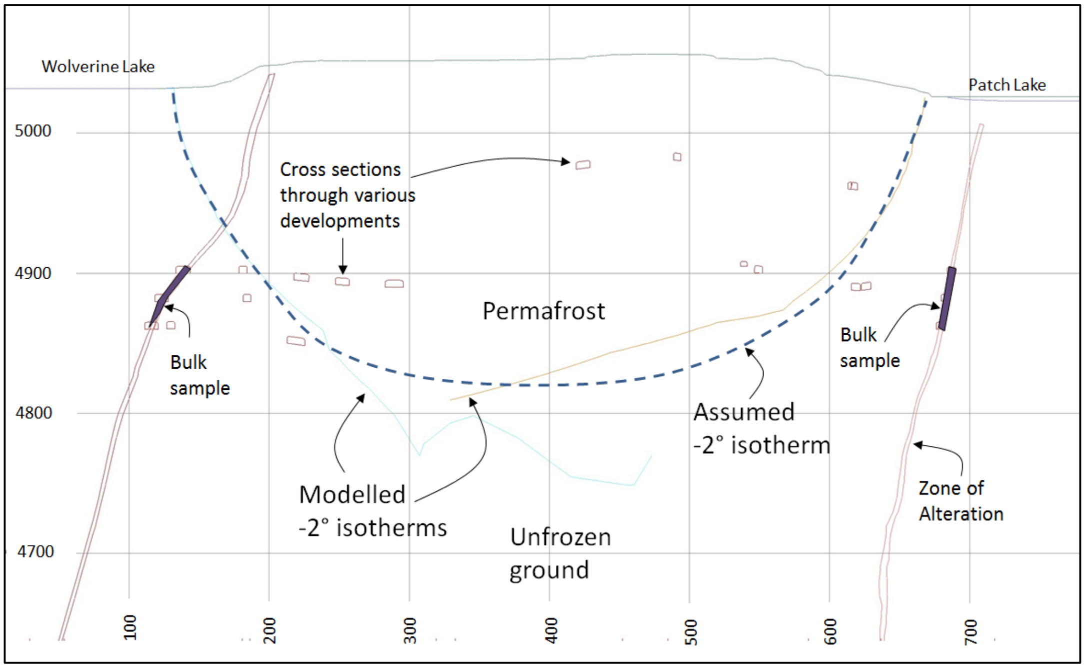

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Figure 4. Cross Section of Bulk Sample areas and -2° Isotherm.

Looking at the map view in Figure 2, a portion of both the Patch14 and Wolverine deposits may be below land and not below the lakebed. In general, a larger portion of the development occuring below land can be assumed to be in permafrost, but the stope areas for the bulk sample are within unfrozen ground.

For Patch14, the deposit is very close to the lake edge and Patch Lake is not particularly deep (about 2 to 3 meters deep to a couple of hundred meters offshore). Under these conditions the lake may freeze to the bottom during winter such that permafrost actually extends under the lake.

2.3 Water Quality

There is no groundwater quality data available for the Madrid South Advanced Exploration Bulk Sample.

Groundwater quality for this area is assumed based on data from Doris and Boston areas. Both areas have saline groundwater at relatively shallow depths in the respective taliks. There is no reason to believe these areas are any different than the Madrid South Bulk Sample. Table 1 presents data from Doris Central that can be used as the assumption for Madrid South Advanced Exploration Bulk Sample groundwater quality.

Table 1. 75th Percentile of Selected Parameters for Hope Bay Waters at Doris Central

		Doris Central		
Parameters	**Units**	**10WBW001 Zone 1 (548 m)**	**10WBW001 Zone 6 (246 m)**	**10WBW001 Zone 10 (63 m)**
pH		7.67	7.65	7.57
TDS	mg/L	44900	37550	38550
Alkalinity	mg/L	2.18	71.6	115
Bicarbonate	mg/L	9.98	56.5	115
Ammonia	mg/L	0.0625	3.44	4.05
Chloride	mg/L	19000	19050	19350
Sulphate	mg/L	976	2025	1853
Calcium	mg/L	4920	1540	1730
Sodium	mg/L	7200	9093	9100
Potassium	mg/L	39	232	258
Magnesium	mg/L	69.5	1480	1310
Dissolved Metals				
Aluminum	mg/L	0.005	0.005	0.005
Arsenic	mg/L	0.002	0.0043	0.002
Cadmium	mg/L	0.00012	0.00007	0.00011
Chromium	mg/L	0.0005	0.0005	0.005
Cobalt	mg/L	0.000059	0.00027	0.00015
Copper	mg/L	0.00083	0.0005	0.0005
Iron	mg/L	0.056	4.5	6.3
Lead	mg/L	0.0003	0.0003	0.0003
Manganese	mg/L	0.73	2.1	1.9
Mercury	mg/L	0.00005	0.00005	0.00005
Molybdenum	mg/L	0.011	0.034	0.013
Nickel	mg/L	0.0016	0.0010	0.00067
Selenium	mg/L	0.002	0.002	0.002
Zinc	mg/L	0.137	0.228	0.0659

Source: \\van-svr0\Projects\01_SITES\Hope.Bay\1CT022.001_2014 Hope Bay Ongoing Support\310_Response to Information Requests\Groundwater Quality 2011

3 Inflow Estimates

Previous estimates for inflows to the Patch14 deposit were developed based on scaling of results from the Doris Central area. When these previous Patch14 estimates were initially completed, there was little K data on which to base any calculations, thus specific modeling was not justified.

Inflow estimates for the Madrid South Advance Exploration Bulk Sample have been updated taking into consideration K data collected since completion of initial results and portions of the bulk sample areas (Patch 14 and Wolverine deposits) that are within the talik zones (as modeled). Revised estimates have been made using a 3D groundwater model.

3.1 3D Numerical Modeling

For the numerical model, the 3D geometry of the Madrid South Advanced Exploration Bulk Sample and the -2 degree Celsius isotherm previously discussed were incorporated into model design. Patch and Wolverine lakes are assigned constant head boundary conditions and the model sides are no flow boundaries. The model is essentially a box with groundwater flow driven by lake levels; this is consistent with the overall hydrogeological conceptual model for the region.

Because the hydraulic conductivity of any given unit is not precisely known, multiple scenarios were assessed. The scenarios represent a reasonable set of hydraulic conductivity distributions that could occur, and provide a range of potential inflows. Table 2 summarizes results.

Further details on the 3D model are provided in Section 4.

Table 2. Inflow Estimates (m^3/d).

Scenario	Best Case	Best Judgement	High Inflow Case 1	High Inflow Case 2
	K of deep volcanic rock = 1x10-10 m/s	K is observed mean for each rock formation	Worst Case K is maximum observed for each rock formation	Reasonable Case K for for deep volcanic or altered rock is maximum observed
Patch14 Deposit	11	60	672	300
Wolverine Deposit	5	35	401	200
Total Inflow	16	95	1073	500

Sources: “case_list&Inflows.xlsx”`

The results from the 3D groundwater model are consistent with previous calculation.

The Best Case scenario demonstrates that inflows to the Patch 14 and Wolverine deposits may not be an issue for the project if K of deep volcanic rock remains low.

The “Best Judgement” case is thought to be a reasonable indication of average inflow conditions that could be observed.

High Inflow Case 1 represents the maximum inflows that may occur if K of the volcanic and altered rock were characterized by the maximum K values reported from observations. This scenario represents extreme conditions that are highly unlikely to occur.

High Inflow Case 2 represents inflows that could occur if K of the deep volcanic rock and alteration zone are represented by the maximum K values observed. This high flow scenario is considered more plausible than Case 1.

For the purposes of water management design it is recommended that results of Case 2 be used. The results from Case 2 represent a reasonable design basis for average inflow *when working in talik areas*.

4 3D Groundwater Model

4.1 Model Geometry

The model domain covers an area of 870,000 m^2. The limit of the domain was defined according to the spatial extent and water elevations of Patch and Wolverine Lakes as well as consideration for potential groundwater flow directions between taliks.

The finite element mesh has 1,831,260 elements with average element dimensions varying gradationally depending on what model elements represent. The mesh is largest in areas outside of the underground developments (average dimensions of about 10 m x 10 m), and smallest at the stopes (average dimensions of about 2 m x 2 m).

The layer thickess is 20 m for the ground surface to 200 m depth and 20 m from 20 m to 400 m depth.

4.2 Model Boundary Conditions

The Patch and Wolverine Lakes are assigned with a constant head node and respectively assigned with head values of 34 m mean annual sea level (masl) and 25 m masl. The stopes are assigned with seepage conditions.

4.3 Model K Values

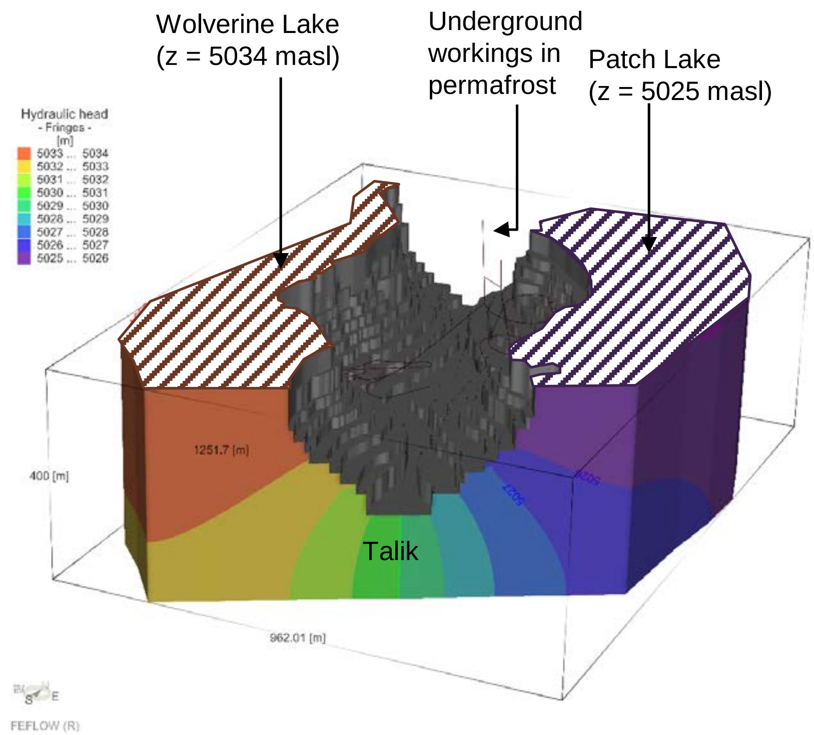
There are four distinct rock formation represented in the Groundwater Model. K for each formation are compiled in Table 3. The spatial distribution of these formations were defined from the Gemcom model.

All simulations were run at steady state; therefore, storage properties are not defined.

Table 3. Hydraulic Conductivity Values.

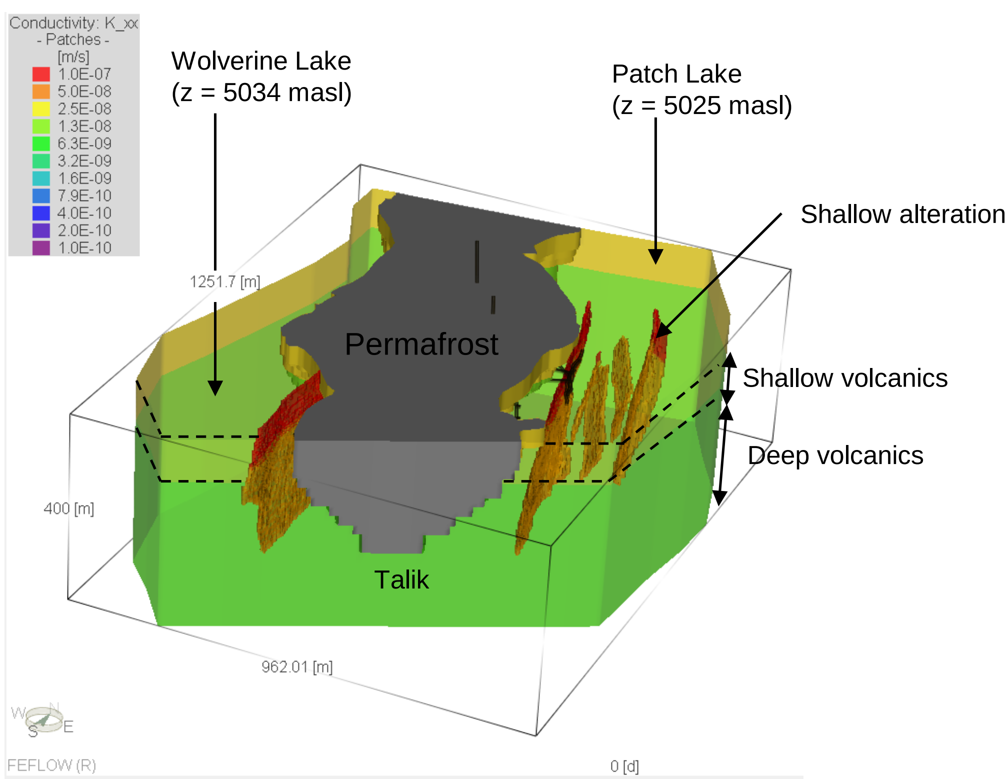
Material	K_{min}	Selected	K_{max}
Shallow Volcanics	$1x10^{-10}$	$3x10^{-08}$	$1x10^{-07}$
Deep Volcanics	$1x10^{-10}$	$9x10^{-09}$	$1x10^{-07}$
Shallow altered	$1x10^{-09}$	$1x10^{-07}$	$1x10^{-06}$
Deep altered	$1x10^{-10}$	$7x10^{-08}$	$1x10^{-06}$

4.4 Model Screenshots



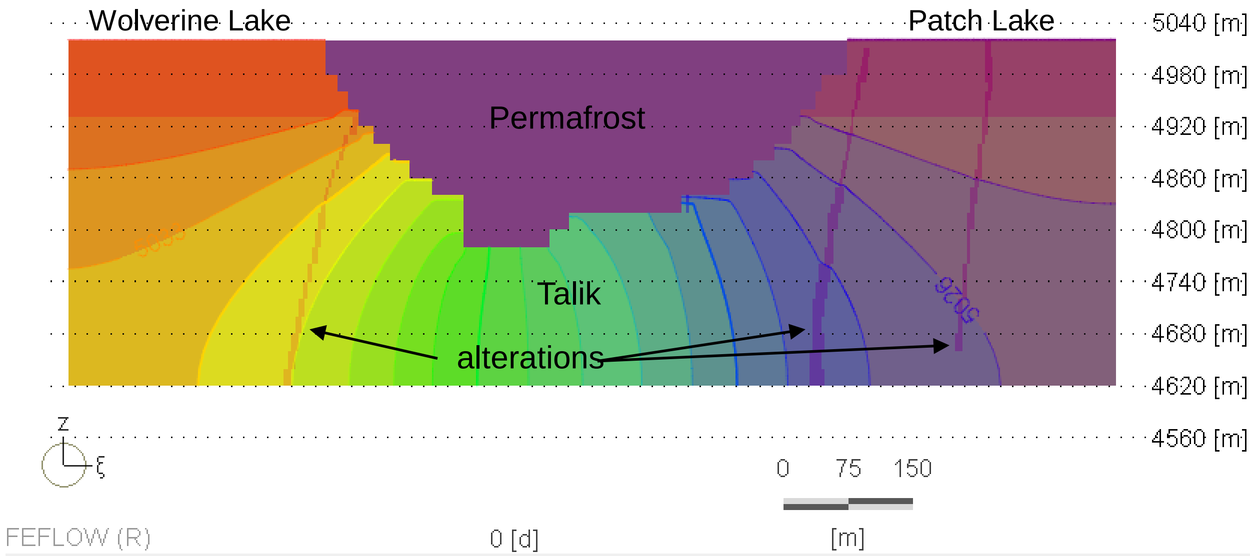
Note: Elevation in mine grid coordinates.

Figure 5: 3D View of the Groundwater Model Showing Hydraulic Head (m).



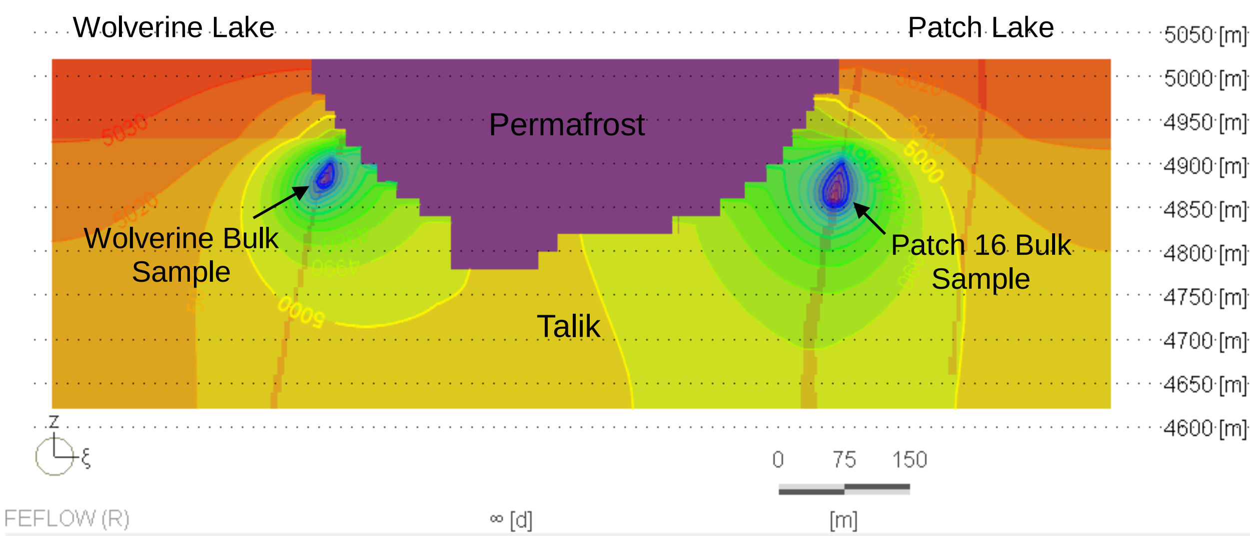
Note: Elevation in mine grid coordinates.

Figure 6: 3D view of the Groundwater Model Showing Conductivity (K m/s)



Note: Elevation in mine grid coordinates.

Figure 7: Cross Section Across the Stopes Showing the Distribution of Hydraulic Head at Time = 0



Note: Elevation in mine grid coordinates.

Figure 8: Cross Section Across the Stopes Showing the Distribution of Hydraulic Head after Bulk Samples are Extracted at time = ∞

5 References

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Appendix 7-B

SRK, December 2014 Memo – Hope Bay Project: Madrid Advanced Exploration Project: Water Quality Prediction

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4Memo

To:	John Roberts	**Client:**	TMAC Resources Inc.
From:	Sarah Portelance Tom Sharp	**Project No:**	1CT022.001.410
Cc:	Maritz Rykaart, SRK	**Date:**	December 2, 2014
Subject:	Hope Bay Project: Madrid Advanced Exploration Project Water Quality Prediction		

1 Introduction

TMAC Resources Inc. is currently in the process of constructing their Doris North Project (Project) in the Kitikmeot region of Nunavut, Canada. Mining and processing the Doris North deposit is currently permitted under Nunavut Water Board Water Licence No. 2AM-DOH1323 and Nunavut Impact Review Board Project Certificate No. 3. In addition to the permitted mining activities, TMAC wishes to begin the Madrid Advanced Exploration Project at the Madrid North and Madrid South deposits. This bulk exploration project includes the development of underground workings to access two deposits to collect 50,000 tonne and 55,000 tonne ore samples from Madrid North and Madrid South, respectively. This ore is to be transported to the Doris North mill for processing, with tailings deposited to the Doris North Tailings Impoundment Area (TIA). The underground development work to access these deposits will produce waste rock that will be stored above ground. The ore deposits at Madrid South are located in talik (outside of permafrost) so the underground workings in this area may intercept groundwater. The Madrid North deposit is located in permafrost and the underground workings are not expected to intercept groundwater. Groundwater and contact water from the mining operations and waste rock piles will need to be managed.

SRK (2014a) describes the water management strategy for the Madrid Advanced Exploration Project. Contact water from mine operations, waste rock piles and ore stockpiles will be collected in Pollution Control ponds. Intercepted groundwater at Madrid South will also be collected and contained in the Pollution Control ponds. All contact water that does not meet discharge criteria will be hauled by trucks and disposed of in the Doris North TIA during the Madrid Advanced Exploration Program. When the Madrid Advanced Exploration Program is completed, the waste rock piles will be covered with a geomembrane and capped with a protective layer of crushed rock. The Pollution Control ponds will be breached and site runoff will flow onto the tundra.

This memorandum describes how the discharge of water and milling of the bulk sample from the Madrid Advanced Exploration Project at the Doris North processing facilities may affect the TIA water quality while ore from Doris North (300,000 tonnes) is being processed.

Table 1 summarizes the project milestones used in the water and load balance model. The Madrid Advanced Exploration Program ends in Year 6 when the Madrid South bulk sample milling is complete.

Table 1: Summary of Milestones in the Water and Load Balance Model

Mine Date Description	Start	End
Mill load from Doris North	Year 3 (April)	Year 4 (April)
Madrid North bulk sampling (mining)	Year 3 (April)	Year 4 (November)
Madrid South bulk sampling (mining)	Year 4 (December)	Year 6 (April)
Underground Dewatering (Madrid South)	Year 5 (August)	Year 6 (April)
Madrid North Mill Load	Year 4 (May)	Year 4 (June)
Madrid South Mill Load	Year 6 (February)	Year 6 (April)
Decommissioning of bulk sample sites	Year 6 (May)	Year 7 (April)
Bulk sample site pollution control ponds breached	Year 7 (April)	Year 7 (April)

Source: \\VAN-SVR0\Projects\01_SITES\Hope.Bay\1CT022.001_2014 Hope Bay Ongoing Support\410_Preparation of Submission (Patch 14, Wolverine & Madrid)\Water Quality Prediction\Model\Madrid_Doris_SB_SPB_Rev7.gsm

2 Water and Load Balance Description

The water and load balance integrates dissolved constituent concentrations and flow rates to predict water quality during operations and closure. This mass balance predicts water quality in the TIA and in Doris Creek downstream of the TIA discharge point.

Model inputs for Doris North mining and mineral processing were not modified from the existing water and load balance model presented in the Water Quality Model Report (SRK 2011) included in the Doris North Mine Modifications and Related Amendments to Project Certificate No. 003 and Type A Water Licence No. 2AM-DOH1323 (TMAC 2013). The model was run on a monthly time step for a period of 300 months (25 years). A Monte Carlo simulation of 100 realizations was used to stochastically vary annual precipitation to model a range of possible climate and runoff conditions.

2.1 Model Components

The following components are included in the water and load balance to predict water quality in the TIA when the Doris North ore is milled (as permitted by Nunavut Water Board Water Licence No. 2AM-DOH1323 and Nunavut Impact Review Board Project Certificate No. 3) and the bulk samples are collected from Madrid North and Madrid South:

- Tail Lake watershed runoff and direct precipitation to the TIA;
- Runoff from the waste rock piles at Doris North (640,845 tonnes), Madrid South (225,000 tonnes), and Madrid North (285,000 tonnes);
- Runoff from the bulk sample ore stockpiles;
- Doris North, Madrid South and Madrid North contact water from surface infrastructure pads and all-weather roads;

- Treated mill tailings discharged to the TIA for Doris North (300,000 tonnes), Madrid North (50,000 tonnes), and Madrid South (55,000 tonnes) at a milling rate of 800 tpd;
- Treated sewage effluent discharge to the TIA for a Doris North camp of 360 people (includes 70 people for Madrid North and South developed sequentially);
- Saline groundwater inflows (500 m^3/d during the Madrid South Bulk Sample, SRK 2014b);
- Saline drilling fluids (6.7 m^3/d during Doris North, Madrid South and Madrid North underground mining at a rate of 185 kg/m^3 of $CaCl_2$);
- Ammonium nitrate fuel oil (ANFO) residuals on waste rock, quarried rock, ore and mine water (groundwater);
- Salinity release to the TIA from permafrost thawing along shores of the TIA. Incorporated in the model at closure during water level drawdown; and
- Degradation of cyanide destruction products to ammonia.

2.2 Water Balance Summary

Figure 1 illustrates the water balance for Doris North, Madrid South and Madrid North. The preferred option for managing and treating excess contact water at Madrid North and Madrid South is to transport water collected in the Pollution Control ponds to the TIA. Table 2 provides a summary of the total catchment areas included in the water balance model.

Table 2: Catchment Area Summary

Catchment Area		Size (ha)
Upstream Tail Lake Catchment Area		450
Doris North Mine Area[1]		21.2
Madrid North Mine Area (Collection Pond)	Total Area	9.4
	Waste Rock / Ore Stockpile	3.3
	Mine Site Fill	1.3
	Natural Catchment[2]	4.8
Madrid South Mine Area 1 (Collection Pond 1)	Total Area	3.4
	Mine Site Fill	0.8
	Natural Catchment[2]	2.6
Madrid South Mine Area 2 (Collection Pond 2)	Total Area	8.6
	Waste Rock / Ore Stockpile	4.8
	Mine Site Fill	1.3
	Natural Catchment[2]	2.5

Source: \\VAN-SVR0\Projects\01_SITES\Hope.Bay\1CT022.001_2014 Hope Bay Ongoing Support\410_Preparation of Submission (Patch 14, Wolverine & Madrid)\Water Quality Prediction\Model\Bulk_Sample_Model_Results.xlsx

Notes:

[1] Includes the total area flowing to the sedimentation pond and pollution control pond with the clean water diversion in place.
[2] Includes pond surface areas.

As described previously, inter-annual climatic variability is modelled using a Monte Carlo simulation. Table 3 summarizes average, wet and dry year runoff for Madrid South and Madrid North. Average runoff volumes are based on the average annual rainfall year (229 mm, SRK 2011). The wet annual runoff volume represents an annual runoff with a 20-year return period interval or a 5% chance of exceeding in a given year. The dry scenario represents the annual runoff with a 20-year return period interval for a 5% chance of not exceeding in a given year.

Table 3: Madrid South and Madrid North Runoff Volumes. Units are m^3/year.

Mine Location	Runoff Source	Dry Year	Average Year	Wet Year
		5th Percentile	50th Percentile	95th Percentile
Madrid North (Collection Pond)	Total Area	16,169	21,384	30,946
	Waste Rock Pile / Ore Stockpile	5,676	7,507	10,864
	Surface Infrastructure Pads and All-Weather Roads	2,236	2,957	4,280
	Undisturbed Ground	8,257	10,920	15,802
Madrid South (Collection Pond 1)	Total Area	3,520	4,655	6,737
	Surface Infrastructure Pads and All-Weather Roads	828	1,095	1,585
	Undisturbed Ground	2,692	3,560	5,152
Madrid South (Collection Pond 2)	Total Area	8,904	11,775	17,040
	Waste Rock Pile / Ore Stockpile	4,969	6,572	9,510
	Surface Infrastructure Pads and All-Weather Roads	1,346	1,780	2,576
	Undisturbed Ground	2,589	3,423	4,954

Source: \\VAN-SVR0\Projects\01_SITES\Hope.Bay\1CT022.001_2014 Hope Bay Ongoing Support\410_Preparation of Submission (Patch 14, Wolverine & Madrid)\Water Quality Prediction\Model\Bulk_Sample_Model_Results.xlsx

Contact water collected in the Pollution Control ponds will continuously be hauled to the TIA by trucks with a 50 m^3 capacity. Table 4 provides a summary of peak truck traffic and monthly volumes of water transported to the TIA. The total number of trucks summarized in Table 4 represents the peak daily round trips. Peak traffic will typically occur during freshet (June) where peak traffic during Madrid South mining occurs during the open water season when groundwater is intercepted.

For a wet hydrological condition (95th percentile), the peak truck traffic during Madrid North mining and Madrid South mining (during groundwater inflows) was estimated at 11 and 12 trucks/day respectively.

Table 4: Bulk Sample Water Management Contact Water Volumes for Dry, Average and Wet Hydrologic Conditions.

Phase	Month	Year	Madrid North Bulk Sample			Madrid South Bulk Sample		
			5th	50th	95th	5th	50th	95th
Madrid North Mining	4	3	0	0	0	0	0	0
	5	3	0	0	0	0	0	0
	6	3	8,586	11,546	16,204	0	0	0
	7	3	4,047	5,442	7,638	0	0	0
	8	3	1,254	1,686	2,366	0	0	0
	9	3	1,571	2,113	2,965	0	0	0
	10	3	417	555	779	0	0	0
	11	3	0	0	0	0	0	0
	12	3	0	0	0	0	0	0
	1	4	0	0	0	0	0	0
	2	4	0	0	0	0	0	0
	3	4	0	0	0	0	0	0
	4	4	0	0	0	0	0	0
	5	4	0	0	0	0	0	0
	6	4	8,135	11,592	16,741	0	0	0
	7	4	3,834	5,464	7,891	0	0	0
	8	4	1,188	1,693	2,445	0	0	0
	9	4	1,489	2,121	3,064	0	0	0
	10	4	391	557	805	0	0	0
	11	4	0	0	0	0	0	0
Madrid South Mining	12	4	0	0	0	0	0	0
	1	5	0	0	0	0	0	0
	2	5	0	0	0	0	0	0
	3	5	0	0	0	0	0	0
	4	5	0	0	0	0	0	0
	5	5	0	0	0	0	0	0
	6	5	8,748	11,569	16,741	6,721	8,888	12,863
	7	5	4,123	5,453	7,891	3,168	4,190	6,063
Madrid South Mining in Talik	8	5	1,277	1,689	2,445	16,200	16,517	17,097
	9	5	1,601	2,117	3,064	16,449	16,845	17,573
	10	5	420	556	805	15,542	15,646	15,837
	11	5	0	0	0	15,219	15,219	15,219
	12	5	0	0	0	15219	15,219	15,219
	1	6	0	0	0	15,219	15,219	15,219
	2	6	0	0	0	15,219	15,219	15,219
	3	6	0	0	0	15,219	15,219	1,5219

Phase	Month	Year	Madrid North Bulk Sample			Madrid South Bulk Sample		
			5th	50th	95th	5th	50th	95th
	4	6	0	0	0	15,219	15,219	15,219
Closure	5	6	0	0	0	0	0	0
	6	6	8,667	11,612	16,204	6,659	8,922	12,450
	7	6	4,085	5,473	7,638	3,139	4,205	5,868
	8	6	1,266	1,696	2,366	972.4	1,303	1,818
	9	6	1,586	2,125	2,965	1,219	1,633	2,278
	10	6	417	559	779	320	429	598
	11	6	0	0	0	0	0	0
	12	6	0	0	0	0	0	0
	1	7	0	0	0	0	0	0
	2	7	0	0	0	0	0	0
	3	7	0	0	0	0	0	0
	4	7	0	0	0	0	0	0
Peak Volume (m^3/month)			8,748	11,612	16,741	16,449	16,845	17,573
Peak Daily Truck Traffic (trucks/day)			6	8	11	11	11	12

Source: Z:\01_SITES\Hope.Bay\1CT022.001_2014 Hope Bay Ongoing Support\410_Preparation of Submission (Patch 14, Wolverine & Madrid)\Water Quality Prediction\Model\Bulk_Sample_Model_Results.xlsx

2.3 Water Quality Inputs

Constituent loads from waste rock, ore and site rockfill (used in surface infrastructure pad construction) are a function of source terms and the total tonnage. Table 5 summarizes waste rock and site rockfill tonnages used in the load balance. Source terms for waste rock and ore at Madrid North and Madrid South are based on current geochemical testing.

Table 5: Total Waste Rock and Surface Rock Summary

Mine Phase	Total Waste Rock and Ore (tonne)	Total Rock Used to Construct Pads for Infrastructure (tonne)
Doris North	640,845[1]	923,835
Madrid South	225,000	62,806[2]
Madrid North	285,000	37,605[2]

Source: \\VAN-SVR0\Projects\01_SITES\Hope.Bay\1CT022.001_2014 Hope Bay Ongoing Support\410_Preparation of Submission (Patch 14, Wolverine & Madrid)\Water Quality Prediction\Model\Madrid_Doris_SB_SPB_Rev7.gsm

Notes:

[1] total Doris North waste rock is 1,095,000 tonne, where 65% of tonnes mined (454,155) backfilled
[2] Assumed an average 1.5 m depth and 1.98 tonne/m^3 density

Mass dependent source terms for Madrid South and Madrid North waste rock and surface infrastructure rockfill are shown in Table 6. A surface area correction factor of 0.3 and a release factor of 40% were used to estimate net release rates (SRK 2011). Leaching of drilling brine and ANFO residue from the waste rock were also included in the model. The rate salt and ANFO residue rinse from waste rock was calculated assuming 40% of the salt and ANFO residue mass present is released from the rock annually. Blast residue volumes are based on data reported in a study on ammonium nitrate dissolution rates for the Diavik Diamond Mine in Northwest Territories. The method to estimate salinity releases and nitrogen nutrient loading rates is described in the Water Quality Model Report (SRK 2011).

Background concentrations for Doris Creek are based on water quality data obtained in 2004 to 2006 and 2011 to 2013 from compliance monitoring point, TL-2 in Doris Creek. Concentrations for upstream runoff into Tail Lake are based on compliance monitoring point, TL-1, data from 2004 to 2006 before site runoff collected in the Sedimentation and Pollution Control ponds was trucked to Tail Lake. Median monthly concentrations during open water season were used. When results were below the method detection limit, the detection limit was used. Table 7 summarizes background monthly concentrations used in the model during the open water season.

Table 8 provides mill effluent water quality for processed ore from Doris North and Madrid Advanced Exploration Project Bulk Samples. The Madrid North tailings solution chemistry is based on Naartok samples collected and analyzed by Newmont Metallurgical Services. No metallurgical testing of Madrid South ore has been conducted to date. The results of Naartok ore testing were also used for the Madrid South predictions. Further descriptions and other inputs and source terms included in the model are described in the Doris North Mine Modification Report (TMAC 2013).

Table 6: Input Source Terms (mg/kg/week)

Parameter	Mine Area Surface Rock*	Doris North Waste Rock	Madrid South Waste Rock	Madrid North Waste Rock
Sulphate	0.86	23.2	0.8	4.5
Aluminum Al	0.025	0.013	0.015	0.02
Antimony Sb	0.00012	0.02172	0.00033	0.00045
Arsenic As	0.00058	0.00049	0.039	0.067
Barium Ba	0.00008	0.00109	0.00032	0.00022
Beryllium Be	0.000115	0.000543	0.000005	0.000010
Bismuth Bi	0.000115	0.0217218	0.0000023	0.0000083
Boron B	0.006	0.011	0.023	0.022
Cadmium Cd	0.0000288	0.0000002	0.0000023	0.0000034
Calcium Ca	1.5	4.7	2.2	3.0
Chromium Cr	0.000115	0.001086	0.000046	0.000062
Cobalt Co	0.00012	0.00109	0.0005	0.0003
Copper Cu	0.00015	0.00043	0.00026	0.00027
Iron Fe	0.0058	0.0033	0.0014	0.0050
Lead Pb	0.00011500	0.00021722	0.0000225	0.000026
Lithium Li	0.00012	0.00109	0.00026	0.00036
Magnesium Mg	0.15	2.18	1.14	1.30
Manganese Mn	0.0001	0.0029	0.002	0.002
Mercury Hg	0.0000023	0.0000004	0.000001	0.0000039
Molybdenum Mo	0.000001	0.00022	0.00014	0.0002
Nickel Ni	0.00013	0.00217	0.00034	0.0016
Phosphorus P	0.0173	0.0326	0.0018	0.0033
Potassium K	0.04	0.45	0.34	0.29
Selenium Se	0.000115	0.000002	0.000055	0.000076
Silicon Si	0.28	0.18	0.15	0.20
Silver Ag	0.000039	0.000043	0.000002	0.000004
Sodium Na	0.04	0.22	0.29	0.39
Strontium Sr	0.0008	0.0058	0.0064	0.0062
Thallium Tl	0.0000115	0.0000004	0.0000009	0.0000065
Tin Sn	0.00012	0.00326	0.00006	0.00002
Titanium Ti	0.00012	0.00109	0.00023	0.00023
Vanadium V	0.00023	0.00326	0.00017	0.00047
Zinc Zn	0.00058	0.00374	0.00036	0.00033

Source: \\VAN-SVR0\Projects\01_SITES\Hope.Bay\1CT022.001_2014 Hope Bay Ongoing Support\410_Preparation of Submission (Patch 14, Wolverine & Madrid)\Water Quality Prediction\Model\Bulk_Sample_Model_Results.xlsx

Note: * Mine fill source terms for Madrid North and Madrid South based on source terms developed for the Doris North source terms (SRK 2011).

Table 7: Background Water Quality Inputs

Parameter	Tail Lake Background Concentrations (TL-1)					Doris Creek Background Concentrations (TL-2)				
	June	July	August	September	October	June	July	August	September	October
TDS	110	80	90	105	105	128.5	145.5	142	154.75	145
TSS	1	1	1.5	2	2	3	3.5	3	3	3
Total_CN	0.001	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.003	0.001
Sulphate	3	3	3	3.25	3.25	3.5	3	2.75	2.84	3
Chloride	30.1	30	37	37	37	49	63	62	62	63
Ammonia_N	0.008	0.008	0.007	0.008	0.008	0.029	0.033	0.031	0.029	0.008
Nitrate_N	0.005	0.006	0.005	0.006	0.006	0.028	0.028	0.028	0.028	0.005
Nitirite_N	0.001	0.001	0.001	0.002	0.002	0.026	0.026	0.026	0.026	0.001
Alkalinity	28	29	30	25	25	26	27	28	28	28
Ortho_P	0.002	0.002	0.002	0.002	0.002	0.0009	0.0009	0.0009	0.0009	0.0008
Phosphate_P	0.008	0.006	0.006	0.004	0.004	0.02	0.023	0.026	0.025	0.027
TOC	6	5	5	5	5	5	5	5	5	5
Hardness	33	34	41	38	38	36	46	46	49	45
Aluminum	0	0	0	0	0.016	0.057	0.055	0.05	0.05	0.048
Antimony	0.00001	0.00001	0.00001	0.00001	0.00001	0.00021	0.00021	0.00021	0.00021	0.00001
Arsenic	0.00024	0.00026	0.00033	0.00023	0.00023	0.00039	0.0004	0.00044	0.00041	0.00042
Barium	0.0021	0.002	0.0031	0.0023	0.0023	0.0031	0.0033	0.003	0.0033	0.003
Boron	0.014	0.015	0.015	0.013	0.013	0.035	0.036	0.036	0.036	0.022
Cadmium	0.000002	0.000003	0.000002	0.000002	0.000002	0.000006	0.000006	0.000006	0.000006	0.000002
Calcium	6.09	6.13	7.58	6.54	6.54	6.33	8.32	7.74	7.95	7.35
Chromium	0.000248	0.000158	0.00025	0.0002215	0.0002215	0.00066	0.00062	0.00065	0.0006	0.00019
Cobalt	0.00002	0.00005	0.00008	0.00006	0.00006	0.001	0.001	0.001	0.001	0.0001
Copper	0.0009	0.0008	0.0007	0.0007	0.0007	0.0014	0.0015	0.0014	0.0015	0.0014
Iron	0.042	0.089	0.404	0.068	0.068	0.093	0.14	0.094	0.123	0.09
Lead	0.00003	0.00005	0.00006	0.00001	0.00001	0.000073	0.000078	0.000109	0.000068	0.000035
Magnesium	4.63	4.63	5.59	4.59	4.59	4.84	6.15	6.11	6.13	6.37
Manganese	0.001	0.002	0.008	0.002	0.002	0.013	0.021	0.017	0.021	0.01

Parameter	Tail Lake Background Concentrations (TL-1)					Doris Creek Background Concentrations (TL-2)				
	June	July	August	September	October	June	July	August	September	October
Molybdenum	0.0001	0.00007	0.00007	0.00007	0.00007	0.00256	0.00257	0.00257	0.00257	0.00014
Nickel	0.00052	0.00051	0.00051	0.00043	0.00043	0.0012	0.0013	0.0012	0.0012	0.0004
Potassium	1.58	1.35	1.48	1.84	1.84	1.91	2.28	2.11	2.26	2.34
Selenium	0.0004	0.00042	0.00062	0.00046	0.00046	0.00059	0.00061	0.00062	0.00076	0.00076
Silver	0.000001	0.000002	0.000001	0.000001	0.000001	0.000011	0.00001	0.00001	0.00001	0.000001
Sodium	15.7	16	18.6	18.1	18.1	24	30.75	29.98	30.47	32.13
Strontium	0.025	0.027	0.034	0.029	0.029	0.035	0.039	0.039	0.04	0.04
Thallium	0.000006	0.000014	0.000002	0.000002	0.000002	0.000059	0.000061	0.000055	0.000052	0.000003
Tin	0.00003	0.00004	0.00004	0.00003	0.00003	0.02502	0.02506	0.02502	0.02502	0.00003
Uranium	0.00001	0.00001	0.00001	0.00001	0.00001	0.000064	0.000066	0.000068	0.000066	0.000032
Vanadium	0.0004	0.0001	0.00008	0.00001	0.00001	0.00079	0.00056	0.00057	0.00056	0.00012
Zinc	0.0054	0.0021	0.0026	0.0024	0.0024	0.0027	0.0028	0.0034	0.003	0.0017

Table 8: Mill Effluent Water Quality Concentrations (mg/L)

Parameter	Doris North	Maximum (North/Central/Connector)	Madrid Bulk Samples* (Naartok)
Nitrate as N	0.23	0.74	0.28
Nitrite as N	0.09	0.28	3.85
Sulphate	137	137	55
Aluminum Al	0.12	0.59	0.05
Antimony Sb	0.08	0.08	0.04
Arsenic As	0.007	0.007	0.404
Barium Ba	0.008	0.13	0.01
Beryllium Be	0.001	0.001	0.01
Bismuth Bi	0.00	0.00	0.00
Boron B	0.194	0.27	0.66
Cadmium Cd	0.00015	0.0007	0.0000
Calcium Ca	400	400	400
Chromium Cr	0.020	0.024	0.001
Cobalt Co	0.095	0.10	0.36
Copper Cu	0.023	0.64	0.07
Iron Fe	1.51	2.79	1.06
Lead Pb	0.0002	0.01	0.00
Lithium Li	0.013	0.01	0.00
Magnesium Mg	7.4	35.3	46.3
Manganese Mn	0.009	0.14	0.04
Mercury Hg	0.0001	0.0001	0.00
Molybdenum Mo	0.045	0.12	0.16
Nickel Ni	0.243	0.24	0.03
Phosphorus P	0.97	1.20	0.27
Potassium K	54	54	42
Selenium Se	0.011	0.025	0.064
Silicon Si	3.90	3.90	2.48
Silver Ag	0.0011	0.0474	0.0002
Sodium Na	1918	1918	437
Strontium Sr	0.204	0.30	0.29
Thallium Tl	0.0004	0.0004	0.0001
Tin Sn	0.050	0.05	0.05
Titanium Ti	0.099	0.099	0.05
Vanadium V	0.006	0.006	0.023
Zinc Zn	0.50	0.50	0.50

Source: \\VAN-SVR0\Projects\01_SITES\Hope.Bay\1CT022.001_2014 Hope Bay Ongoing Support\410_Preparation of Submission (Patch 14, Wolverine & Madrid)\Water Quality Prediction\Model\Mill Effluent WQ.xlsx

Note: * Mill effluent for Madrid Bulk Samples based on Naartok samples (Croall and Bucknam 2011).

2.4 Water Management Constraints

The Madrid Advanced Exploration Project water management plan defines the water management strategy used in the water quality model (SRK 2014a).

The following key components were applied to the water management strategy during operations and closure:

- The TIA will discharge seasonally to Doris Creek until end of closure.
- The maximum discharge from the TIA to Doris Creek is limited to 10% of background flow in Doris Creek.
- Discharge from the TIA must meet the water quality objectives in the water licence.
- Doris Creek downstream of the discharge must meet water quality objectives in the water licence.
- The maximum water elevation during operations is 32.5 m when concentrations in the TIA meet discharge objectives and is 33.5 m when concentrations exceed discharge objectives.
- The minimum depth of water cover is 4 m above the surface of tailings during operations and closure to prevent re-suspension of sediments.

3 Water Quality Predictions

The median and 95th percentiles of maximum concentrations for discharge water quality of the TIA during operations and closure were predicted. The 95th percentile of concentrations represent the maximum concentration expected in the TIA based on 100 realizations for a range of hydrological conditions.

A monthly discharge timing window (June to October) during open water season was applied to ensure modelled TIA discharges met water quality targets during operations and closure as specified in the Water Licence for the Doris North Project (NWB No. 2AM-DOH1323). As described in the Water Licence Part G, Items 28 and 30, all water discharged from the TIA (end-of-pipe) cannot exceed specified effluent quality limits and during periods of discharge, water quality in Doris Creek cannot exceed the greater of the background water quality at the time of discharge or specified limits.

Enough water must be stored in the TIA to dilute the chloride load from Madrid South groundwater. Discharge from the TIA to Doris Creek can only start when mining progresses into the Madrid South talik. If water is discharged prior to this, there is insufficient dilution in the TIA for the discharge to meet water quality guidelines in Doris Creek. The maximum water quality predictions for Madrid North and Madrid South and guidelines for parameters of concern during operations and closure are presented in Table 9.

Table 9: Water Quality Results

Parameter	Effluent Limits Item 28	Max TIA Discharge Concentration		Doris Creek Limits Item 30	Doris Creek Concentration	
		Median	95th Percentile		Median	95th Percentile
TDS		1800	1900		290	310
Free_CN		0.000005	0.000005	0.005	0.002	0.002
Total_CN	1	0.0001	0.0001	0.01	0.003	0.003
WAD_CN		0.0003	0.0003		0.002	0.002
SCN		14	15		1	1
Sulphate		82	89		10	11
Chloride		790	860	150	130	140
Ammonia_N		0.2	0.2	1.5	0.05	0.05
Nitrate_N		1.8	1.9	2.9	0.2	0.2
Nitirite_N		0.2	0.2	0.06	0.04	0.04
Alkalinity		71	76		32	32
Hardness		400	430		78	80
Aluminum		0.2	0.3	0.1	0.07	0.07
Antimony		0.03	0.03		0.002	0.003
Arsenic	0.5	0.05	0.05	0.005	0.005	0.005
Barium		0.008	0.008		0.004	0.004
Beryllium		0.0009	0.001		0.0005	0.0005
Boron		0.1	0.2		0.04	0.05
Cadmium		0.0001	0.0001	0.00002	0.00001	0.00001
Calcium		300	330		34	36
Chromium		0.003	0.003	0.001	0.0008	0.0008
Cobalt		0.01	0.01		0.002	0.002
Copper	0.3	0.004	0.005	0.002	0.002	0.002
Iron		0.4	0.4	0.3	0.2	0.2
Lead	0.2	0.0006	0.0006	0.001	0.0001	0.0001
Manganese		0.05	0.06		0.02	0.02
Mercury		0.00002	0.00003	0.00003	0.00001	0.00001
Molybdenum		0.006	0.007	0.07	0.003	0.003
Nickel	0.5	0.02	0.02	0.03	0.003	0.003
Selenium		0.002	0.003	0.001	0.0009	0.0009
Silver		0.0002	0.0002	0.0001	0.00003	0.00003
Thallium		0.00006	0.00007	0.0008	0.00006	0.00006
Uranium		0.0003	0.0003		0.00008	0.00008
Zinc	0.5	0.05	0.05	0.0350	0.007	0.007

Source: \\VAN-SVR0\Projects\01_SITES\Hope.Bay\1CT022.001_2014 Hope Bay Ongoing Support\410_Preparation of Submission (Patch 14, Wolverine & Madrid)\Water Quality Prediction\Model\Mill Effluent WQ.xlsx

The water and load balance model predicts that by restricting discharges until the start of underground mining in Madrid South (August Year 5), predicted water quality meets discharge limits.

Figure 2 illustrates the predicted maximum (95th percentile) and minimum (5th percentile) water levels in the TIA during operations and closure. As noted above, water is not released during operations to provide additional dilution in the TIA prior to discharging to Doris Creek. The maximum (95th percentile) elevation modelled during operations was determined to be approximately 32.40 m amsl. The water elevation at closure is the natural Tail Lake elevation of 28.3 masl and provides a minimum water cover of 4.0 m above the deposited tailings (321,961m^3, 24.36 m amsl).

Arsenic levels in the TIA discharge determine the number of years required for water quality in the TIA to meet water licence limits to directly discharge to Doris Creek. Figure 3 illustrates that it would take approximately 15 years after the end of Madrid South bulk sampling (modelled month 250) before the 95th percentile arsenic levels in the TIA decrease below 0.005 mg/L during open water season (June to October). This is assuming that arsenic concentrations in the Bulk Sample Mill effluent are similar to Naartok metallurgical testing.

Additional metallurgical testing is underway to verify the concentrations in the tailings slurry. The model will be updated with these results as they become available. If the initial results significantly differ from the results used for these predictions, TMAC will prepare a contingency plan to address managing mill effluent.

4 Conclusion

The effect of managing and discharging excess collected contact water in the Madrid South and Madrid North Pollution Control ponds to the Doris North Project TIA was evaluated. Water balance and water quality modelling indicate that the water level in the TIA and water quality objectives in the water licence (2AM-DOH1323) can be met for the Madrid Advanced Exploration Project.

5 References

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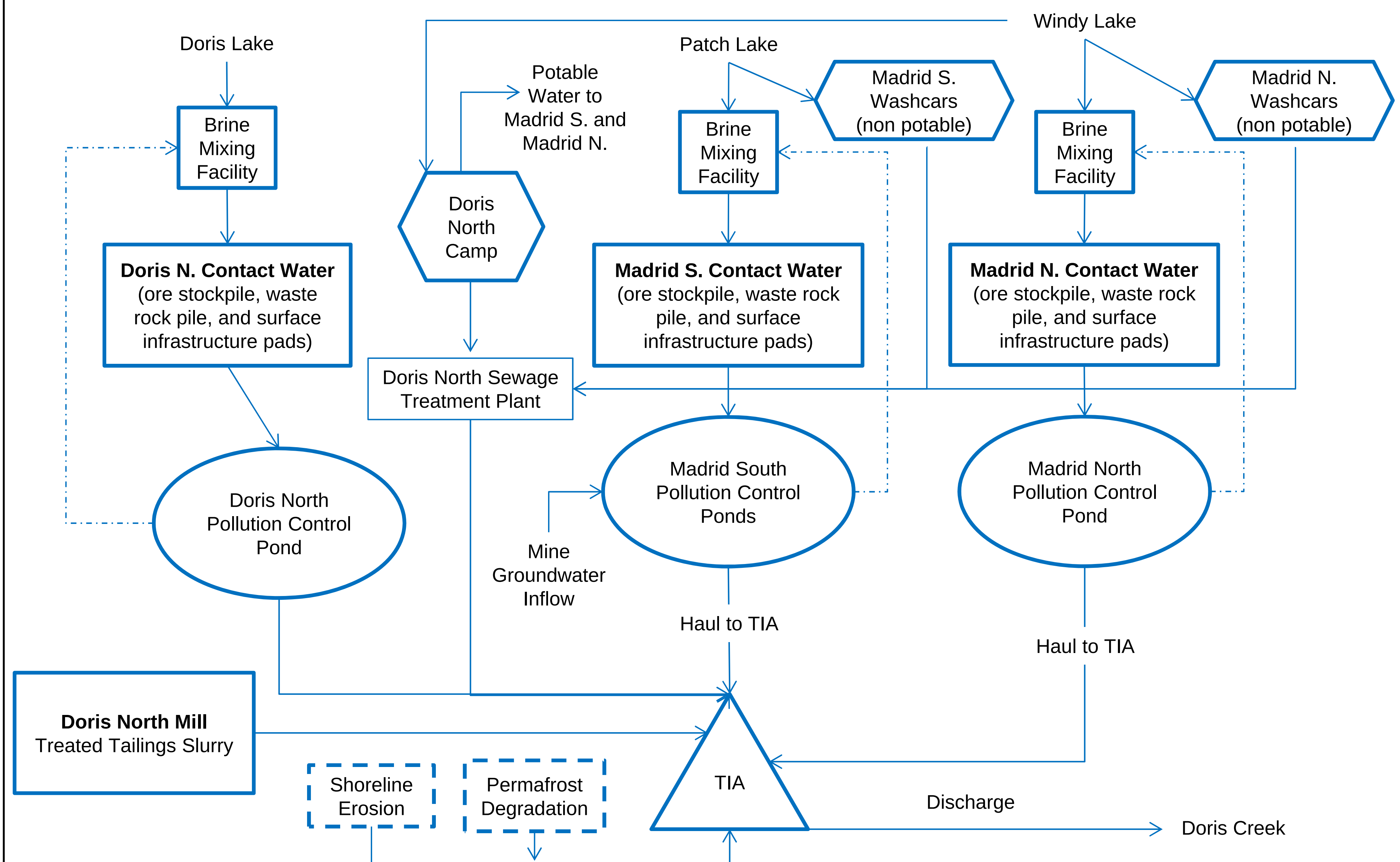
Figures



Flow Direction

srk consulting

TMAC RESOURCES

Madrid Advanced Exploration Project
Water Quality Prediction

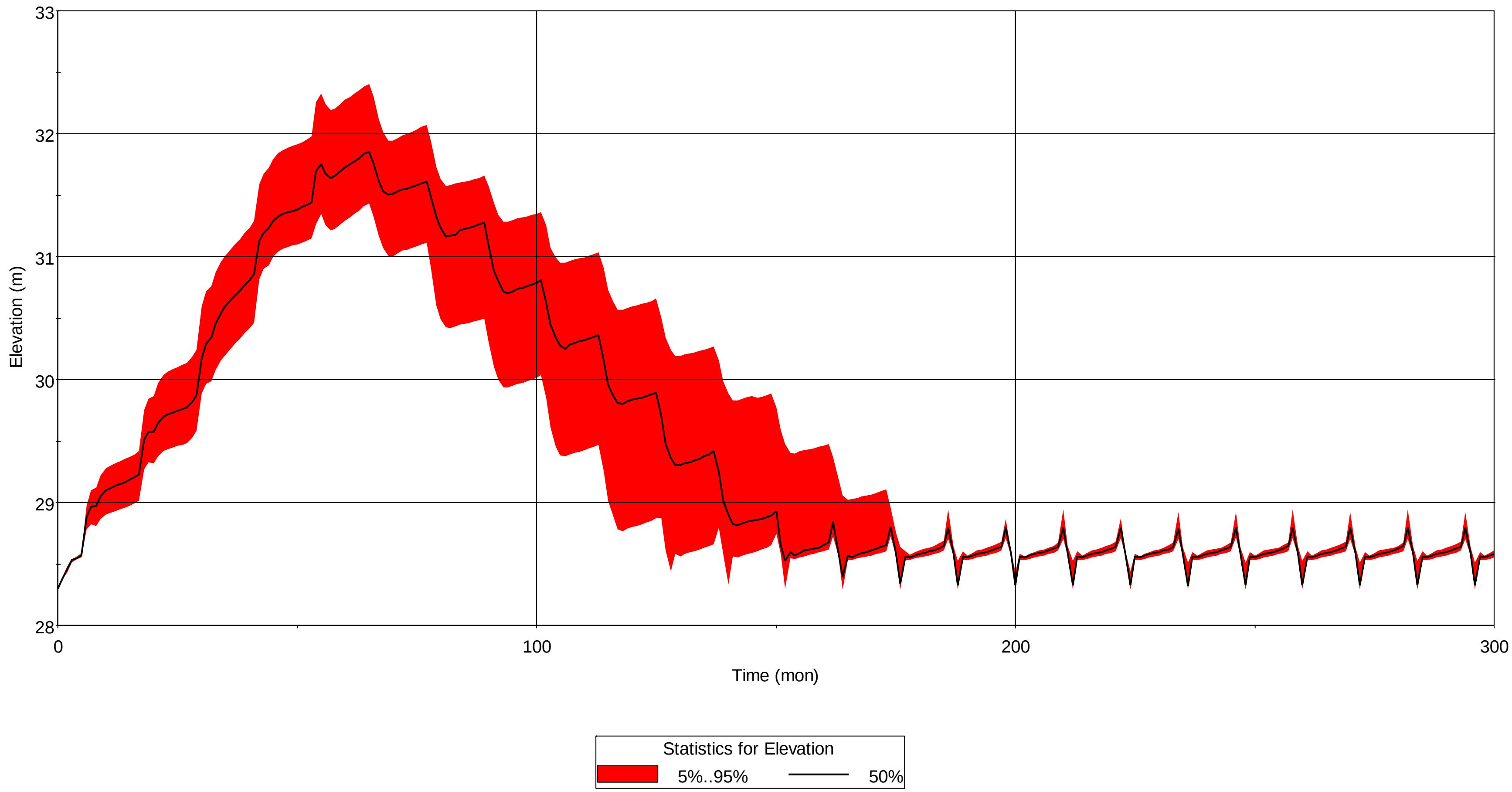
Water Management Schematic

Job No: 1CT022.000.410

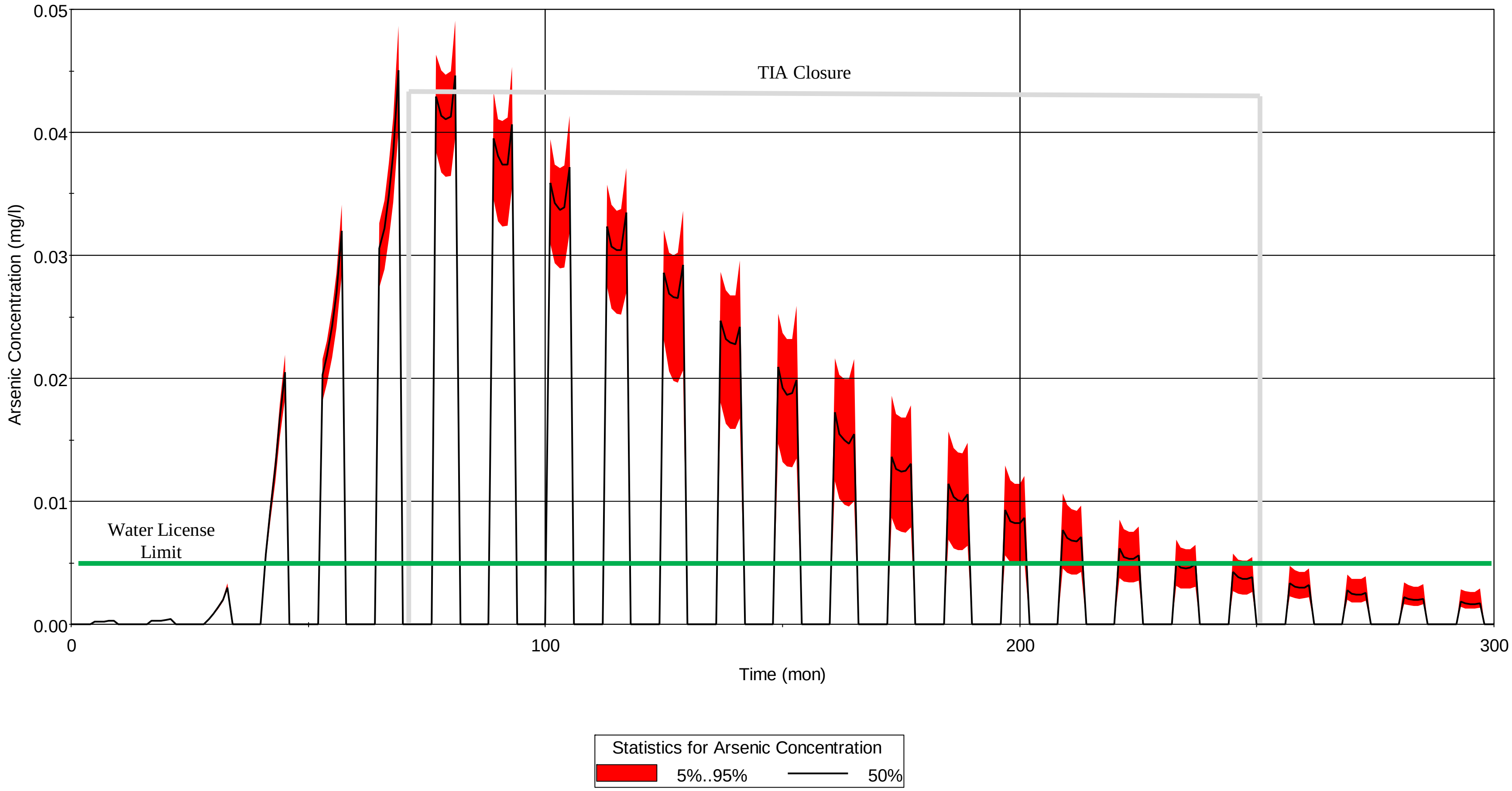
Filename: Figure 1 Water Balance Schematic_SPB_lw.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2014	SPB	1



srk consulting	TMAC RESOURCES	Madrid Advanced Exploration Project Water Quality Prediction
		Tail Lake Water Elevation
Job No: 1CT022.000.410 Filename: Figure 2 Tail Lake Water Elevation.pptx	Hope Bay Project	Date: November 2014 / Approved: SPB / Figure: **2**



srk consulting	TMAC RESOURCES	Madrid Advanced Exploration Project Water Quality Prediction
		Tail Lake Arsenic Concentration
Job No: 1CT022.000.410 Filename: Figure 3 Arsenic Concentration.pptx	Hope Bay Project	Date: November 2014 / Approved: SPB / Figure: **3**

Appendix 8

(for Chapter 8, Management Plans)

8-A SRK, December 2014 Memo – Water Management Plan: Madrid Advanced Exploration Program, North and South Bulk Samples

8-B SRK, December 2014 Memo – Overview of Madrid North and South Bulk Sample ML/ARD Characterization Programs and Conceptual Waste Rock Management Plans

8-C SRK, December 2014 – Hope Bay Project Quarry Management and Monitoring Plan - Revision 02

Appendix 8-A

SRK, December 2014 Memo – Water Management Plan: Madrid Advanced Exploration Program, North and South Bulk Samples

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Memo

To:	John Roberts	**Client:**	TMAC Resources Inc.
From:	Mark Liskowich	**Project No:**	1CT022.001.410
Cc:	Maritz Rykaart, SRK	**Date:**	December 1, 2014
Subject:	Water Management Plan: Madrid Advanced Exploration Program, North and South Bulk Samples		

1 Introduction

This plan is intended primarily for TMAC Resources Inc. staff and their contractors with the objective to ensure that best practices are employed throughout all water management activities associated with the operation and closure of the Madrid Advanced Exploration Program, Madrid North and South bulk samples, thus ensuring minimal potential environmental impacts.

There are no camp facilities at Madrid North or South bulk sample locations; therefore, potable water is limited to daily usage by the work force which will be transported to site from the Doris Camp on an as needed basis. All remaining water use will be limited to that needed to support mining the bulk samples. Water is needed to prepare brine for drilling in the underground workings. The goal of the water management system is to use intercepted contact water in preference to lake water for make-up water, and to maximize the mine contact water reuse within the underground workings.

This plan has been written in a manner allowing it to be appended to the Hope Bay Water Management Plan, following regulatory approval to proceed with the Madrid North and South bulk samples. This plan involves the collection and transportation of all excess water from the bulk samples via truck to Tail Lake Tailings Impoundment Area (TIA).

This plan does not include management of any water used or consumed as part of the surface exploration drill program which is covered under the standard terms and conditions of exploration licences issued by the Nunavut Water Board (NWB).

2 Background

From beginning to end, the bulk samples will require approximately 590 days or 20 months for the Madrid North bulk sample and approximately 520 days or 18 months for the Madrid South bulk sample.

In the case of the Madrid North bulk sample all waste and ore mining will be completed outside of the talik zone resulting with the production of relatively low volumes of mine water.

The Madrid South bulk sample will initially require approximately 260 days of development mining (waste rock) in order to reach the area of interest. Once the ore zone is reached, a combination of ore and waste mining will be carried out for an additional 260 days to the completion of the bulk sample. This latter phase of the Madrid South bulk sample is assumed to be in the talik zone and therefore is expected to generate the highest volumes of mine water.

3 Responsibilities

The overall responsibility for the implementation of this Water Management Plan rests with TMAC's General Manager of Operations. The general manager will be responsible to ensure that all necessary resources and personnel are made available to ensure that components of the water management plan such as pipelines, diversion berms, lined ponds, holding tanks are ready for operation prior to initiating the bulk sample mining activities.

Day-to-day operational responsibilities will be in accordance with those outlined in the Doris North Water Management Plan; however, it is expected the following will also apply.

The Manager of Environmental Compliance and the Environmental Coordinator will be responsible for reporting requirements related to all monitoring associated with all components of this plan, such as pond water volumes, as well as coordination with the surface foreman responsible for transporting water from the bulk sample sites to the TIA.

4 Infrastructure

Both the Madrid North and Madrid South bulk samples will occur at undeveloped sites with no existing infrastructure. An all-weather road will be constructed in order to access both sites. The following infrastructure will be required and constructed at both the Madrid North and Madrid South bulk sample sites:

- 1 Pollution Control Pond (Madrid North bulk sample site), 2 Pollution Control Ponds (Madrid South bulk sample site);
- Waste rock pile;
- Bulk sample ore stockpile;
- Laydown area, infrastructure pads and vent raise;
- Fuel storage area; and
- Mine portal.

The locations of these facilities are shown on Figures 1 and 2 for the Madrid North and Madrid South bulk sample sites, respectively.

4.1 Pollution Control Ponds

All water interacting with the above infrastructure will be collected in the Pollution Control Pond or ponds in the case of the Madrid South bulk sample and managed as described in Section 5.

The ponds at both bulk sample locations will be lined with a geomembrane and will act as sedimentation basins facilitating the settling of suspended solids. The runoff water captured by these ponds will either be used within the Brine Mixing Facilities (BMF) or transferred to the TIA.

4.1.1 Madrid North Bulk Sample

The single pond at the Madrid North bulk sample site will be located downstream of the portal, ore and waste rock pile pads as shown in Figure 1. The pond will be contained by a 6 m wide berm. This berm has been designed to allow for light vehicle access around the pond for regular inspection; to assist in accommodating any required maintenance; and to allow for a vacuum truck to remove any retained water. The surface area of the Pollution Control Pond is 13,900 m^2 and its maximum depth is 2.8 m.

The Pollution Control Pond will have the capacity to contain flow from the overall drainage area plus 25% of the annual snow coverage combined with a 100-year, 24-hour storm event or an approximate 14,940 m^3 in total. However, it is expected that this pond will always be operated in a manner allowing pumping to commence as soon as the containment volume is large enough for one continuous hour of pumping.

The run-off water captured by this pond will be used within the BMF or transferred to the TIA.

4.1.2 Madrid South Bulk Sample

The primary Pollution Control Pond will be constructed downstream of the waste rock and ore stockpiles and will be contained by an 8-m wide berm which will double as a roadway and allow for access around the pond and to the waste rock storage location as shown in Figure 2.
The surface area of the primary Pollution Control Pond will be 12,300 m^2 and will have the capacity to contain flow from the overall drainage area plus 25% of annual snow coverage combined with a 100-year, 24-hour storm event (approximately 15,000 m^3 in total).

The secondary Pollution Control Pond will be contained by a 6-m wide berm located next to the Madrid South portal and the BMF. The berm was designed to allow for light vehicle access around the pond for regular inspection and to assist in accommodating any required maintenance. The secondary Pollution Control Pond will have the capacity to contain flow from the overall drainage area plus 25% of the annual snow coverage for an approximate total of 900 m^3. However, it is expected that this pond will always be operated in a manner allowing pumping to commence as soon as the containment volume is large enough for one continuous hour of pumping.

Operation of both primary and secondary ponds will be done in a manner that both ponds are maintained in a 90% empty state.

The run-off water captured by these ponds will be used within the BMF or transferred to the TIA.

4.2 Waste Rock Piles

As shown in Figures 1 and 2, the waste rock piles at each bulk sample sites will be located adjacent to the Pollution Control Ponds.

The Madrid North bulk sample waste rock pile has a base area of 21,530 m^2 and is designed to hold 285,000 m^3 of waste rock. The Madrid South bulk sample waste rock pile has a base area of 31,230 m^2 and is designed to hold a volume of 276,000 m^3 of waste rock.

All water coming into contact with the waste rock piles will be collected in the Pollution Control Ponds and managed in accordance with Section 5.

4.3 Bulk Sample Ore Stockpiles

The bulk sample ore stockpiles will be constructed adjacent to the waste rock piles (Figures 1 and 2). The Madrid North bulk sample ore stockpile is designed with a base of 5,560 m^2 and the ability to hold 28,000 m^3 (50,000 tonnes) of ore and the Madrid South bulk sample ore stockpile is designed with a base area of 12,200 m^2 and the capacity to hold 31,000 m^3 (55,000 tonnes) of ore.

All water coming into contact with the bulk sample stockpiles will be collected in the Pollution Control Ponds and managed in accordance with Section 5.

4.4 Laydown Area and Infrastructure Pads

4.4.1 Madrid North Bulk Sample

The Madrid North laydown area is located on the Portal Upper Pad (Figure 1). The Portal Pad provides a base for the Shop, Laydown Area, office trailers, the BMF and the storage of calcium chloride. The Vent Raise Pad provides a base for the vent raise, air heating facility and fuel containment.

Each of these facilities will be constructed and graded at 0.5% to collect and route all contact water to the Pollution Control Pond for collection, reuse and/or management as discussed in Section 5.

4.4.2 Madrid South Bulk Sample

The laydown area and infrastructure pads consist of the infrastructure pad, the portal pad, the upper portal pad and the vent raise pad. The infrastructure pad provides a base for the shop, fuel transfer station, laydown area and office trailers. The vent raise pad provides a base for the vent raise, air heating facility and associated fuel storage tank. The Upper Portal Pad provides a base for the water tank. The Madrid South Portal Pad provides a base for the BMF and the storage of calcium chloride ($CaCl_2$) (Figure 2).

Each of these facilities will be constructed to collect and route all contact water to either the Primary or Secondary Pollution Control Pond for collection, reuse and/or management as discussed in Section 5.

4.5 Fuel Storage Area

At both the Madrid North and South Bulk Sample sites, fuel will be stored in two separate locations. One 75,000 L double-walled tank will be located adjacent to the Portal Pad Haul Road (Figure 1) at the Madrid North bulk sample site and one 75,000 L double-walled tank will be located on the infrastructure pad at the Madrid South bulk sample site (Figure 2). A second storage tank with a capacity of 60,000 L will be located on the vent raise pads associated with both the Madrid North and Madrid South bulk sample sites. These tanks will be placed in lined containment designed to hold 100% of the tank volume plus 10% of the fuel transport truck as well as 25% of annual snow cover combined with a 1-in-100 year 24-hour storm event.

A sump will be installed in one corner of each tank's containment to allow for collection and removal of runoff and snow melt that accumulates inside the containment. If seasonal accumulation of water meets discharge criteria it may be discharged to the tundra in the area of the fuel storage and/or used in activities, such as dust suppression if said approval is pre-approved.

4.6 Mine Portal

The mine portals will provide access to the underground workings and be used to recover all mine water from both bulk sample sites. The portal is located on Figures 1 and 2. All brine needed for drilling will be transported via pipeline from the BMF to the underground drilling equipment. Following settlement of suspended solids in the underground sumps the clarified water will be directly recycled from the sumps to the underground equipment and/or pumped to the BMF water supply tank which supplies raw water to the BMF for re-use in the underground workings. All runoff entering the mine portal will report to the underground sumps.

5 Water Management

Runoff from the waste rock piles, ore stockpiles and the site infrastructure pads will be collected in Pollution Control ponds and transferred to the 50,000 L water supply tank located at each bulk sample site. Supply water for the BMF will be drawn from this tank to create a brine to be used in underground operations. Additional freshwater for the BMF should only be needed when water already being used for drilling can no longer be recycled. When make-up water cannot be drawn from the Pollution Control ponds it will be drawn from Windy Lake in the case of the Madrid North bulk sample, and from Patch Lake in the case of the Madrid South bulk sample. All excess water collected in the Pollution Control ponds will be transported to the TIA.

5.1 Water Management during Operations

The sources of water during operations are runoff from site infrastructure pads, waste rock piles and ore stockpiles (collected in the Pollution Control ponds) and fresh make-up water drawn from either Windy or Patch Lake.

Water will be stored in a 50,000 L water supply tank located near the BMF.

During operations, the underground mine water demand will be supplied from three sources, as shown in Figures 3 and 4 and listed by priority of use below:

1. Reuse mine water collected in underground settling sumps;
2. Contact water from waste rock and ore stockpiles, collected in the Pollution Control ponds and directed to the 50,000 L tank as needed; and
3. Freshwater as make-up water from Windy Lake or Patch Lake.

It is estimated that there will be four underground drilling rigs used for the bulk sampling at the Madrid North and Madrid South bulk sample sites resulting in the use of 34 m^3 of water daily per site. Of this 34 m^3/d an estimated 6.7 m^3/d will be consumed and 27 m^3/d will be recycled. Water will initially be drawn from Windy Lake (in the case of the Madrid North bulk sample) and from Patch Lake (in the case of the Madrid South bulk sample) to make brine for drilling. Brine used underground will be reused to the maximum extent possible by settling solids in sumps underground. Some of the drilling brine will be lost in waste rock and ore, and additional make-up water will be required.

Contact water runoff from the pads, waste rock piles and ore stockpiles will be collected in the Pollution Control ponds. Once the ponds have filled to a 10% capacity the water will be pumped from the Pollution Control ponds to the 50,000 L water supply tank for the BMF at each of the bulk sample sites.

Water will be pumped from the supply tank through the BMF, and will be stored in a secondary containment structure within the BMF. This additional brine will be pumped underground and used by the underground drilling as needed.

If the Pollution Control ponds and underground settling sumps cannot meet the demand for brine, additional make-up water will be drawn from Windy Lake for the Madrid North bulk sample or from Patch Lake for the Madrid South bulk sample. When necessary the freshwater pumped from either lake will be done so utilizing a water truck. All intakes will be screened in accordance with guidelines published by DFO (1995).

Potable water will be limited to that used for drinking water. This water will be provisioned to each site from the Doris North water treatment facility on an as-needed basis. Water for washroom facilities and the emergency shower located at each of the bulk sample sites will be sourced from Windy Lake for the Madrid North bulk sample or from Patch Lake for the Madrid South bulk sample and will be provisioned by truck.

All grey water and sewage will be transported via truck from the bulk sample locations to Doris North for disposal in the Doris North Sewage Treatment Facility.

5.2 Excess Water Management

Excess water from the underground workings or the Pollution Control ponds will be managed in the following manner and as shown schematically on Figures 3 and 4.

Excess water accumulating in the Pollution Control ponds above 10% of the pond holding capacity that is not required as supply water for the BMF, will be transferred to trucks and hauled to the TIA.

The volume of water that will need to be transported to the TIA will vary depending on the season and the climatic conditions of the season (i.e., dry, average or wet year) and what point in the mining schedule each bulk sample is at.

5.2.1 Madrid North Bulk Sample

In the case of the Madrid North bulk sample the entire bulk sample should be completed without intersecting the talik zone therefore the major fluctuations in mine contact water volumes should be climate dependent. Table 1 provides anticipated monthly volumes and estimated water truck trips on an annual basis while mining the bulk sample under different climatic conditions.

Table 1: Bulk Sample Water Management Contact Water Volumes for Dry, Average and Wet Hydrologic Conditions (SRK 2014).

Phase	Month	Year	Madrid North Bulk Sample			Madrid South Bulk Sample		
			5th	50th	95th	5th	50th	95th
Madrid North Mining	4	3	0	0	0	0	0	0
	5	3	0	0	0	0	0	0
	6	3	8,586	11,546	16,204	0	0	0
	7	3	4,047	5,442	7,638	0	0	0
	8	3	1,254	1,686	2,366	0	0	0
	9	3	1,571	2,113	2,965	0	0	0
	10	3	417	555	779	0	0	0
	11	3	0	0	0	0	0	0
	12	3	0	0	0	0	0	0
	1	4	0	0	0	0	0	0
	2	4	0	0	0	0	0	0
	3	4	0	0	0	0	0	0
	4	4	0	0	0	0	0	0
	5	4	0	0	0	0	0	0
	6	4	8,135	11,592	16,741	0	0	0
	7	4	3,834	5,464	7,891	0	0	0
	8	4	1,188	1,693	2,445	0	0	0

Phase	Month	Year	Madrid North Bulk Sample			Madrid South Bulk Sample		
			5th	50th	95th	5th	50th	95th
	9	4	1,489	2,121	3,064	0	0	0
	10	4	391	557	805	0	0	0
	11	4	0	0	0	0	0	0
Madrid South Mining	12	4	0	0	0	0	0	0
	1	5	0	0	0	0	0	0
	2	5	0	0	0	0	0	0
	3	5	0	0	0	0	0	0
	4	5	0	0	0	0	0	0
	5	5	0	0	0	0	0	0
	6	5	8,748	11,569	16,741	6,721	8,888	12,863
	7	5	4,123	5,453	7,891	3,168	4,190	6,063
Madrid South Mining in Talik	8	5	1,277	1,689	2,445	16,200	16,517	17,097
	9	5	1,601	2,117	3,064	16,449	16,845	17,573
	10	5	420	556	805	15,542	15,646	15,837
	11	5	0	0	0	15,219	15,219	15,219
	12	5	0	0	0	15219	15,219	15,219
	1	6	0	0	0	15,219	15,219	15,219
	2	6	0	0	0	15,219	15,219	15,219
	3	6	0	0	0	15,219	15,219	1,5219
	4	6	0	0	0	15,219	15,219	15,219
Closure	5	6	0	0	0	0	0	0
	6	6	8,667	11,612	16,204	6,659	8,922	12,450
	7	6	4,085	5,473	7,638	3,139	4,205	5,868
	8	6	1,266	1,696	2,366	972.4	1,303	1,818
	9	6	1,586	2,125	2,965	1,219	1,633	2,278
	10	6	417	559	779	320	429	598
	11	6	0	0	0	0	0	0
	12	6	0	0	0	0	0	0
	1	7	0	0	0	0	0	0
	2	7	0	0	0	0	0	0
	3	7	0	0	0	0	0	0
	4	7	0	0	0	0	0	0
Peak Volume (m^3/month)			8,748	11,612	16,741	16,449	16,845	17,573
Peak Daily Truck Traffic (trucks/day)			6	8	11	11	11	12

5.2.2 Madrid South Bulk Sample

It is anticipated that much of the waste and ore mining at the Madrid South bulk sample will occur in the talik zone. The initial ±260 days of mining will be developed in waste rock which is anticipated to be outside of the talik zone and therefore be relatively dry. The final ±260 days of mining is expected to be within the talik and therefore responsible for the production of the majority of the groundwater encountered during the Madrid South bulk sample program. Table 1 provides anticipated monthly volumes and estimated water truck trips on an annual basis while mining in the different zones (with or without groundwater) and under different climatic conditions.

5.3 Water Management at Closure and Temporary Closure

In the case of temporary mine shut down, or permanent closure, mine contact water will be managed as excess water described in Section 5.2. Any remaining waste rock or ore remaining on the stockpiles will either be transported to the Doris North Project or covered in place with a HDPE liner to eliminate contact, or some combination of both management approaches.

Runoff from the site infrastructure pads, waste rock piles and ore stockpiles will be collected in the Pollution Control ponds for settling. The water collected in the ponds will be tested and if it meets discharge criteria it will be discharged to the tundra. Water not meeting the discharge guidelines will be transported via truck to the TIA as described in Section 5.2 (Figure 5).

Subsequent to the water quality meeting all discharge limits, the site infrastructure will be decommissioned and reclaimed as described in the Madrid Advanced Exploration Program: Conceptual Closure and Reclamation Plan (SRK 2014).

6 Inspections

Daily visual inspections of all pads and dykes located throughout the bulk sample infrastructure areas will be completed by operations or environmental staff. These inspections will look for the following types of issues:

- Drainage channels have not been inadvertently blocked or re-routed in a manner that could alter the intended routing of the runoff to the Pollution Control ponds.
- Signs of erosion, occurring during high flow periods.
- Volumes of water in the Pollution Control ponds.
- Any irregularities identified during the visual inspections will be recorded in field books and immediately relayed to the General Manager of Operations and/or the Engineering, Procurement and Construction (EPC) Manager in order to ensure immediate corrective action can be implemented.

7 Monitoring

The Pollution Control ponds will be constructed with permanent staff gauges to allow for visual monitoring of incoming flows to each pond. Daily volumes will be recorded in a dedicated log book for each pond. These log books should be maintained by the operations or environmental staff. The volume of all water transferred from the Pollution Control ponds either to the BMF or to the TIA will be monitored with a flow meter or tracked by truckload as appropriate during the transfers.

Pond water quality in the Pollution Control ponds will be monitored in accordance with the Water Licence.

The Site General Manager and operations are responsible for monitoring.

All sampling procedures and QA/QC activities will follow those documented in the SNP requirements stipulated in the Water Licence.

8 Reporting

In accordance with the approval to proceed with the Madrid North and Madrid South bulk samples, a construction monitoring report will be prepared documenting the construction of all infrastructure at each site.

The report will include, but not necessarily be limited to the following:

- A summary of all inspections conducted during construction, and
- Updated “As-built” drawings of the constructed infrastructure.

All inspection and monitoring data will be compiled, documented and incorporated into the existing monthly and annual monitoring reports submitted to the Board. These reports will include, but not be limited to:

- An assessment of data to identify areas of non-compliance; and
- A site water balance incorporating water volumes transferred from the Pollution Control Ponds to the BMF and/or volumes trucked to the Doris North TIA.

9 References

DFO 1995, Freshwater Intake End-Of-Pipe Fish Screen Guideline, DFO / 5080, March 1995.

SNC-Lavalin, 2009. Hope Bay Mining Limited. Doris North Infrastructure Project. Fresh Water Supply Pipeline (Permanent) Plan, Profile & Section. As-Built Drawings Prepared for Newmont Mining Corporation. Project Number 334499, January 26, 2009.

SRK Consulting (Canada) Inc. 2014, Hope Bay Project: Madrid Advanced Exploration Program: Conceptual Closure and Reclamation Plan. Technical Memorandum prepared for TMAC Resources Inc., Project No.: 1CT022.001.410. October 31 2014.

SRK Consulting (Canada) Inc. 2014b. Hope Bay Project: Madrid Advanced Exploration Project Water Quality Prediction. Technical Memorandum prepared for TMAC Resources Inc., Project No.: 1CT022.001.410. November 5, 2014.

Figures