GREAT LAKES INDIAN FISH & WILDLIFE COMMISSION
P. O. Box 9 • Odanah, WI 54861 • 715/682-6619 • FAX 715/682-9294

• MEMBER TRIBES •

MICHIGAN	WISCONSIN		MINNESOTA
Bay Mills Community	Bad River Band	Red Cliff Band	Fond du Lac Band
Keweenaw Bay Community	Lac Courte Oreilles Band	St. Croix Chippewa	Mille Lacs Band
Lac Vieux Desert Band	Lac du Flambeau Band	Sokaogon Chippewa	

April 30, 2013

Tom Hingsberger
Project Manager
United States Army Corps of Engineers, St. Paul District
190 Fifth St. East
St. Paul, MN 55101-1638

Mr. Hingsberger,

Enclosed please find an analysis of indirect impacts to wetlands due to drawdown at the NorthMet mine site developed by the Great Lakes Indian Fish and Wildlife Commission (GLIFWC). GLIFWC is an intertribal agency exercising delegated authority from 11 federally recognized Ojibwe (or Chippewa) tribes in Wisconsin, Michigan and Minnesota.[1] Those tribes have reserved hunting, fishing and gathering rights in territories ceded in various treaties with the United States. GLIFWC's mission is to assist its member tribes in the conservation and management of natural resources and to protect habitats and ecosystems that support those resources.

As you know, the proposed Polymet mine is located within the territory ceded in the Treaty of 1854. GLIFWC member tribes have expressed concern about the potential impacts of sulfide mining, whether those impacts occur within the 1854 ceded territory, in the 1842 ceded territory, which includes portions of Lake Superior, or the 1837 ceded territory. The following analysis is submitted by GLIFWC staff with the explicit understanding that each GLIFWC member tribe or any other tribe may choose to submit analysis and information from its own perspective.

Potential impacts to wetlands due to groundwater drawdown at the NorthMet mine site

1 GLIFWC member tribes are: in Wisconsin -- the Bad River Band of the Lake Superior Tribe of Chippewa Indians, Lac du Flambeau Band of Lake Superior Chippewa Indians, Lac Courte Oreilles Band of Lake Superior Chippewa Indians, St. Croix Chippewa Indians of Wisconsin, Sokaogon Chippewa Community of the Mole Lake Band, and Red Cliff Band of Lake Superior Chippewa Indians; in Minnesota -- Fond du Lac Chippewa Tribe, and Mille Lacs Band of Chippewa Indians; and in Michigan -- Bay Mills Indian Community, Keweenaw Bay Indian Community, and Lac Vieux Desert Band of Lake Superior Chippewa Indians.

are described in the NorthMet Project Wetland Data Package Version 7 dated March 1, 2013. Potential impacts due to drawdown are assessed using an analog method where information from another site is used to provide a best guess as to how wetlands surrounding NorthMet might be affected. The data package states that this method came out of the Wetlands IAP process however it does not state that GLIFWC and other cooperating and reviewing agencies have objected to using this method. The objections are detailed in the comments that GLIFWC provided within the IAP process (Attachment A).

GLIFWC continues to believe that the analog method can be informative in the process. We also reiterate that the lead agencies' reliance on analogs as the only source of information to gauge impacts from pit dewatering is not a rigorous approach to impact estimation. However, because of the lead agencies insistence that this method be used in the SDEIS, GLIFWC is providing an independent analysis using information from other mine pits located on the Mesabi Range.

Analog Data Used

- Randal Property (Wells T3 and T4), Rhino and Highway 7 wells in the vicinity of the Canisteo pit. (Source: Adams and Liljegren 2011)
- MNDNR observation well, in the vicinity of Hibtac pits (Source: Crotteau, 2013).
- Dom-ex and Pinto wells north of Hibbing in the vicinity of Hibtac (Source: Crotteau, 2013).
- Keewatin City wells #1 and #2 in the vicinity of the Keetac pit (Source: Liesh and Associates Technical Memorandum, 2009).

Contour lines showing the analog well information in relation to the proposed NorthMet mine site are provided in Figure 1.

Wetland Analog Impact Zones and Significance Criteria

GLIFWC objections to the impact zones developed by the lead agencies are presented in Attachment A. We believe these distance zones are somewhat arbitrary and continue to have concerns regarding their use. Despite these concerns, we are using similar impact zones so that the results we present can be compared to the analysis that in presented in the NorthMet Project Wetland Data Package Version 7.

GLIFWC impact zones (Figure 2) are:

- Zone 1 – 0 to 1000 feet from the mine pit edge.
- Zone 2 – 1000 to 2000 feet from the mine pit edge.
- Zone 3 – 2000 to 5000 feet from the mine pit edge.
- Zone 4 – 5000 to 10000 feet from the mine pit edge.

For impact assessment, this analysis applies the significance criteria outlined in large table 8 of the NorthMet Project Wetland Data Package Version 7. However, GLIFWC does not automatically exclude wetlands that have been classified as ombotrophic in the data package from being considered impacted by drawdown. Literature indicates that ombotrophic wetlands can and are impacted by drawdown (Grootjans et al 2009, Jaatinen et al 2006, Vassander 1995). Furthermore, the analysis in the NorthMet Project Wetland Data Package Version 7 relies on surface observations of plant communities to classify bog wetlands as ombotrophic or minerotrophic. GLIFWC agrees that this is useful information but we maintain that it is not a substitute for detailed understanding of the relationship of the water table and wetlands at the site. NorthMet Project Wetland Data Package Version 7 states that hydraulic conductivity in the unconsolidated deposits around the mine site can range between 0.012 to 31 feet per day. Therefore unless there is information on whether the unconsolidated deposits that underlie wetlands are saturated or not it is not possible to know the degree to which groundwater supports wetland hydrology.

The data package assumes that wetlands deemed to be ombotrophic based on plant lists are not connected to groundwater and therefore are not impacted by drawdown. We believe that this assumption is not supportable. Instead, GLIFWC assumes that there is at least a partial connection between ombotrophic wetlands and groundwater. Therefore, if groundwater under these “perched” wetlands is drawn down by several feet, this new head pressure would lead to impacts to the wetlands because of a “bathtub effect”. In other words, water would seep out of ombotrophic wetlands in areas where there is a hydrologic connection to the saturated layer. This assumption is the support for assigning significance criteria for Deep Mersh/Shallow Marsh and Open bog wetlands. This assumption is also factored into the significance criteria for the proposed Crandon project on which large table 8 of the NorthMet Project Wetland Data Package Version 7 is based.

Finally, the data package ignores the fact that the proposed NorthMet pits would be several times deeper than a typical pt located up on the Mesabi Range. Thus the hydrologic effects on the surrounding aquifer will likely be greater.

Zone 1 Impacts (0 – 1000 Feet)

Wetlands within Zone 1 are depicted in Figure 3. Information provided by MNDNR Mining Hydrologist Michael Crotteau indicates that 2 wells at the Randall property (Wells T3 and T4) were artesian before a drain tile was installed to reduce groundwater levels in the area. This indicates a strong hydrologic connection between these wells and the Canisteo pit approximately 700 feet from the edge of the pit (Figure 4). The basement of the Randall residence was built when the Canisteo pit was dewatered is at an elevation of 1300 feet above sea level. The surface elevation at the site is 1310.73 feet above sea level. This indicates at least an 8 to 10 foot increase in the elevation of the water table 792 feet away from a reflooded Canisteo pit.

Based on these analog wells, a drawdown of up to 10 feet could affect wetlands in zone 1. We believe it is reasonable to assume that 5 to 10 feet of drawdown would occur throughout zone 1. In addition, these wetlands are often remnants of wetlands directly impacted by the pits and stockpiles, are surrounded by roads and ditches, and directly border the pits. Therefore, all wetlands in zone 1 are assessed as severely impacted (Table 1).

UNIQUE ID	EGGERS & REED CLASS	ACRES	IMPACT	IMPACT DESCRIPTION
24	Alder thicket	5.920	Severe	Conversion of wetland type
33A	Alder thicket	142.927	Severe	Conversion of wetland type
43	Alder thicket	7.456	Severe	Conversion of wetland type
44	Alder thicket	14.704	Severe	Conversion of wetland type
45	Alder thicket	159.903	Severe	Conversion of wetland type
51	Alder thicket	5.542	Severe	Conversion of wetland type
52	Alder thicket	18.113	Severe	Conversion of wetland type
53D	Alder thicket	39.376	Severe	Conversion of wetland type
100	Coniferous bog	981.692	Severe	Possible conversion of wetland type
101	Coniferous bog	60.631	Severe	Possible conversion of wetland type
103	Coniferous bog	174.579	Severe	Possible conversion of wetland type
107	Coniferous bog	126.238	Severe	Possible conversion of wetland type
25	Coniferous bog	20.965	Severe	Possible conversion of wetland type
32	Coniferous bog	73.745	Severe	Possible conversion of wetland type
48	Coniferous bog	190.986	Severe	Possible conversion of wetland type
62	Coniferous bog	1.782	Severe	Possible conversion of wetland type
76	Coniferous bog	22.181	Severe	Possible conversion of wetland type
77	Coniferous bog	118.315	Severe	Possible conversion of wetland type
79	Coniferous bog	25.709	Severe	Possible conversion of wetland type
82	Coniferous bog	44.293	Severe	Possible conversion of wetland type
888	Coniferous bog	12.481	Severe	Possible conversion of wetland type
90	Coniferous bog	499.822	Severe	Possible conversion of wetland type
96	Coniferous bog	52.276	Severe	Possible conversion of wetland type
97	Coniferous bog	32.904	Severe	Possible conversion of wetland type
99	Coniferous bog	14.536	Severe	Possible conversion of wetland type
107A	Coniferous swamp	3.090	Severe	Change in vegetation
33B	Coniferous swamp	47.690	Severe	Change in vegetation
68	Coniferous swamp	172.129	Severe	Change in vegetation
72	Coniferous swamp	14.910	Severe	Change in vegetation
13	Deep marsh	54.139	Severe	Conversion of wetland type
20	Sedge meadow	2.237	Severe	Conversion to upland
107B	Shallow marsh	27.922	Severe	Conversion of wetland type
9	Shallow marsh	19.424	Severe	Conversion of wetland type

Table 1. Zone 1 impact assessment.

Zone 2 Impacts (1000 – 2000 Feet)

Wetlands within zone 2 are depicted in Figure 5. The Dom-ex well is located on the north side of the city of Hibbing is 1320 feet from the nearest dewatered pit at Hibtac. According to Mr. Crotteau this well experienced a drop of 3.07 feet in response to pit dewatering. Because wells in zone 3 (discussed below) indicate drawdown values ranging between 1 and 3 feet, and wells in zone 1 indicate dewatering of up to 10 feet, this analysis assumes that drawdowns in zone 2 are on the order of 3 to 5 feet. In adition to drawdown, wetlands in zone 2 are remnants of wetlands directly impacted by the project, are surrounded by roads, ditches and other mine features, or have sections in zone 1. These wetlands can also be impacted by aerial deposition of mine related contaminants. The impact assessment for wetlands in zone 2 are outlined in Table 2.

It is important to note that a section of the upper Partridge River is located within Zone 2. Drawdowns of 3 to 5 feet under a river could severely reduce baseflow leading to reductions in flow in the river channel. Reductions in flow could indirectly impact riparian wetlands downstream.

UNIQUE ID	EGGERS & REED CLASS	ACRES	IMPACT	IMPACT DESCRIPTION
100A	Alder thicket	8.275	Moderate to Severe	Change in vegetation to change in wetland type
53D	Alder thicket	802.660	Moderate to Severe	Change in vegetation to change in wetland type
43	Alder thicket	9.150	Moderate to Severe	Change in vegetation to change in wetland type
53	Alder thicket	15.967	Moderate to Severe	Change in vegetation to change in wetland type
100A	Alder thicket	8.210	Moderate to Severe	Change in vegetation to change in wetland type
22C	Alder thicket or Shrub-carr	30.447	Moderate to Severe	Change in vegetation to change in wetland type
315	Alder thicket or Shrub-carr	185.118	Moderate to Severe	Change in vegetation to change in wetland type
100	Coniferous bog	49.041	Severe	Possible conversion of wetland type
48	Coniferous bog	556.958	Severe	Possible conversion of wetland type
62	Coniferous bog	108.797	Severe	Possible conversion of wetland type
80	Coniferous bog	3.138	Severe	Possible conversion of wetland type
86	Coniferous bog	4.866	Severe	Possible conversion of wetland type
88	Coniferous bog	14.561	Severe	Possible conversion of wetland type
100	Coniferous bog	105.174	Severe	Possible conversion of wetland type
104	Coniferous bog	4.747	Severe	Possible conversion of wetland type
90	Coniferous bog	383.229	Severe	Possible conversion of wetland type
773	Coniferous bog	53.424	Severe	Possible conversion of wetland type
888	Coniferous bog	940.711	Severe	Possible conversion of wetland type
77	Coniferous bog	20.517	Severe	Possible conversion of wetland type
552	Coniferous bog	31.210	Severe	Possible conversion of wetland type
61	Coniferous swamp	3.727	Moderate to Severe	Possible changes in vegetation
701	Coniferous swamp	3.968	Moderate to Severe	Possible changes in vegetation
856	Coniferous swamp	74.335	Moderate to Severe	Possible changes in vegetation
22A	Coniferous swamp	9.564	Moderate to Severe	Possible changes in vegetation
53C	Coniferous swamp	28.741	Moderate to Severe	Possible changes in vegetation
48A	Coniferous swamp	7.821	Moderate to Severe	Possible changes in vegetation
57	Coniferous swamp	36.143	Moderate to Severe	Possible changes in vegetation
64	Hardwood swamp	3.290	Moderate to Severe	Change in vegetation to change in wetland type
47	Open bog	2.341	Severe	Change in vegetation to change in wetland type
90A	Open bog	78.350	Severe	Change in vegetation to change in wetland type
22B	Shallow marsh	29.190	Severe	Conversion of wetland type
16	Shallow marsh	3.317	Severe	Conversion of wetland type
22	Shallow marsh	15.372	Severe	Conversion of wetland type

Table 2. Zone 2 impact assessment.

Zone 3 Impacts (2000 – 5000 Feet)

GLIFWC has modified Zone 3 in response to available data (from 2000 to 3500 feet in data package to 2000 to 5000 feet). Wetlands within zone 3 are depicted in Figure 6. The Rhino and Highway 7 wells are 2150 and 2625 feet respectively from the Canisteo pit. In response to reflooding in the pit, the Rhino well responded with a greater than 1 foot increase (Figure 7) and the Highway 7 well responded with a greater than 2 foot increase. Two additional wells provide analog information for this zone. First, the Pinto well north of Hibbing is 2112 feet from the nearest active pit shows a drop of at least 3.55 feet in response to pit dewatering. Second, a MNDNR observation well located 4224 feet from the nearest active pit at Hibtac shows a 3.5 foot drop in water level. Attachment B is a slide from a presentation given by Mr. Crotteau outlining the water level drop at this well.

In addition to these wells, the city of Keewatin has been greatly impacted by pit dewatering. Well #2 at approximately 4220 feet from the Mesabi Chief pit dropped 75 feet in response to a 150 foot drop in water levels in the pit. Water levels in Well #1 at approximately 4750 feet from the pit dropped are also correlated with pit dewatering at the pit although the report indicates that the amount of water drop was less than at well #2. The correlations between pit dewatering and water level drop at the wells were also supported by chemical characterization of the water in the pit (Attachment C).

UNIQUE ID	EGGERS & REED CLASS	ACRES	IMPACT	IMPACT DESCRIPTION
53	Alder thicket	184.092	Moderate	Change in vegetation
53D	Alder thicket	714.287	Moderate	Change in vegetation
54B	Alder thicket	6.040	Moderate	Change in vegetation
54C	Alder thicket	8.015	Moderate	Change in vegetation
58	Alder thicket	372.266	Moderate	Change in vegetation
53D	Alder thicket	1283.309	Moderate	Change in vegetation
55	Alder thicket	15.732	Moderate	Change in vegetation
678	Alder thicket	1.676	Moderate	Change in vegetation
743	Alder thicket	4.750	Moderate	Change in vegetation
744	Alder thicket	10.344	Moderate	Change in vegetation
746	Alder thicket	3.572	Moderate	Change in vegetation
747	Alder thicket	10.027	Moderate	Change in vegetation
749	Alder thicket	99.326	Moderate	Change in vegetation
752	Alder thicket	36.908	Moderate	Change in vegetation
315	Alder thicket or Shrub-carr	2907.52	Moderate	Change in vegetation
565	Alder thicket or Shrub-carr	20.622	Moderate	Change in vegetation
566	Alder thicket or Shrub-carr	63.204	Moderate	Change in vegetation
480	Alder thicket or Shrub-carr	47.863	Moderate	Change in vegetation
555	Alder thicket or Shrub-carr	61.723	Moderate	Change in vegetation
557	Alder thicket or Shrub-carr	31.464	Moderate	Change in vegetation
890	Alder thicket or Shrub-carr	157.349	Moderate	Change in vegetation
106	Coniferous bog	581.72	Moderate to Severe	Change in vegetation
114	Coniferous bog	7.911	Moderate to Severe	Change in vegetation
406	Coniferous bog	26.125	Moderate to Severe	Change in vegetation
48	Coniferous bog	14.142	Moderate to Severe	Change in vegetation
552	Coniferous bog	31.738	Moderate to Severe	Change in vegetation
559	Coniferous bog	229.834	Moderate to Severe	Change in vegetation
562	Coniferous bog	56.744	Moderate to Severe	Change in vegetation
564	Coniferous bog	38.575	Moderate to Severe	Change in vegetation
62	Coniferous bog	20.018	Moderate to Severe	Change in vegetation
714	Coniferous bog	1692.646	Moderate to Severe	Change in vegetation
773	Coniferous bog	33.980	Moderate to Severe	Change in vegetation
774	Coniferous bog	88.486	Moderate to Severe	Change in vegetation
84	Coniferous bog	14.276	Moderate to Severe	Change in vegetation
84A	Coniferous bog	55.627	Moderate to Severe	Change in vegetation
88	Coniferous bog	6.396	Moderate to Severe	Change in vegetation
887	Coniferous bog	1359.301	Moderate to Severe	Change in vegetation
888	Coniferous bog	1123.789	Moderate to Severe	Change in vegetation
90	Coniferous bog	685.002	Moderate to Severe	Change in vegetation
98	Coniferous bog	24.180	Moderate to Severe	Change in vegetation
984	Coniferous bog	162.094	Moderate to Severe	Change in vegetation
105	Coniferous bog	62.495	Moderate to Severe	Change in vegetation
11	Coniferous bog	95.587	Moderate to Severe	Change in vegetation
479	Coniferous bog	157.954	Moderate to Severe	Change in vegetation
558	Coniferous bog	50.111	Moderate to Severe	Change in vegetation
697	Coniferous bog	48.894	Moderate to Severe	Change in vegetation
699	Coniferous bog	23.740	Moderate to Severe	Change in vegetation
713	Coniferous bog	80.451	Moderate to Severe	Change in vegetation
782	Coniferous bog	10.815	Moderate to Severe	Change in vegetation
783	Coniferous bog	20.604	Moderate to Severe	Change in vegetation
949	Coniferous bog	19.484	Moderate to Severe	Change in vegetation
53B	Coniferous swamp	4.626	Moderate	Minor vegetation change
53C	Coniferous swamp	2.275	Moderate	Minor vegetation change
54	Coniferous swamp	44.113	Moderate	Minor vegetation change
54A	Coniferous swamp	34.455	Moderate	Minor vegetation change
54D	Coniferous swamp	17.547	Moderate	Minor vegetation change
553	Coniferous swamp	27.413	Moderate	Minor vegetation change
57	Coniferous swamp	293.943	Moderate	Minor vegetation change
701	Coniferous swamp	1642.996	Moderate	Minor vegetation change
745	Coniferous swamp	143.479	Moderate	Minor vegetation change
81	Coniferous swamp	13.507	Moderate	Minor vegetation change
856	Coniferous swamp	29.496	Moderate	Minor vegetation change
864	Coniferous swamp	1005.134	Moderate	Minor vegetation change
1145	Coniferous swamp	30.313	Moderate	Minor vegetation change
404	Coniferous swamp	137.651	Moderate	Minor vegetation change
53A	Coniferous swamp	25.257	Moderate	Minor vegetation change
53E	Coniferous swamp	20.088	Moderate	Minor vegetation change
554	Coniferous swamp	23.212	Moderate	Minor vegetation change
891	Coniferous swamp	74.816	Moderate	Minor vegetation change

Table 3. Zone 3 impact assessment.

These two wells are drilled into the bedrock and therefore it is not clear how those large water level drops in bedrock wells are expressed in the surficial aqufer and in wetlands. Regardless, this information fits with the analog approach of the lead agencies for NorthMet and illustrates that pit induced groundwater drawdowns can be expected to extend well into zone 3. The analog information suggests that drawdowns of 1 to 3.5 feet can be expected throughout zone 3. The impact assessment for zone 3 wetlands is provided in Table 3.

It should also be noted that there are wetlands that fall within Zone 3 that have not been delineated by PolyMet. GLIFWC has used National Wetland Inventory (NWI) data for that area to calculate the acreage of potential impacts. The NWI classification for these wetlands is PFO4B which corresponds to a Black Spruce Forest. Therefore, in impact criteria of Coniferous swamp/bog is applied.

Zone 3 wetlands on the north side of the mine pits are also subject to impacts related to the dewatering of the Peter Mitchell pit. Figure 8 illustrates the possible extent of drawdown impacts at the Peter Mitchell pit based on the Hibtac well data provided by the MNDNR Mining Hydrologist Michael Crotteau. This cumulative effect is not included in version 7 of the data package and should be analyzed. Therefore, GLIFWC is assuming that the analog information also applies to the Peter Mitchell pit and assumes that wetlands to the north are impacted by both projects.

Most of the east west reach of the Partridge River on the north side of the mine pits is within zone 3. As previously suggested, 1 to 3.5 feet of drawdown could be a significant impact to the hydrology of the river. In addition, the City of Kewaatin wells indicate that drawdowns of tens of feet in the bedrock aquifer below the Partridge River are likely. This potential hydrologic impact should be assessed as part of the NEPA process. Finally, reductions in flow to the Partridge River could indirectly impact riparian wetlands downstream.

Zone 4 Impacts (5000 – 10000)

Wetlands within zone 4 are depicted in Figure 7. There is no well data that can be used to draw conclusions about mine pit related drawdown in this zone. Based on Zone 3, it is reasonable to assume that 0 to 1 feet of drawdown would occur under wetlands within this zone.

As discussed above zone 4 wetlands on the north side of the proposed mine pits are also subject to impacts related to the dewatering of the Peter Mitchell pit (Figure 8).

UNIQUE ID	EGGERS & REED CLASS	ACRES	IMPACT	IMPACT DESCRIPTION
752	Alder thicket	36.908	None	None
53D	Alder thicket	1283.309	None	None
55	Alder thicket	15.732	None	None
58	Alder thicket	235.493	None	None
678	Alder thicket	1.676	None	None
743	Alder thicket	4.750	None	None
744	Alder thicket	10.344	None	None
746	Alder thicket	3.572	None	None
747	Alder thicket	10.027	None	None
749	Alder thicket	99.326	None	None
53	Alder thicket	130.786	None	None
480	Alder thicket or Shrub-carr	47.863	None to Moderate	None to vegetation change
555	Alder thicket or Shrub-carr	61.723	None to Moderate	None to vegetation change
557	Alder thicket or Shrub-carr	31.464	None to Moderate	None to vegetation change
566	Alder thicket or Shrub-carr	35.777	None to Moderate	None to vegetation change
890	Alder thicket or Shrub-carr	157.349	None to Moderate	None to vegetation change
315	Alder thicket or Shrub-carr	1256.836	None to Moderate	None to vegetation change
558	Coniferous bog	50.111	None	None
84A	Coniferous bog	41.351	None	None
11	Coniferous bog	95.587	None	None
105	Coniferous bog	62.495	None	None
90	Coniferous bog	230.686	None	None
479	Coniferous bog	157.954	None	None
559	Coniferous bog	228.822	None	None
564	Coniferous bog	33.827	None	None
697	Coniferous bog	48.894	None	None
699	Coniferous bog	23.740	None	None
713	Coniferous bog	80.451	None	None
714	Coniferous bog	1002.456	None	None
782	Coniferous bog	10.815	None	None
783	Coniferous bog	20.604	None	None
887	Coniferous bog	1128.525	None	None
888	Coniferous bog	90.125	None	None
949	Coniferous bog	19.484	None	None
106	Coniferous bog	451.616	None	None
54A	Coniferous swamp	16.573	None to Moderate	None to minor vegetation change
57	Coniferous swamp	20.917	None to Moderate	None to minor vegetation change
404	Coniferous swamp	137.651	None to Moderate	None to minor vegetation change
553	Coniferous swamp	18.531	None to Moderate	None to minor vegetation change
554	Coniferous swamp	23.212	None to Moderate	None to minor vegetation change
701	Coniferous swamp	852.230	None to Moderate	None to minor vegetation change
745	Coniferous swamp	82.463	None to Moderate	None to minor vegetation change
53A	Coniferous swamp	25.257	None to Moderate	None to minor vegetation change
891	Coniferous swamp	74.816	None to Moderate	None to minor vegetation change
864	Coniferous swamp	901.932	None to Moderate	None to minor vegetation change
1145	Coniferous swamp	30.313	None to Moderate	None to minor vegetation change
53E	Coniferous swamp	20.088	None to Moderate	None to minor vegetation change
899	Open bog	23.039	None	None
83	Open bog	16.555	None	None
83	Open bog	26.414	None	None
885	Open bog	950.076	None	None
889	Shallow marsh	3.279	None	None
17	Shallow marsh	12.072	None	None
1	Shallow marsh	4.560	None	None
3	Shallow marsh	3.808	None	None
6	Shallow marsh	6.654	None	None
29	Shallow marsh	126.876	None	None
708	Shallow marsh	42.189	None	None
709	Shallow marsh	18.496	None	None
NWI	Black Spruce Forest - Undelineated	778.140	Moderate	Change in vegetation

Table 4. Zone 4 impact assessment.

Impacts to Riparian Wetlands along the Partridge River

The applicant and lead agencies have ignored repeated requests by cooperating agencies to better characterize the hydrology of the mine site through a robust surface and groundwater data collection program. Therefore data with which to assess the effects of drawdown in the surficial and bedrock aquifers to riparian wetlands along the Partridge River are not available. Based on pit dewatering induced drawdowns at other sites described in this report, it is reasonable to assume that flow in the Partridge River would be significantly reduced if the NorthMet project proceeds as currently designed. This would have an effect on riparian wetlands far downstream. To date, these potential impacts have not been characterized.

We look forward to discussing this issue further as the SDEIS process moves forward.

Sincerely,

Esteban Chiriboga
GLIFWC

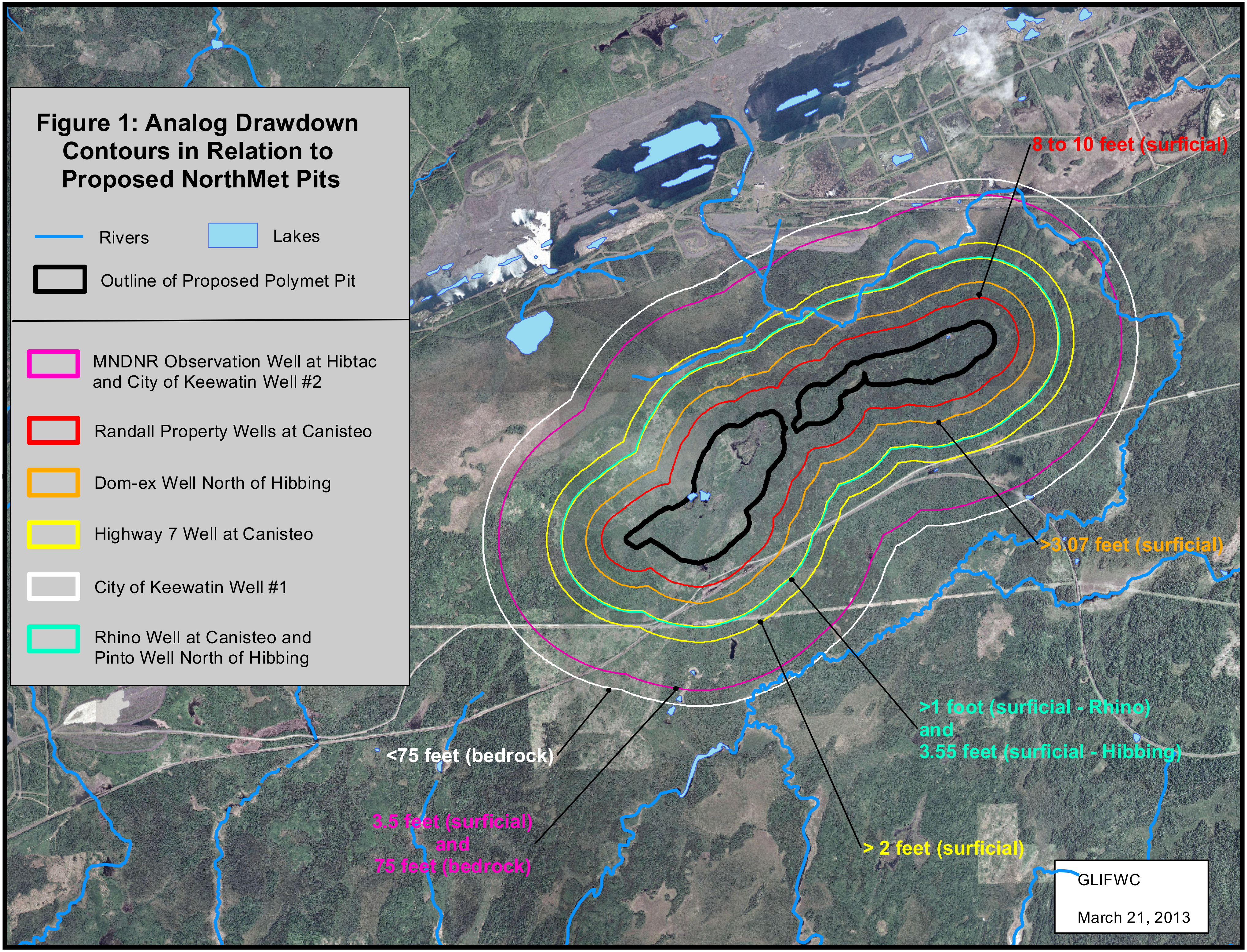


Figure 1: Analog Drawdown Contours in Relation to Proposed NorthMet Pits
Rivers
Lakes
Outline of Proposed Polymet Pit
MNDNR Observation Well at Hibtac and City of Keewatin Well #2
Randall Property Wells at Canisteo
Dom-ex Well North of Hibbing
Highway 7 Well at Canisteo
City of Keewatin Well #1
Rhino Well at Canisteo and Pinto Well North of Hibbing
8 to 10 feet (surficial)
>3.07 feet (surficial)
>1 foot (surficial - Rhino) and 3.55 feet (surficial - Hibbing)
> 2 feet (surficial)
<75 feet (bedrock)
3.5 feet (surficial) and 75 feet (bedrock)
GLIFWC
March 21, 2013

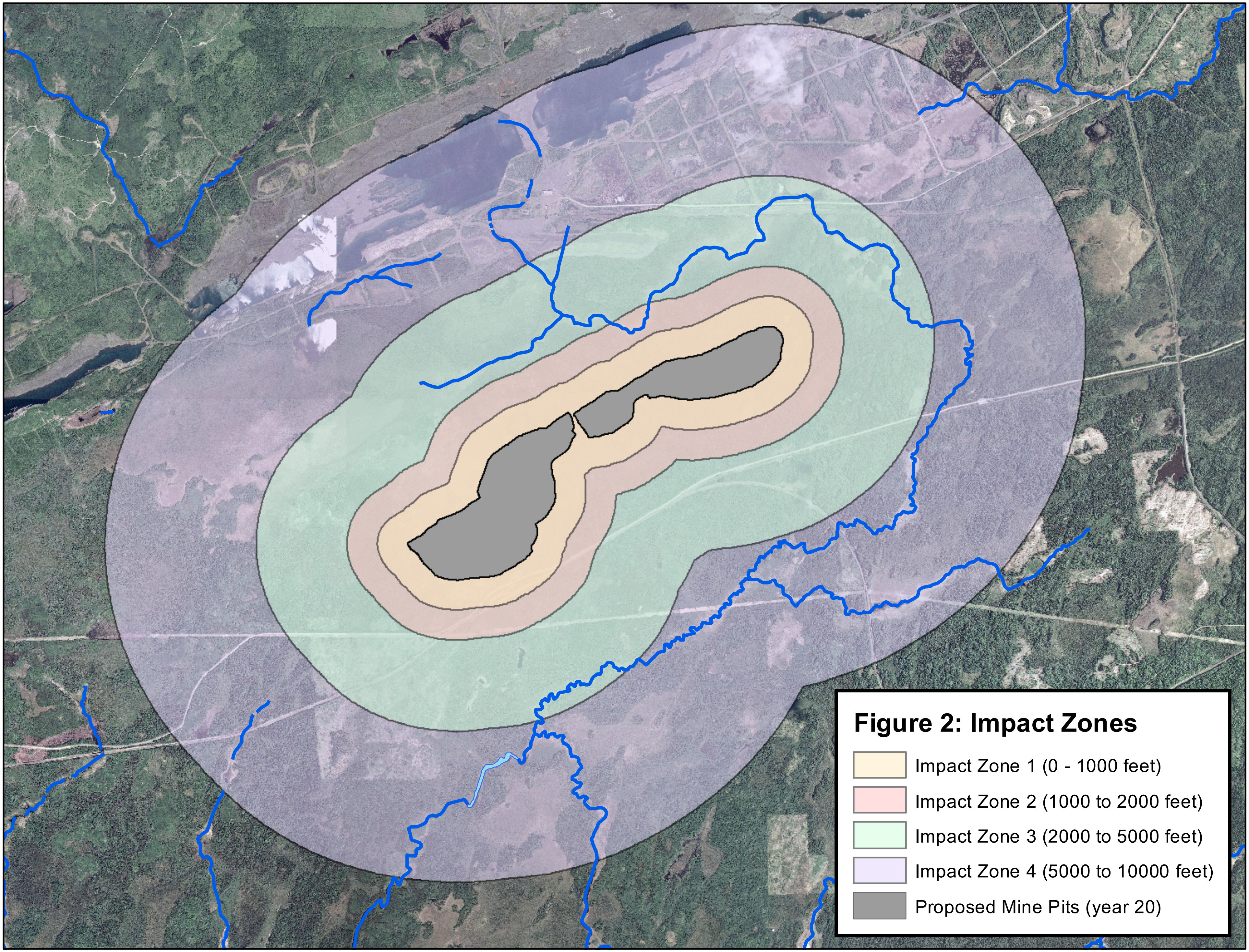


Figure 2: Impact Zones
Impact Zone 1 (0 - 1000 feet)
Impact Zone 2 (1000 to 2000 feet)
Impact Zone 3 (2000 to 5000 feet)
Impact Zone 4 (5000 to 10000 feet)
Proposed Mine Pits (year 20)

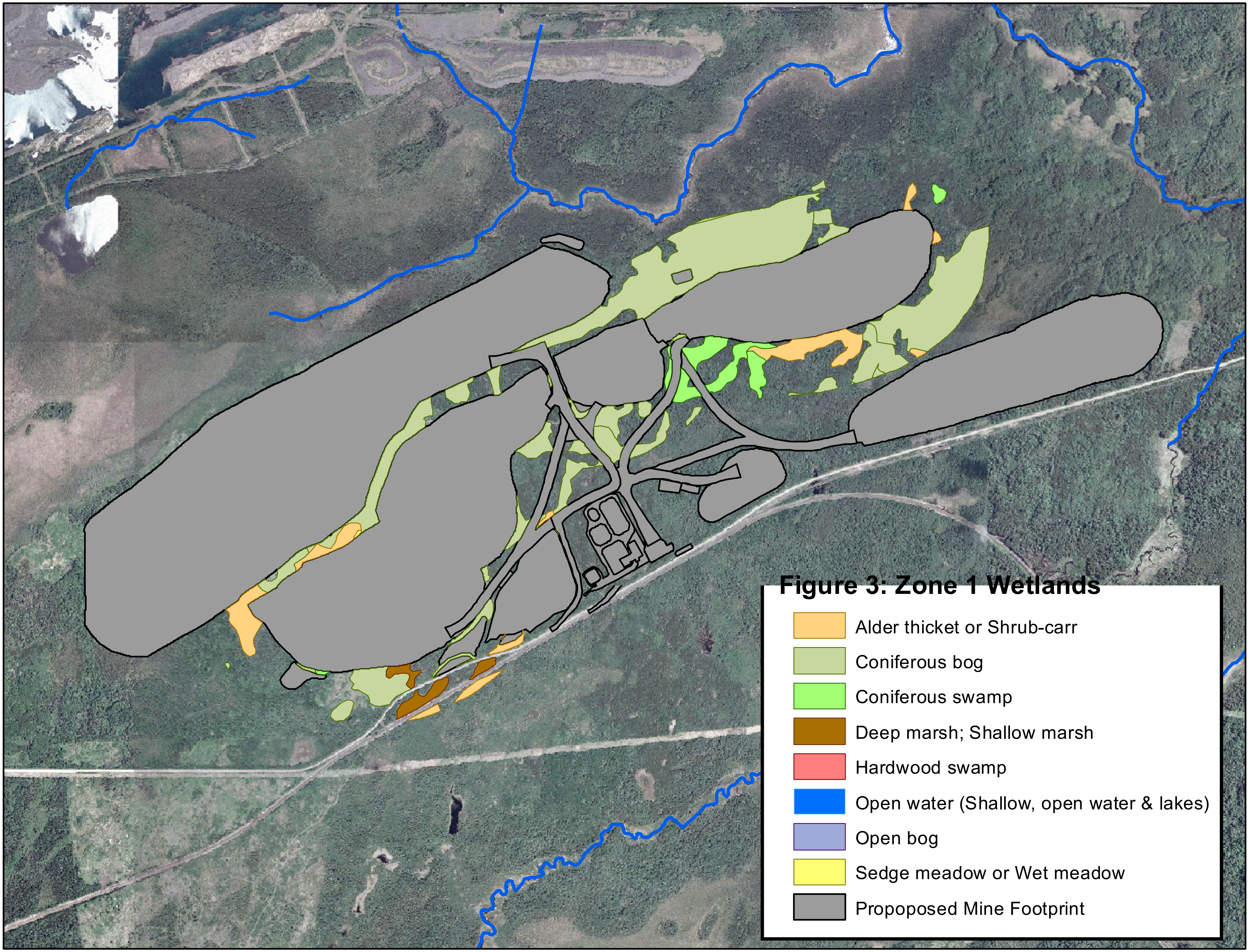
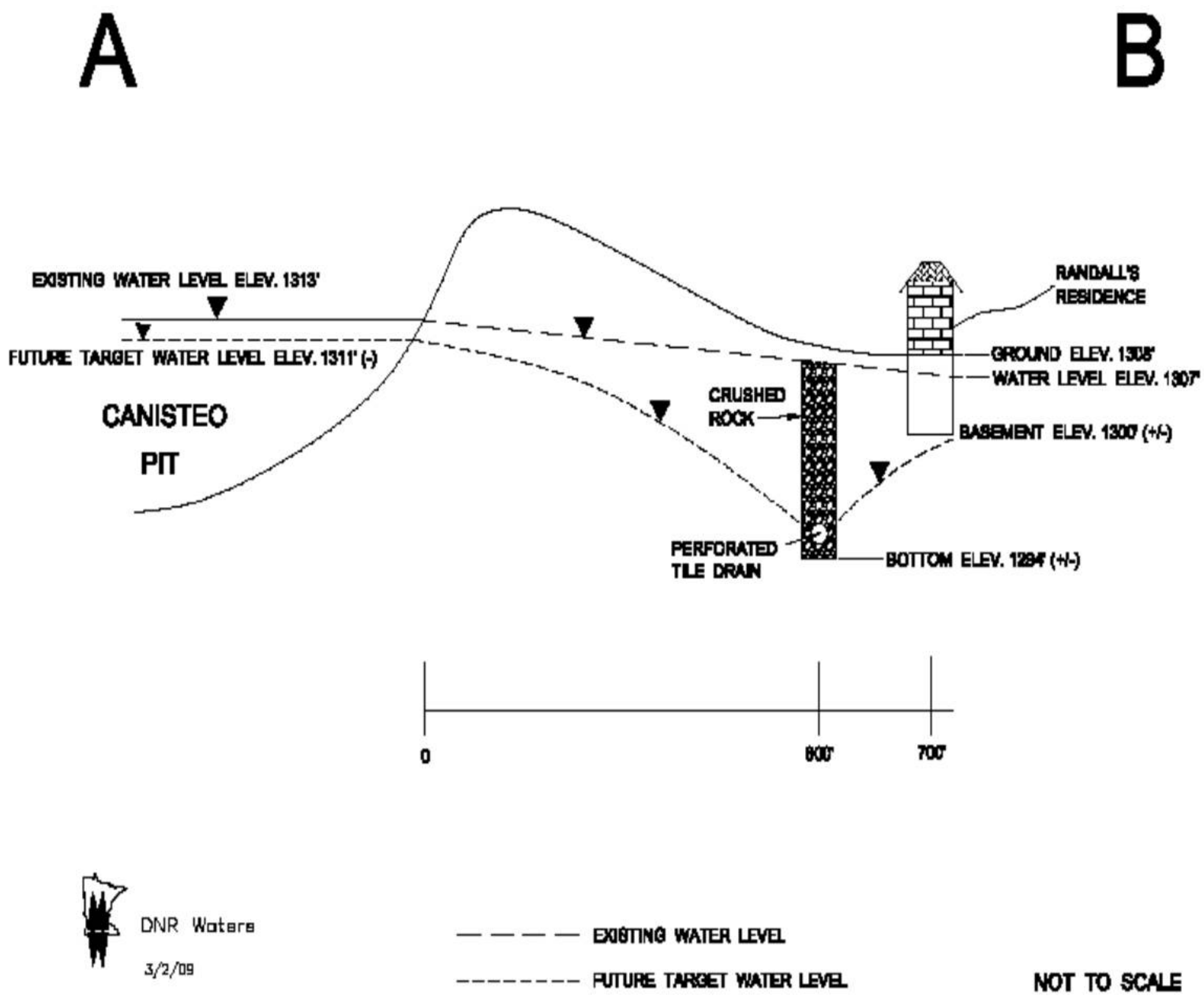


Figure 3: Zone 1 Wetlands
Alder thicket or Shrub-carr
Coniferous bog
Coniferous swamp
Deep marsh; Shallow marsh
Hardwood swamp
Open water (Shallow, open water & lakes)
Open bog
Sedge meadow or Wet meadow
Propoposed Mine Footprint


A
B
EXISTING WATER LEVEL ELEV. 1313'
FUTURE TARGET WATER LEVEL ELEV. 1311' (-)
CANISTEO
PIT
RANDALL'S
RESIDENCE
GROUND ELEV. 1308'
WATER LEVEL ELEV. 1307'
CRUSHED
ROCK
BASEMENT ELEV. 1300' (+/-)
PERFORATED
TILE DRAIN
BOTTOM ELEV. 1294' (+/-)
0
600'
700'
DNR Waters
3/2/09
EXISTING WATER LEVEL
FUTURE TARGET WATER LEVEL
NOT TO SCALE

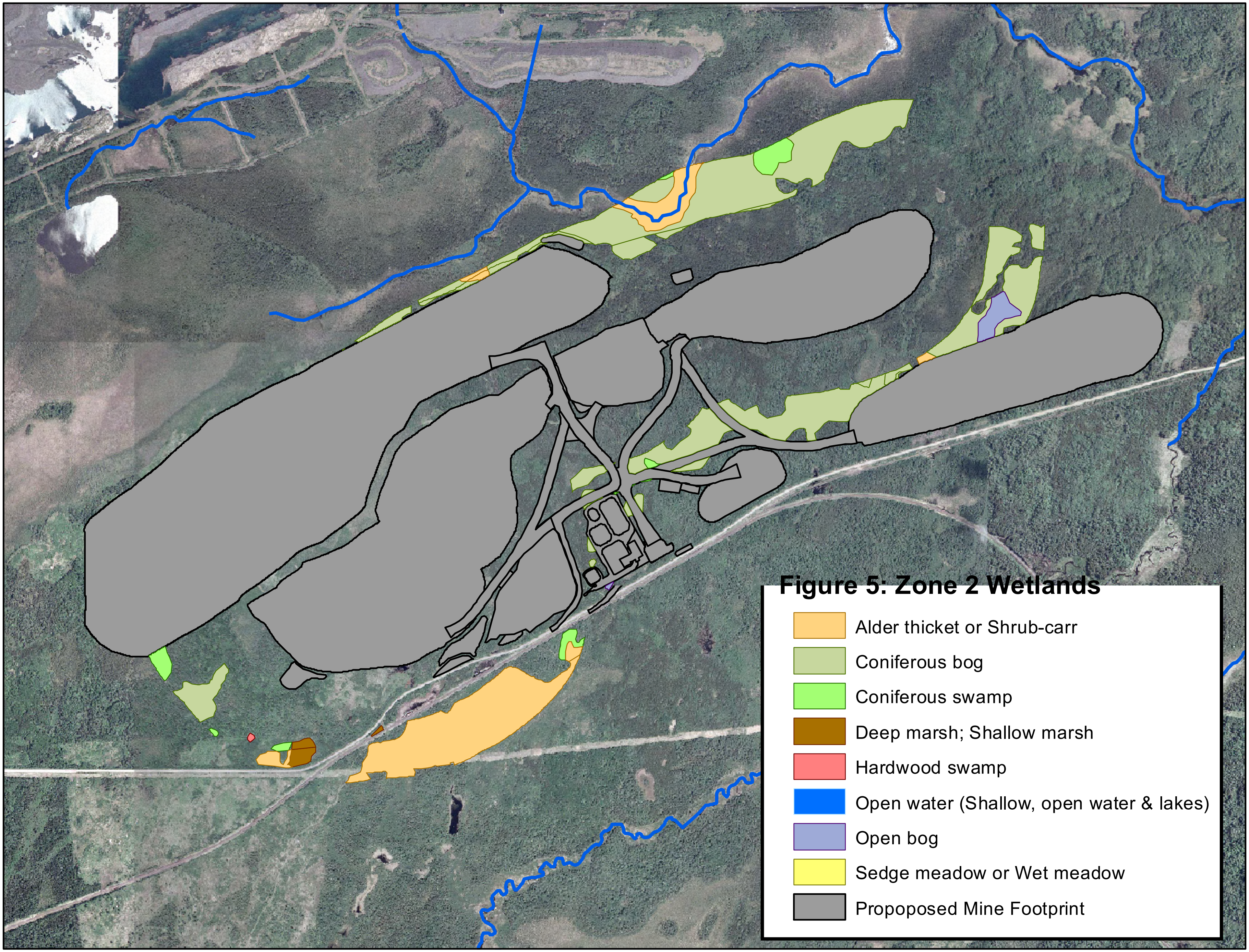


Figure 5: Zone 2 Wetlands
Alder thicket or Shrub-carr
Coniferous bog
Coniferous swamp
Deep marsh; Shallow marsh
Hardwood swamp
Open water (Shallow, open water & lakes)
Open bog
Sedge meadow or Wet meadow
Propoposed Mine Footprint

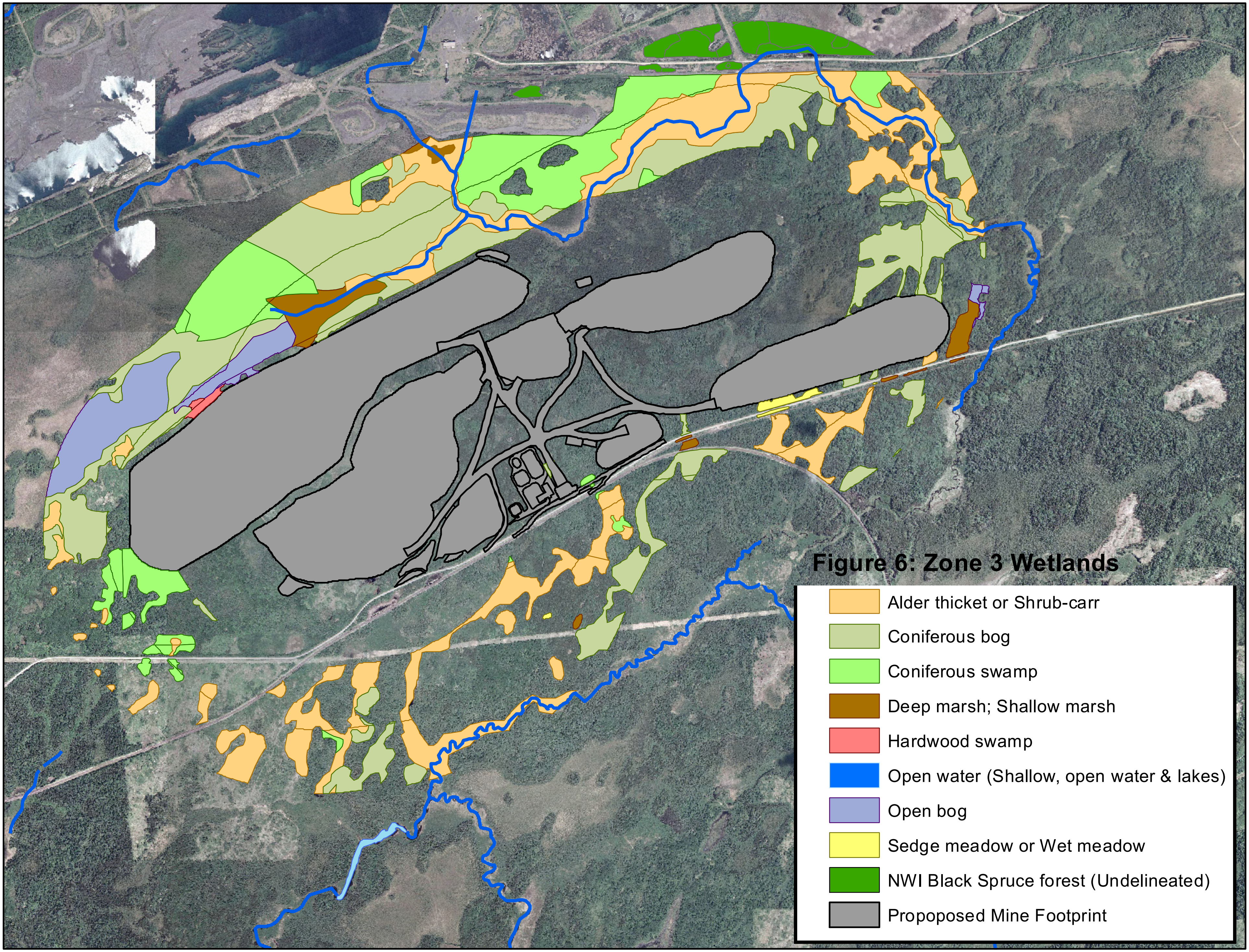


Figure 6: Zone 3 Wetlands
Alder thicket or Shrub-carr
Coniferous bog
Coniferous swamp
Deep marsh; Shallow marsh
Hardwood swamp
Open water (Shallow, open water & lakes)
Open bog
Sedge meadow or Wet meadow
NWI Black Spruce forest (Undelineated)
Propoposed Mine Footprint

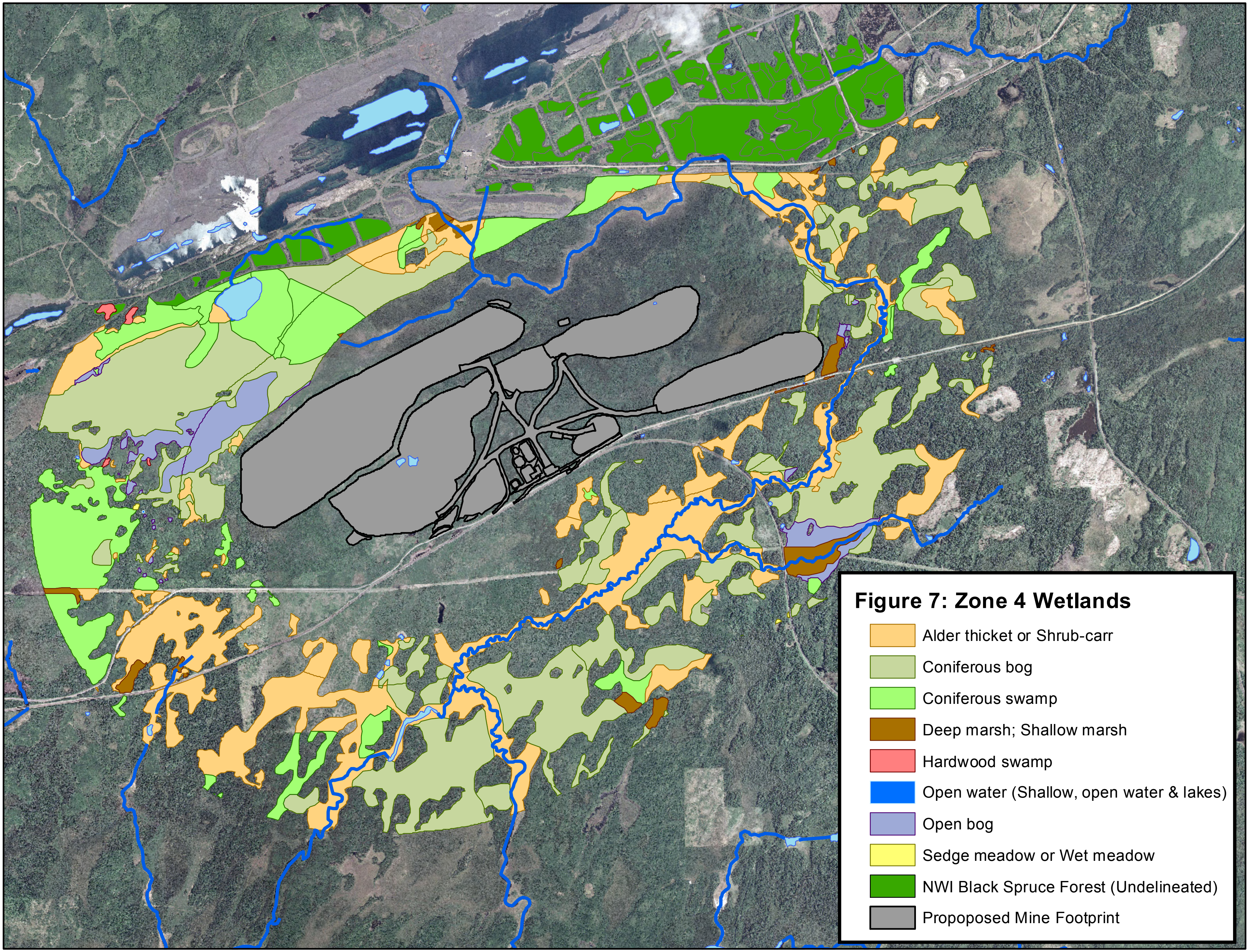


Figure 7: Zone 4 Wetlands
Alder thicket or Shrub-carr
Coniferous bog
Coniferous swamp
Deep marsh; Shallow marsh
Hardwood swamp
Open water (Shallow, open water & lakes)
Open bog
Sedge meadow or Wet meadow
NWI Black Spruce Forest (Undelineated)
Propoposed Mine Footprint

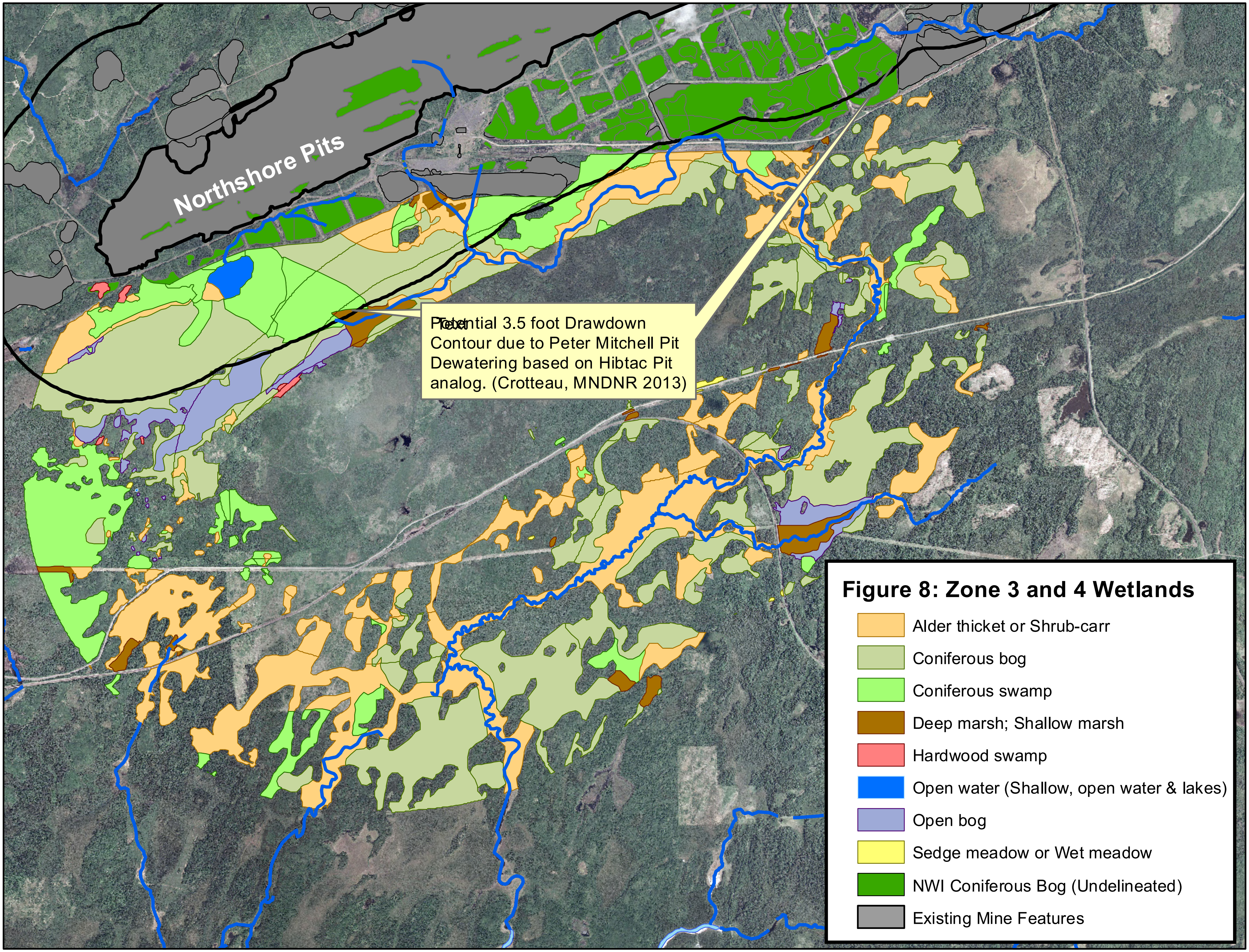
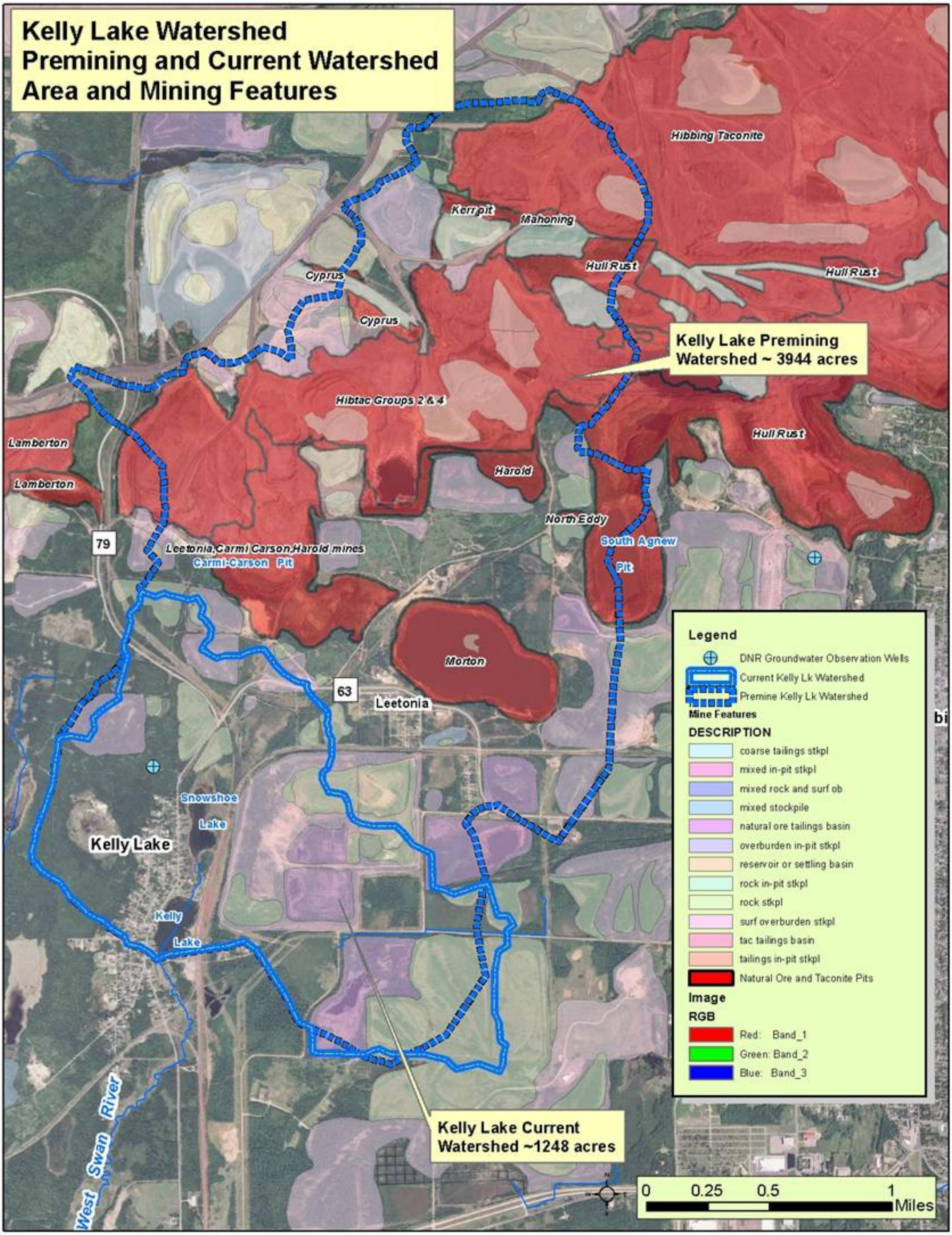


Figure 8: Zone 3 and 4 Wetlands

Wetland Resources IAP Draft Summary Memo

Line Number	Comments
	[insert your name]
General Comments (per line number)	
105	The Co-lead position described here is unchanged from the 2009 DEIS. This position is contrary to standard analysis that mining companies have to conduct as part of sulfide mine EIS processes across the country.
118	This characterization requires further detail. According to our meeting notes, the need for a quantitative assessment of drawdown at the mine site was a unanimous position among the tribal cooperating agencies, the EPA, and the Fish and Wildlife Service. This position also received strong support from the PCA. This is why the original request by the wetland workgroup for a quantitative method of assessing drawdown impacts at the mine site was described as a "consensus". This should be clarified in the summary memo. See attached comment letter for additional detail on the groundwater modeling issue.
143	GLIFWC staff concur with Margaret Watkins that the cumulative impact assessment should be conducted for the same area that is used in the cultural resource assessment (Wetland area of potential effect).
148	As discussed during the Wetland IAP call of May 13th 2011, baseline data for water quality in wetlands are essential to this analysis. We support the Corps request that the applicant provide a list of available baseline data that will be assessed for adequacy in describing the existing condition and no action alternative. We request that this be specifically included in the workplan.
PolyMet NorthMet Project Co-Lead Agency Workplan Preparation Guidance for Wetland Assessment General Comments	
032	GLIFWC staff maintains that the analogue method proposed by the Army Corps does not provide sufficient information to base the indirect wetland impact analysis for the entire project.
078	GLIFWC staff believe that the analysis area for cumulative impacts is not adequate. See comment on line 143 of the summary memo. In addition, the cumulative impact assessment should cover topics that were not part of the 2009 DEIS. Climate change in the region is a stressor for wetlands. This additional factor should be assessed. Cumulative impacts of Iron Range mine projects on water quality of wetlands should be described.
085	GLIFWC staff do not agree with the Corps' definition of "reasonably foreseeable project". Several mine projects to the east and northeast of Polymet are likely to be proposed, some as early as this summer. A mining company interested in the Dunka deposit will be installing a stream gauge on the upper Partridge River this spring. Because this project will likely impact some of the same areas as Polymet (Partridge River watershed), this project should be included in the analysis.

090	GLIFWC staff agree that the analogue data prepared by John Adams can be used as <u>part</u> of the indirect impact analysis. We remain concerned that this analysis is being used as the sole data source for the discussion of indirect wetland impacts at the Polymet mine site. As discussed during the wetland IAP call of May 13th 2011, a detailed report that includes all data and assumptions used by John Adams to assess the Canisteo Pit data should be developed and reviewed by the wetlands IAP group. After that review, a determination on the adequacy of the analysis as an analogue to Polymet can be made.
102	GLIFWC staff believe that these distances are open to a great deal of interpretation. We do not believe that the distance categories listed in this document are conservative interpretations of the Canisteo pit data.
118	The Canisteo Pit data indicated that water levels at a well 2300 feet from the pit were correlated with water fluctuations in the pit. Therefore it is inappropriate to exclude the "high likelihood" category from this distance category.
123	For the same reason stated in the comment on line 118, it is not appropriate to exclude the "high likelihood" or "moderate likelihood" of impact from this distance category.


Kelly Lake Watershed
Premining and Current Watershed
Area and Mining Features
Hibbing Taconite
Kerr pit
Mahoning
Hull Rust
Hull Rust
Cyprus
Cyprus
Kelly Lake Premining
Watershed ~ 3944 acres
Hibtac Groups 2 & 4
Lamberton
Lamberton
Hull Rust
Harold
North Eddy
South Agnew
Pit
79
Leetonia,Carmi Carson,Harold mines
Carmi-Carson Pit
Morton
63
Leetonia
Snowshoe
Lake
Kelly Lake
Kelly
Lake
West Swan River
Kelly Lake Current
Watershed ~1248 acres
Legend
DNR Groundwater Observation Wells
Current Kelly Lk Watershed
Premine Kelly Lk Watershed
Mine Features
DESCRIPTION
coarse tailings stkpl
mixed in-pit stkpl
mixed rock and surf ob
mixed stockpile
natural ore tailings basin
overburden in-pit stkpl
reservoir or settling basin
rock in-pit stkpl
rock stkpl
surf overburden stkpl
tac tailings basin
tailings in-pit stkpl
Natural Ore and Taconite Pits
Image
RGB
Red: Band_1
Green: Band_2
Blue: Band_3
0 0.25 0.5 1
Miles

Liesch Associates, Inc. ■ 13400 15th Avenue North ■ Minneapolis, MN 55441
Phone: (763) 489-3100 ■ Toll Free: (800) 338-7914 ■ Fax: (763) 489-3101

TECHNICAL MEMORANDUM

TO: **Mike Johnson, PE - Liesch Associates, Inc.**

FROM: **Jim de Lambert, PG - Liesch Associates, Inc.**

DATE: **February 18, 2009**

RE: **Water Supply Contingency Plans for Keewatin and Nashwauk**

U.S. Steel – Minnesota Ore Operations (US Steel) is proposing to increase production at the US Steel Corporation Keewatin Taconite Facility under a project known the Keetac Expansion Project (the "Project"). The Project involves continuous dewatering operations that are ongoing and will continue in current and future mining areas. These planned activities are expected to generate drawdown in the aquifer locally and potentially at the water supply wells for the Cities of Keewatin and Nashwauk.

This memorandum is intended to provide background on the City water supplies and the Biwabik Iron Formation and to outline a plan to monitor the effects of mine pit dewatering on the aquifer so that appropriate steps can be taken to maintain the water supplies.

Relatively little information exists concerning the hydrogeology of the Biwabik Iron Formation (BIF) and the City water supplies. The Minnesota Department of Health (MDH) has assisted both Cities with Wellhead Protection activities and the results of this work probably represent the most comprehensive source of information concerning the source of water discharging at the City wells. In conducting this work it was apparent that traditional groundwater flow models would not be appropriate tools to estimate capture zones in the fractured BIF Aquifer. Instead, MDH utilized isotopic and chemical characteristics of water from the wells and nearby surface water bodies to estimate the source of water discharging at the wells. This work is summarized in separate reports titled Wellhead Protection Plan for the City of Keewatin - Part I (Walsh 2003) and Wellhead Protection Plan for the City of Nashwauk - Part I (Walsh 2007). Each report includes a delineation of the Wellhead Protection Area (WHPA), determination of the Drinking Water Supply Management Area (DWSMA) and assessments of Well and DWSMA Vulnerability. In addition, the reports include a summary of the hydrogeologic conditions concerning the city water supplies. Additional information used in preparing this memorandum includes various published maps and reports and personal communication with representatives from MDH, Department of Natural Resources and the Cities.

Keetac Mine Hydrogeology

The Keetac Mine extracts iron ore from the Biwabik Iron Formation (BIF) of the Mesabi Iron Range. The BIF is Precambrian in age, was deposited under marine conditions and is composed primarily of chert and iron minerals. Its subcrop area extends along strike for a distance of at least 100 miles generally from Grand Rapids to Babbitt and varies in width from one to three miles. The BIF has an overall thickness 350 to 750 feet and dips generally to the south at three to twelve degrees (Grout 1951). Information provided by the MDH from a deep test hole drilled near Keewatin suggests a BIF thickness of 590 feet in this area.

According to a suggestion by J. F. Wolf in 1917, and elaboration by J. W. Gruner in 1946 (Grout 1951), the BIF is generally divided into four members. From top to bottom, these are Upper Slaty, Upper Cherty, Lower Slaty, and Lower Cherty. The low grade magnetic iron ores, known as taconite, are mined from the Upper Cherty and Lower Cherty members. The Upper Cherty Member has a thickness ranging from 80 to 250 feet. The Lower Cherty ores are typically 120 to 425 feet thick. The slaty units can alter to form a sticky, clayey rock that generally exhibits low permeability including the Intermediate Slate which is a thin bedded silicate taconite, also known as paint rock that occurs at the base of the Lower Slaty Member. This is an important marker horizon for water supply purposes as it marks the contact with the Lower Cherty Member. Borehole logs suggest that the more productive zones for water supply wells may occur below this contact in the Lower Cherty Member.

In addition to being an important source of iron ore the BIF is also an important aquifer locally. Both Nashwauk and Keewatin, and numerous other range Cities and water users, utilize the BIF Aquifer. Depending on the amount of water desired and other factors, BIF aquifer wells are typically constructed by drilling a casing to solid rock, usually the top of the BIF Formation, and then drilling an open hole to a sufficient depth to obtain the required quantity of water. Yields in the 300 to 600 gallon per minute (gpm) range have been reported from existing wells. For Nashwauk and Keewatin, geochemical work conducted by MDH has indicated that a significant percentage of the water discharging at some of the wells originates from nearby mine pits.

The BIF Aquifer consists primarily of fine grained chert and iron minerals, exhibiting very little primary porosity. Groundwater movement appears to be restricted to zones of secondary permeability controlled by fractures and joints particularly in the cherty portions of the BIF. The MDH has conducted a suite of borehole logs at available wells constructed in the BIF Aquifer in an attempt indentify preferred flow paths and to further characterize the hydrogeology of the formation. This information suggests the occurrence of preferred flow zones in both of the cherty members.

The Virginia Formation immediately overlies the BIF while the Pokegama Formation and the Giants Range Batholith underlay the BIF. These bedrock formations generally do not yield significant volumes of water to wells and are generally not considered important aquifers. Up to 200 feet of glacial drift lies above the consolidated bedrock near the Mesabi Range. Where these deposits include saturated granular outwash they may provide a potential source for significant volumes of water.

Little information is available regarding groundwater flow fields in the BIF due to a lack of available wells and detailed water level measurements over time. Mining operations conducted to date have undoubtedly altered natural flow patterns and planned mine dewatering activities in the Mesabi Range will continue to influence flow patterns.

Keewatin Water Supply

In recent years the City of Keewatin has obtained its water supply from two wells, designated Well 1 and Well 2. The City has indicated that it drilled an additional well in 2007, designated Well 3, in response to increasing manganese concentrations at Well 2. All wells are shown on the attached **Figure 1** (Attachment 1). Keewatin Well 3 has been added to the City's water supply system and Well 2 has been removed from service.

Basic information concerning Keewatin's wells is summarized on **Table 1** below and logs for each well are included in Attachment 2.

Table 1

Well	Well	Casing		Open Hole, Elevation (ft msl)			
Name	Number	Diameter	Depth (ft)	Top	Bottom	Status	Notes
1	192359	8-inch	249	1224	867	Active	Drilled in 1952/1982
2	228828	10-inch	344	1113	984	Observation	Drilled in 1951
3	751520	12-inch	198	1274	857	Active	Drilled in 2007

Water level information contained in Keewatin's Part 1 WHP plan shows a direct correlation between the dewatering of the Mesabi Chief Pit which was initiated in 1995 and Keewatin Well 2. As of 2002, the water level was lowered approximately 150 feet at the Mesabi Chief Mine while the static water level fell approximately 75 feet at Keewatin Well 2. Water levels were not collected at Keewatin Well 1 after 1998, however, the earlier measurements at Keewatin Well 1 also showed water level declines but somewhat less than those observed at Well 2. The WHP plan shows a correlation between water levels at select existing mine pits within the footprint of the proposed Project during dewatering and the water level at Well 2. The correlation was also supported by chemical characterization of water from the mine pits and well.

Details of the connection between mine dewatering, water levels and water chemistry at the City Wells are not clear. Long term monitoring is recommended to obtain additional information concerning the connection and to provide a mechanism to determine whether additional steps are needed to maintain the City's source of water supply.

Keewatin Water Use

The City of Keewatin is currently operating under Minnesota Department of Natural Resources (DNR) Appropriations Permit number 1972-2192. This permit allows Keewatin to pump up to 75 million gallons of water per year (mgy) at a permitted rate not to exceed 350 gallons per minute. The yearly reported pumping volumes submitted to the DNR are provided on **Table 2**. The reported values illustrate that the City's annual water use has increased from 45 to approximately 65 mgy in recent years.

Table 2

Permit	Well	Unique Well No.	Permit Vol (mgy)	Permit Rate (gpm)	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
1979-2192	1	192359	75.0	350.0	54.6	49.5	44.0	43.7	24.3	29.2	28.8	23.8	18.3	26.2
	2	228828			8.8	14.5	16.2	16.9	29.2	15.8	17.1	22.8	25.8	18.2
	3	751520			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ten Year Average = 52.8 mgy				**Total:**	63.4	64.1	60.2	60.5	53.5	45.0	45.9	46.6	44.1	44.4

Nashwauk Water Supply

The water supply for the City of Nashwauk is obtained from two bedrock wells located within the City limits of Nashwauk as shown on **Figure 1**. Like Keewatin, both of Nashwauk's wells tap portions of the BIF Aquifer. Basic information concerning Nashwauk's wells is summarized on **Table 3** below and logs for each well are included in Attachment 2. Less information is available concerning Nashwauk's wells and some discrepancies exist regarding well numbering and depths. The well names and unique numbers used here are as presented in the MDH Wellhead Protection Plan Part 1, prepared for the City. The log for Well 3 indicates a casing depth of 40 feet in combination with a depth to bedrock of 110 feet. This is an unlikely scenario as the casing would typically extend at least to the top of the rock.

Table 3

Well Name	Well Number	Casing Diameter	Casing Depth (ft)	Open Hole, Elevation (ft msl) Top	Open Hole, Elevation (ft msl) Bottom	Status	Notes
3	241017	8-inch	40	1449	1075	Active	Drilled in 1930
4	228819	16-inch	150	1289	899	Active	Drilled in 1947

The northern portion of the City of Nashwauk and the City's Well 3 are situated directly between two former natural ore pits, the Larue to the northeast and the Hawkins to the southwest. Well 4 is situated in the southern portion of the City approximately 3200 feet south of Well 3. Geochemical information provided in the MDH WHP report suggests that a significant percentage of water discharging at the wells originates at the Larue Pit. It is also likely that a connection exists between the levels in nearby mine pits and the

City wells. To the northeast, the nearest mining proposed under the Keetac Project is more than two miles away. The effects of mine pit dewatering under this Project on the City wells will likely depend on the effects at the former natural ore pits between the Project and the City. Anecdotal evidence suggests that the former natural ore pits are separated by “land bridges” that may serve to reduce the effects of dewatering at the City wells.

To the southwest of Nashwauk, Minnesota Steel also has plans for taconite extraction, including mine pit dewatering and water supply pumping that could also affect water levels in nearby natural ore pits and the City wells.

Nashwauk Water Use

Nashwauk is currently operating under Minnesota Department of Natural Resources (DNR) Appropriations Permit number 1975-2151. This permit allows the City of Nashwauk to pump up to 70 million gallons of water per year (MGY) at a permitted rate not to exceed 1,100 gallons per minute. The yearly reported pumping volumes submitted to the DNR are provided on **Table 4**. Pumping in recent years has ranged from approximately 45 to 65 mgy.

Table 4

Permit	Well	Unique Well No.	Permit Vol (mgy)	Permit Rate (gpm)	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
1975-2151	4	228819	70.0	1,100.0	25.1	25.9	27.7	34.0	33.3	32.9	25.5	23.6	22.1	23.7
	3	241017			27.2	20.1	29.3	29.5	30.6	23.1	26.4	21.6	21.4	22.1
Ten Year Average = 52.5 mgy				**Total:**	52.3	46.0	57.1	63.6	63.9	55.9	52.0	45.2	43.4	45.8

Proposed Monitoring Plan

Monitoring is proposed to establish baseline conditions, to monitor changes in the BIF Aquifer that could impact the existing water supply wells for the Cities of Keewatin and Nashwauk and to assess potential measures to mitigate impacts, if necessary. Development and implementation of the Keetac Project will take place in stages over a period of several years. Sufficient time exists to monitor the resources in question and to develop a mitigation plan, if required. Impacts could include interference drawdown from dewatering activities or water supply pumping and/or changes in water quality that make use of the water undesirable. Therefore, the monitoring program should include both water quantity and quality components.

Water Quality

Existing water quality from both Cities supply wells should be obtained from the City and MDH. Additional baseline samples should be taken from existing wells for dissolved mineral constituents and general chemistry. Annual sampling of the wells should continue for select parameters to detect changes over time. Wells to be sampled include Nashwauk Wells 3 and 4 and Keewatin Wells 1 and 3. Parameter lists for baseline and annual sampling are included in Attachment 3.

The MDH has recommended that the Cities sample for stable isotopes of water, chloride and sulfate as part of their ongoing WHP efforts. MDH has indicated that they will conduct the analysis but the City would be responsible for obtaining the samples. US Steel representatives responsible for sample collection will contact MDH prior to sampling to coordinate collection of MDH samples with the sampling recommended here. The results could assist the Cities in their WHP efforts and provide useful information concerning the hydrogeology of the BIF Aquifer and the source of water discharging at the City wells.

Water Quantity

Long term water level monitoring points are required to assess drawdown in the aquifer. A search should be conducted to identify potential monitoring points including wells and surface water locations. MDH and DNR staff have expressed an interest in long term monitoring and noted a lack of available points in the BIF aquifer.

We understand that not all of the City wells involved are accessible for water level measurements. Arrangements should be made for the wells to be accessible and for City utility personnel to make regular measurements of static levels, pumping levels, pumping rates and volume.

Former Well 2 at Keewatin is now out of service and could serve as a useful monitoring point. We understand that the DNR has recently conducted logging procedures at the well and that both the DNR and MDH are interested in data from this location. The City has indicated that this well is available for long term monitoring by US Steel. A data logger and transducer will be installed and maintained by US Steel for well water level measurement at this location.

At present we are not aware of a suitable BIF Aquifer well for long term monitoring near Nashwauk. A new observation well is proposed for use as a dedicated monitoring point generally between the City and the Keetac project. This well should also be equipped with a transducer and data logger. Transducers and data loggers will be visited quarterly to verify operation, collect data and to reset the instruments to correct for drift.

Measurements of water levels from select mine pits, should also be collected as part of the Monitoring Plan. This includes water levels from pits within the Keetac Project, the LaRue pit complex and data collected by Minnesota steel for their operations southwest of Nashwauk. This information will be useful for correlating mine pit water levels with the City wells and the BIF Aquifer water levels in general.

Reporting

All data should be collected and summarized in a report format annually. The report should include a summary of the data collected during the previous year, a description of any changes to the monitoring network, recommended changes to the monitoring network and a determination as to any effects of the dewatering activities on the Cities well water supplies. If the results of the planned monitoring suggest significant changes in well water quality or level that may be related to Keetac mining activities, additional monitoring activities may be recommended. The annual report will be prepared by US Steel no later than February 15th for the previous calendar year and distributed to the Cities, DNR and MDH for review.

Potential Mitigation Measures

In the event that mine dewatering activities have an adverse impact on the production or quality of the City water supply additional monitoring, treatment, augmentation or replacement of the impacted supply may become necessary. The hydrogeology of the Keewatin/Nashwauk area limits the available options to the following:

- Increased monitoring or changes to the monitoring plan if suspected impacts do not immediately threaten the City's ability to supply water.
- Modification of existing facilities including lowering, or replacing, existing pumps and deepening wells.
- New wells drilled in the BIF Aquifer in areas where interference effects are not as great.
- New wells drilled in the glacial outwash if areas of sufficient saturated thickness and favorable water quality can be identified.
- A new water treatment system to treat surface water, mine water or affected well water.

The extent of potential interference effects associated with the Project cannot be predicted with certainty at this time. The BIF Aquifer is utilized throughout the area and has the potential to supply adequate amounts of water to satisfy municipal needs. However, a better understanding of the effects of pumping on the BIF Aquifer is required to assess the potential for ongoing use and locations for additional BIF wells.

Glacial outwash deposits are utilized as municipal water sources throughout Minnesota. Although historical publications suggest that glacial outwash deposits are present between Keewatin and Nashwauk, glacial outwash deposits can change significantly over very short distances and specific investigations would be required to identify and assess the suitability for use as sources of water supply.

There are surface water resources in the area that could potentially provide a source of water including lakes that fill old mine pits and underground workings. It is anticipated that such a system would require construction of a surface water treatment plant.

Select References

Grout, F. F., Gruner J. W., Schwartz G. M., and Thiel G. A. (1951) Precambrian Stratigraphy of Minnesota, Bulletin of the Geological Society of America, Volume 62, pages 1017-1078

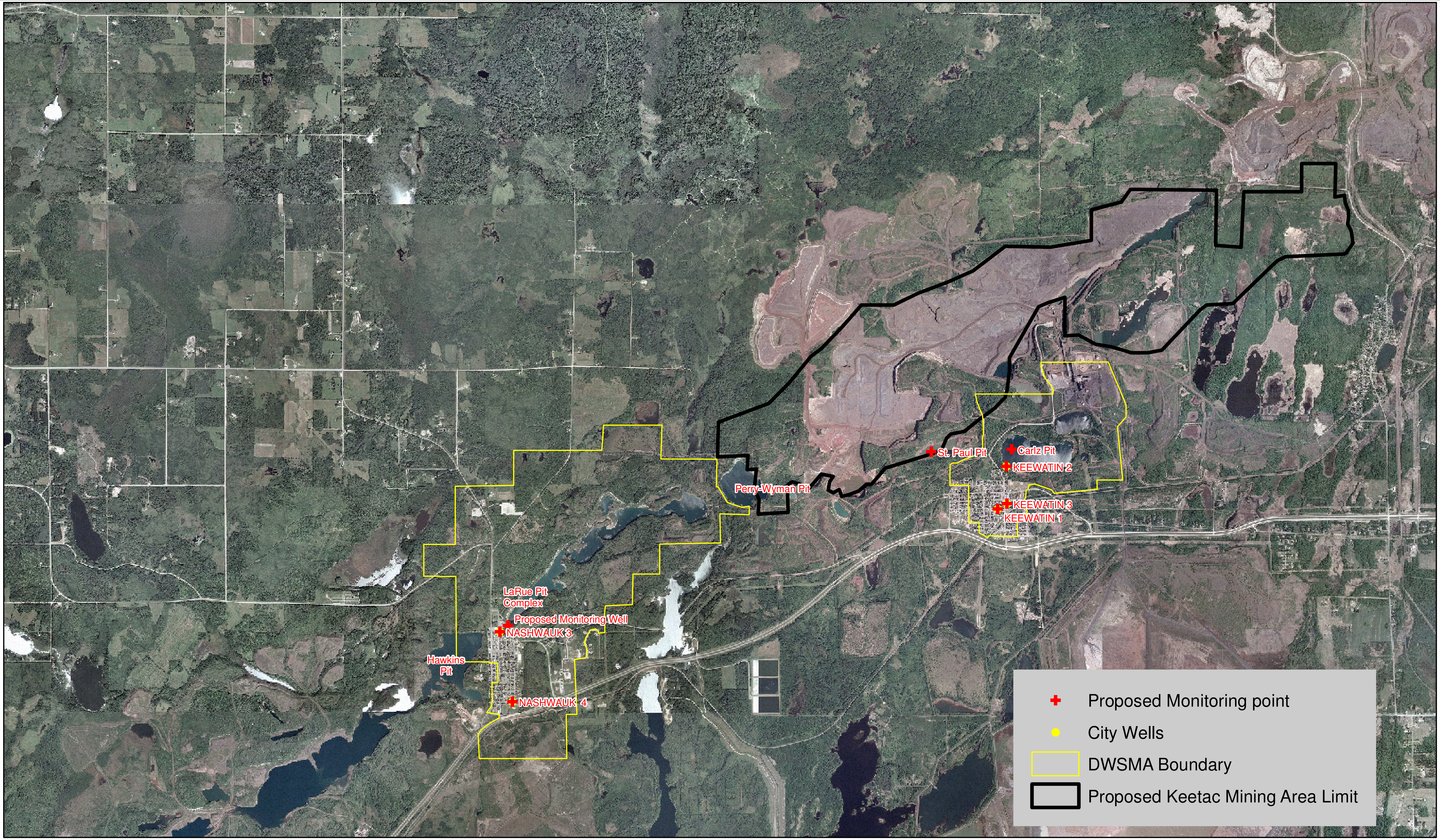
Walsh, J. F. (2003) Wellhead Protection Plan for the City of Keewatin, Part 1 Delineation of the Wellhead Protection Area (WHPA), Drinking Water Supply Management Area (DWSMA) and Assessments of Well and DWSMA Vulnerability, Minnesota Department of Health, St. Paul, MN, 30 p.

Walsh, J. F. (2007) Wellhead Protection Plan, Part 1, Wellhead Protection Area Delineation, Drinking Water Supply Management Area Delineation, Well and Aquifer Vulnerability Assessments for the City of Nashwauk, Minnesota Department of Health, St. Paul, MN, 43 p.

w:\ww\94213\water supply contingency plans\memo report\2009-1-28 keetac memo.doc

Attachment 1

W:\ww\94213\Water Supply Contingency Plans\Memo Report\Figure 1 A.pdf



0 4,000 8,000 12,000 16,000 20,000

Feet

N

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Hydrogeologists ▪ Engineers ▪ Environmental Scientists

Minneapolis ▪ Chicago ▪ Los Angeles ▪ Madison ▪ Milwaukee ▪ Phoenix

Keetac Expansion Project	Feb 09
Location Map Nashwauk and Keewatin Water Supplies	Figure 1

Attachment 2

Unique No. 00192359
County Name Itasca

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
Minnesota Statutes Chapter 1031

Update Date 2002/01/29
Entry Date 1992/08/03

Township Name	Township	Range	Dir	Section	Subsection
	57	22	W	25	ABDC

Well Depth 606 ft. **Depth Completed** 606 ft. **Date Well Completed** 1982/11/03

Well Name KEEWATIN 1

Drilling Method Cable Tool

Contact's Name KEEWATIN 1

KEEWATIN MN 55753

Drilling Fluid

Well Hydrofractured? ☐ Yes ☐ No
From ft. to ft.

Use Community Supply (municipal)

Casing **Drive Shoe?** ☐ Yes ☑ N

Hole Diameter
0 in. to 249 ft
in. to 606 ft

Casing Diameter **Weight(lbs/ft)**
8 in. to 249 ft 28

GEOLOGICAL MATERIAL	COLOR	HARDNESS	FROM	TO
CLAY			0	40
QUICKSAND			40	50
CLAY			50	80
QUICKSAND			80	90
CLAY			90	180
SLATE			180	211
DISSEMINATED TACONITE			211	216
DISSEM. CHERTY & SLATY			216	281
DISSEM. CHERTY & SLATY			281	471
DISSEM. CHERTY TAC. & P			471	481
PAINT ROCK NON-MAG.			481	491
DISSEM. CHERTY TAC. & P			491	496
PORUS DISSEM. CHERTY T			496	526
POURS DISSEM. CHERTY T			526	606

Screen N **Open Hole** From 249 ft. to 606 ft.
Make Type

Static Water Level 86 ft. from Land surface Date 1982/10/13

PUMPING LEVEL (below land surface)
ft. after hrs. pumping g.p.m.

Well Head Completion
Pitless adapter mfr Model
Casing Protection ☑ 12 in. above grade
☐ At-grade(Environmental Wells and Borings ONLY)

Grouting Information Well grouted? ☑ Yes ☐ No

Material	From	To (ft.)	Amount(yds/bags)	
G	0	185	239	Y
G	185	223	22	Y
G	223	249	0.3	Y

Nearest Known Source of Contamination
50 ft. direction type
Well disinfected upon completion? ☑ Yes ☐ No

Pump ☐ Not Installed Date Installed Y
Mfr name RED JACKET
Model HP 60 Volts 460
Drop Pipe Length 441 ft. Capacity 375 g.p.m
Type S

Any not in use and not sealed well(s) on property? ☐ Yes ☐ No

Was a variance granted from the MDH for this Well? ☐ Yes ☐ No

REMARKS, ELEVATION, SOURCE OF DATA, etc.

ORIGIN CASING 12 INCH DIAMETER TO 217 FEET.

WELL ORIGINALLY DRILLED BY MCCARTHY WELL CO. APRIL 1952.

USGS Quad: Keewatin Elevation: 1473
Aquifer: PEBI Alt Id: 79-2192

Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 69183
License Business Name
Name of Driller PETERSON, D.

Report Copy

Unique No. 00228828

County Name Itasca

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 1031

Update Date 2004/03/10

Entry Date 1992/08/03

Township Name	Township	Range	Dir	Section	Subsection
	57	22	W	24	DCDABB

Well Depth 473 ft. **Depth Completed** 473 ft. **Date Well Completed** 1951/00/00

Well Name KEEWATIN 2

Drilling Method Cable Tool

Contact's Name KEEWATIN 2

KEEWATIN MN 55753

Drilling Fluid

Well Hydrofractured? ☐ Yes ☐ No

From ft. to ft.

Use Community Supply (municipal)

Casing **Drive Shoe?** ☐ Yes ☐ N

Hole Diameter

Casing Diameter **Weight(lbs/ft)**

10 in. to 344 ft

GEOLOGICAL MATERIAL	COLOR	HARDNESS	FROM	TO
CLAY	BLUE		0	6
CLAY & BIG STONES	BLUE		6	10
CLAY & BIG STONES, SAND	RED		10	24
CLAY & BIG BOULDERS	BLUE		24	29
CLAY	BLUE		29	58
SANDY CLAY, SOME GRAV			58	73
MUDDY SAND & BIG STONE			73	82
SANDY CLAY	BLUE	HARD	82	90
CLAY	BLUE	HARD	90	115
SLATE			115	124
DECOMPOSED TANCONITE			124	130
SOLID TACONITE			130	133
DECOMPOSED TACONITE			133	143
PAINTY DECOMPOSED TAC			143	165
DECOMPOSED TACONITE			165	170
PAINTY DECOMPOSED TAC			170	201
DECOMPOSED TACONITE			201	205
TACONITE		V.HARD	205	208
DECOMPOSED PAINTY CUT			208	212
SANDY DECOMPOSED TAC			212	220
SOLID TACONITE LITTLE SL			220	224
DECOMPOSED TACONITE L			224	230
SLATY TACONITE			230	345
DECOMPOSED TACONITE			345	350
DEC. TACONITE & PAINT R			350	355
PAINT ROCK			355	365
SAND & ORE (WATER)			365	369
CHERTY TACONITE			369	374

Screen N **Open Hole** From 344 ft. to 473 ft.

Make Type

Static Water Level 279 ft. from Land surface Date 1951/00/00

PUMPING LEVEL (below land surface)

324 ft. after hrs. pumping 280 g.p.m.

Well Head Completion

Pitless adapter mfr Model

Casing Protection ☐ 12 in. above grade

☐ At-grade(Environmental Wells and Borings ONLY)

Grouting Information Well grouted? ☐ Yes ☐ No

Nearest Known Source of Contamination

ft. direction type

Well disinfected upon completion? ☐ Yes ☐ No

Pump ☐ Not Installed Date Installed Y

Mfr name

Model HP 60 Volts

Drop Pipe Length ft. Capacity g.p.m

Type

Any not in use and not sealed well(s) on property? ☐ Yes ☐ No

REMARKS, ELEVATION, SOURCE OF DATA, etc.

WELL DEEPENED FROM 374 TO APPROX.473 AROUND 1960,
CASING IS SLOTTED FROM 344-374

USGS Quad: Keewatin

Aquifer: PEBI

Elevation: 1457

Alt Id: 79-2192

Report Copy

Was a variance granted from the MDH for this Well? ☐ Yes ☐ No

Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 27022

License Business Name

Name of Driller MCCARTHY

HE-01205-06 (Rev. 9/96)

Unique No. 00751520

County Name Itasca

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
Minnesota Statutes Chapter 1031

Update Date 2007/10/01

Entry Date 2007/08/23

Township Name	Township	Range	Dir	Section	Subsection
	57	22	W	25	ABDADB

Well Depth 615 ft. Depth Completed 615 ft. Date Well Completed 2007/08/16

Well Name KEEWATIN 3

Drilling Method Multiple methods used

Contact's Name CITY OF KEEWATIN
P. O. BOX 190
KEEWATIN MN 55753

Drilling Fluid Water

Well Hydrofractured? ☐ Yes ☑ No
From ft. to ft.

Use Community Supply (municipal)

Well Owner's Name KEEWATIN 3
2ND E AV
KEEWATIN MN 55753

Casing Drive Shoe? ☐ Yes ☐ N

Casing Diameter		Weight(lbs/ft)
18 in. to	80 ft	70.59
12 in. to	198 ft	49.56

Hole Diameter

in. to	80 ft
in. to	198 ft
in. to	615 ft

GEOLOGICAL MATERIAL	COLOR	HARDNESS	FROM	TO
FILL	BROW	SOFT	0	3
CLAY	BROW	SOFT	3	7
SAND, GRAVEL, ROCKS	BROW	SOFT	7	20
SANDY CLAY	BROW	SOFT	20	22
SAND & GRAVEL	BROW	SOFT	22	32
GRAVEL & CLAY LAYERS	BROW	SOFT	32	35
CLAY & GRAVEL	GRAY	SOFT	35	163
SLATE & CLAY LAYERS	BLACK	V.SOFT	163	164
SLATE & CLAY LAYERS	BLACK	V.SOFT	164	168
SLATE & CLAY LAYERS (SO	BLK/G	V.SOFT	168	190
SLATE & QUARTZ	BLACK	SFT-MED	190	195
SLATE & QUARTZ	BLACK	SFT-MED	195	245
SLATE	GRN/G	SFT-MED	245	265
SLATE & TACONITE (MAGN	GRN/B	MED-HRD	265	315
TACONITE (MAGNETIC) GR	VARIE	HARD	315	450
TACONITE (MAGNETIC) RU	VARIE	MED-HRD	450	470
TACONITE (MAGNETIC)	VARIE	HARD	470	585
TACONITE (MAGNETIC)	GRN/G	HARD	585	615

Screen N

Open Hole From 198 ft. to 615 ft.

Make Type

Static Water Level 186 ft. from Land surface Date 2007/08/16

PUMPING LEVEL (below land surface)
370 ft. after 6 hrs. pumping 450 g.p.m.

Well Head Completion
Pitless adapter mfr Model
Casing Protection ☑ 12 in. above grade
☐ At-grade(Environmental Wells and Borings ONLY)

Grouting Information Well grouted? ☑ Yes ☐ No

Material	From	To (ft.)	Amount(yds/bags)	
G		80	3	Y

Nearest Known Source of Contamination
100 ft. direction E type SEW
Well disinfected upon completion? ☐ Yes ☐ No

Pump ☑ Not Installed Date Installed N
Mfr name
Model HP Volts
Drop Pipe Length ft. Capacity g.p.m
Type

Any not in use and not sealed well(s) on property? ☐ Yes ☑ No

Was a variance granted from the MDH for this Well? ☐ Yes ☑ No

REMARKS, ELEVATION, SOURCE OF DATA, etc.

CALIPER, MULTI TOOL, & FLOW METERED 9-12-2007. LOGGED FOR MDH.

GAMMA LOGGED 8-31-2007. M.G.S. NO. 4741. LOGGED BY JIM TRAEN.

USGS Quad: Keewatin Elevation: 1472
Aquifer: PEBI Alt Id: 4741

Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 1404
License Business Name
Name of Driller TONY/DAN

Report Copy

Unique No. 00241017

County Name Itasca

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 1031

Update Date 2005/06/23

Entry Date 1992/08/03

Township Name	Township	Range	Dir	Section	Subsection
	57	22	W	32	BACD

Well Depth 414 ft. **Depth Completed** 414 ft. **Date Well Completed** 1930/00/00

Well Name NASHWAUK 3

Drilling Method

Drilling Fluid

Well Hydrofractured? ☐ Yes ☐ No
From ft. to ft.

Use Community Supply (municipal)

Casing **Drive Shoe?** ☐ Yes ☐ N

Hole Diameter

Casing Diameter **Weight(lbs/ft)**
8 in. to 40 ft

GEOLOGICAL MATERIAL	COLOR	HARDNESS	FROM	TO
DRIFT			0	110
BIWABIK OXIDES OF IRON			110	210
BIWABIK, MASSIVE IRON F			210	414

Screen **Open Hole** From ft. to ft.
Make Type

Static Water Level ft. from Date

PUMPING LEVEL (below land surface)
ft. after hrs. pumping g.p.m.

Well Head Completion
Pitless adapter mfr Model
Casing Protection ☐ 12 in. above grade
☐ At-grade(Environmental Wells and Borings ONLY)

Grouting Information Well grouted? ☐ Yes ☐ No

Nearest Known Source of Contamination
ft. direction type
Well disinfected upon completion? ☐ Yes ☐ No

Pump ☐ Not Installed Date Installed
Mfr name
Model HP Volts
Drop Pipe Length ft. Capacity 450 g.p.m
Type T

Any not in use and not sealed well(s) on property? ☐ Yes ☐ No

Was a variance granted from the MDH for this Well? ☐ Yes ☐ No

Well CONTRACTOR CERTIFICATION Lic. Or Reg. No.
License Business Name
Name of Driller

REMARKS, ELEVATION, SOURCE OF DATA, etc.

DATE OF SAMPLE 11/73

INFO FROM CITY CLERK

USGS Quad: Nashwauk Elevation: 1489
Aquifer: PEBI Alt Id: 75-2151

Report Copy

HE-01205-06 (Rev. 9/96)

Unique No. 00228819

County Name Itasca

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 1031

Update Date 2005/06/23

Entry Date 1992/08/03

Township Name	Township	Range	Dir	Section	Subsection
	57	22	W	32	CDAD

Well Depth 540 ft. **Depth Completed** 540 ft. **Date Well Completed** 1947/00/00

Well Name NASHWAUK 4

Drilling Method

Drilling Fluid

Well Hydrofractured? ☐ Yes ☐ No

From ft. to ft.

Use Community Supply (municipal)

Casing **Drive Shoe?** ☐ Yes ☐ N

Hole Diameter

Casing Diameter **Weight(lbs/ft)**

16 in. to 150 ft

GEOLOGICAL MATERIAL	COLOR	HARDNESS	FROM	TO
UPPER SLATEY ABSENT			0	144
UPPER CHERTY			144	335
LOWER SLATE			330	345
LOWER CHERTY MEMBER			345	540

Screen

Make Type

Open Hole From ft. to ft.

Static Water Level 150 ft. from Land surface Date

PUMPING LEVEL (below land surface)

ft. after hrs. pumping g.p.m.

Well Head Completion

Pitless adapter mfr Model

Casing Protection ☐ 12 in. above grade

☐ At-grade(Environmental Wells and Borings ONLY)

Grouting Information Well grouted? ☐ Yes ☐ No

Nearest Known Source of Contamination

ft. direction type

Well disinfected upon completion? ☐ Yes ☐ No

Pump ☐ Not Installed Date Installed

Mfr name

Model HP Volts

Drop Pipe Length ft. Capacity 450 g.p.m

Type T

Any not in use and not sealed well(s) on property? ☐ Yes ☐ No

Was a variance granted from the MDH for this Well? ☐ Yes ☐ No

Well CONTRACTOR CERTIFICATION Lic. Or Reg. No.

License Business Name

Name of Driller

REMARKS, ELEVATION, SOURCE OF DATA, etc.

LOCATED BY CITY CLERK

USGS Quad: Pengilly Elevation: 1439

Aquifer: PEBI Alt Id: 1310024S02

Report Copy

Attachment 3

Table 5 - Baseline and Annual Sampling Lists

Baseline List

Analyte	Units
Gross Alpha	pCI/L
Gross Beta	pCI/L
Uranium	ug/L
Radium 226	pCI/L
Radium 228	pCI/L
Radon 222	pCI/L
Alkalinity, Total	mg/L
Arsenic	mg/L
Barium	mg/L
Cadmium	mg/L
Calcium	mg/L
Carbonate/Bicarbonate	mg/L
Chloride	mg/L
Chromium	mg/L
Fluoride	mg/L
Hardness, Total	mg/L
Iron	mg/L
pH, Lab	units
Lead	mg/L
Magnesium	mg/L
Manganese	mg/L
Mercury	mg/L
Nitrogen, Nitrate +Nitrite	mg/L
Potassium	mg/L
Selenium	mg/L
Silver	mg/L
Sodium	mg/L
Sulfate	mg/L
Thallium	mg/L
Dissolved Solids, Total	mg/L
Cation/Anion Ballance	--
Volatile Organic Compounds 465 F	ug/l

Annual List

Analyte	Units
Alkalinity, Total	mg/L
Arsenic	mg/L
Barium	mg/L
Cadmium	mg/L
Calcium	mg/L
Carbonate/Bicarbonate	mg/L
Chloride	mg/L
Chromium	mg/L
Fluoride	mg/L
Hardness, Total	mg/L
Iron	mg/L
pH, Lab	units
Lead	mg/L
Magnesium	mg/L
Manganese	mg/L
Mercury	mg/L
Nitrogen, Nitrate +Nitrite	mg/L
Potassium	mg/L
Selenium	mg/L
Silver	mg/L
Sodium	mg/L
Sulfate	mg/L
Thallium	mg/L
Dissolved Solids, Total	mg/L
Cation/Anion Ballance	--