ANALOGUE INFORMATION RELATING TO MINE PIT CONE OF DEPRESSION IMPACTS ON THE SURFICIAL AQUIFER

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BACKGROUND

As part of the NorthMet Project groundwater and wetland Impact Assessment Process, an approach to estimating the extent of surficial aquifer drawdown caused by pit dewatering was needed to assess potential indirect impacts to nearby wetlands. One potential approach is to use well water level data from other sites across the Mesabi Iron Range (MIR). The purpose of this report is to document the process followed to produce general guidelines which may be used for the NorthMet Project for helping assess indirect wetland impacts.

DATA SELECTION

There are numerous surficial and bedrock wells located near natural ore and taconite mine pits across the MIR. The majority of these wells were installed to supply water for domestic or industrial purposes. Few of them were installed for the purpose of monitoring the effects of pit dewatering, thus insufficient well or pit water level information exists to draw a correlation between well water level and pit water level. There are two known locations where existing data may be usefull for this purpose. One is the Canisteo Pit area where sixteen surficial wells were installed as part of a cooperative water balance study to estimate the eventual, static pit water level. A few existing surficial wells were also used for the study. Another location is near the west end of Minntac's West Pit, near the community of Kinney, where the DNR installed one surficial well and one deep

bedrock well to help assess the effects of pit expansion on local water tables. There are no other known well data across the MIR that could be used to correlate aquifer water levels with adjacent pit water levels.

DATA USED FOR ANALOGUE EVALUATION

The attached slide presentation documents the data evaluation process used to develop guidelines for potential indirect wetland impacts. Slide 3 shows the location of the two, selected analog sites in relation to the NorthMet Project location. The Canisteo Pit and Kinney areas are approximately 65 miles and 35 miles west of the NorthMet Project, respectively. However, all three sites were affected by similar glacial advances, including the most recent St. Louis Sublobe of the Late Wisconsin advance (see attached Barr report for comparison of hydrogeology between the Canisteo and NorthMet sites). No hydrogeologic data is available for the Kinney site, but similar glaciation at all three sites suggests similar hydrogeologic conditions.

The Canisteo Pit complex consists of about 18 individual natural ore pits that together formed one large open pit approximately 5 miles long and 1 mile wide (slide 7). The last mining in the complex occurred at the east end of the complex in the late 1980's, after which the complex was abandoned and allowed to fill with water. The lowest elevation in the pit is approximately 980 ft. msl. The water level at initiation of the study was approximately 1294 ft. msl, and today's water elevation is approximately 1316 ft. msl.

Slide 7 also shows the location of 18 surficial wells that were monitored for the Canisteo study. Two of the wells (U of M wells near Bovey) existed prior to the study; the remaining 16 wells were installed in 1998 as part of the study. The Granite well (northeast end of Canisteo, slide 7) turned out to be dry and was therefore eliminated from the study. Water level information from the Tailing Basin well (northwest end of Canisteo, slide 7) was used for the water balance study but eliminated from this analog evaluation since it was drilled through an old, natural ore tailing basin and therefore not considered a natural site. Slide 8 shows the recorded Canisteo water levels from beginning of the water balance study (≈1294 ft. msl) to present (≈1316 ft. msl).

Slides 21-23 show the location of the Kinney wells in addition to the location of the Minntac's West Pit from 1998 to 2009.

WELL WATER LEVEL RESPONSE TO PIT WATER LEVEL

***Canisteo* –** Of the 16 Canisteo wells monitored, 3 wells, all in close proximity to the pit (≤ 700 ft.), showed a strong response to the rising pit water level. Six additional wells, all farther away from the pit (900 ft. to 2625 ft.), showed a positive but weaker response. The remaining 7 wells, ranging from 660 ft. to 3,500 ft. from the pit, showed no apparent response.

The location of the 3 wells showing a strong response to the rising pit water level, and the recorded water levels, are shown in slides 9 and 10. All three wells are less than 700 ft. from the pit and located in coarse sand and gravel deposits, and all showed an immediate response to the rising pit water, indicating that the water table they penetrated had been affected by the pit water level sometime prior to well construction.

The location of the 6 wells showing a positive, but weaker response, are shown in slide 11. Four of the 6 wells (slide 12), 1310 ft. to 2150 ft. from the pit, had starting water levels below the pit water level. All 4 wells exhibited apparent, normal response to precipitation events for approximately the first 4 years of the study, and all began rising during spring, 2004. The remaining two wells (IGA at 900 ft. and Hwy 7 at 2625 ft., slides 13 and 14), had starting water levels above the pit water elevation, but showed an apparent, immediate response to the rising pit water. The Hwy 7 well was the farthest well from the pit showing a positive response. The well was located in a sandy, outwash deposit in a north-south trending bedrock valley that was severed by the pits south wall, a hydrogeologic setting that likely contributed to it being affected that far from the pit. Similar hydrogeologic settings should be looked for at the NorthMet site. Slide 15 shows water levels for the 6 wells along with the Canisteo water levels.

The location of the 7 wells that were unaffected by the pit water level is shown in slide 16. These wells vary from 660 ft. to 3,500 ft. away from the pit. Four of the wells (1750' to 3,500', slide17) appear to show a response to the rising pit water

beginning in 2004, similar to the wells shown in slide 12. However, 3 of the wells (Osprey, Hydrant and Taconite) do not show recent water levels higher than recorded earlier in the study. Slide 18 shows the fall, soil recharge precipitation recorded at Coleraine, showing a consecutive 3-year recharge low from 2001-2003, followed by a 2-year recharge high in 2004-2005. This precipitation pattern is similar to the Osprey, Hydrant, and Taconite wells, suggesting that their fluctuating patterns result from local weather conditions rather than the rising pit water. The pattern exhibited by the Taconite Garage well is different, showing an abrupt rise of about 10 ft. in late 2003 with relatively constant water levels thereafter. The water level rise is too abrupt to be attributed to the pit water, and may have resulted from a benchmark or surveying error.

Water levels for the three remaining, unaffected wells (660 ft. to 2190 ft. from pit) are shown in slides 19 and 20. It is apparent that the two U of M wells were located in a perched system above the pit water level and therefore unaffected by it. The Dump Station well has shown no apparent response to the rising pit water level.

Kinney – The location of the Kinney wells and proximity to Minntac's West Pit is shown in slides 21-23, from 1998 to 2009. Monitoring of the surficial well ceased in 2003 because of safety reasons. Slide 24 shows recorded water levels for the two wells from 2000 to 2004. The surficial well showed no apparent response to the dewatered pit up to the time the well was abandoned and the pit was within approximately 900 ft. The bedrock well shows an apparent, slow response from at least 2001 (pit distance estimated at ≈1000 ft.) to 2004 (pit distance less than 900 ft.).

Minntac's West Pit was completely dewatered during the entire 2000 to 2004 monitoring period. It is interesting to note that the surficial well did not show a response while the bedrock well, located only about 200 ft. from the surficial well, showed a slow, but positive response. It is also worth mentioning that the water level in the bedrock well was about 30 ft. to 40 ft. below the surficial well's water level, indicating that a drawdown in the bedrock water table does not necessary

equate to a drawdown in the surficial water table. This is likely due to the low conductivity of the glacial material in the area.

Well information, including surface elevation, well depth, depth to bedrock, and general till description are shown in slides 25-28.

WATER LEVEL RESPONSE CONCLUSIONS

In all, there were 17 surficial wells and one bedrock well that were included in this evaluation. Of the 17 surficial wells, there was no evidence of a linear relationship between distances from the pit and effects on the surficial water table elevation. That is, there were some wells in close proximity to the pit (<700 ft.) that showed no response to the rising water level in the pit, and other wells that were much farther away (one at 2625 ft.) that showed a notable response. This variation is not unexpected considering the extreme variation in hydraulic properties of the glacial till (Canisteo *K* values ranged from 0.05 to 121 ft./day) and the resultant, high probability of localized perching. This extreme variation complicates the ability to draw firm conclusions and interpretations, and develop definitive guidelines for potential impact evaluation. However, the following conclusions are suggested as reasonable for the data used for this evaluation.

Within 900 ft. of the pit: 3 of 7 wells showed a strong response to the rising pit water, rising concurrent (approximately 22 ft. rise since 1998) with the pit water. One of the remaining wells (IGA, 900 ft. from pit) showed a positive, but weaker response, rising about 3 feet since 1998. The three remaining wells showed no response to, and were obviously perched above, the pit water level.

Within 1300' to 1925' from the pit: Three of 5 wells showed a positive, but comparatively weaker response (≈3 ft. rise) than the closer wells. Present water levels in the 3 affected wells ranges from 22 ft. to 31 ft. below the pit water level, and all were installed in coarse sandy to gravelly material.

Within 2150' to 3500' from the pit: Only one of 5 wells showed a positive, but comparatively weak response to the rising pit water. This well was down-gradient 2625 ft. from the pit, and located in a sandy outwash material in an elongated north-south bedrock valley that has an apparent, direct connection with the south

wall of the pit. This is considered a comparatively unique hydrogeologic setting. The existence of this type of setting at NorthMet should be taken into account during impact assessment.

INTERPRETATION AND GUIDELINES

As demonstrated by the data used for this evaluation, the heterogeneity of the glacial till hydraulic properties does not result in a smooth, curvilinear drawdown in the surficial aquifer caused by pit dewatering. Consequently, development of guidelines for assessing potential, indirect wetland impacts is subject to professional judgment, will have exceptions within any suggested impact zone, and may need adjustments as appropriate for NorthMet conditions. The following guidelines are therefore based on interpretation of the Canisteo and Kinney area data; use of these guidelines at NorthMet should be done with an understanding of NorthMet's hydrogeologic conditions, including any glacial hydraulic differences, drift thickness differences, bedrock topography, and proximity and hydrologic functioning of the wetlands adjacent to the proposed pits. (See attached Barr Memo, Comparison of Hydrogeologic Setting – Canisteo Pit, MinnTac Mine near Kinney and NorthMet mine Site.)

- **0' to 1000' from the pits**: significant surficial groundwater drawdown in this zone is most likely to occur. Impacts are most likely to be measurable, but there may also be areas of perched surficial water table that will be unaffected by pit dewatering.
- **1000' to 2000' from the pits**: surficial groundwater drawdown may occur but will likely be much less than within the 1000' zone and may not be discernable from natural variation.
- **2000' to 3500' from the pits**: surficial groundwater drawdown is unlikely, except under unique hydrogeologic conditions, e.g., where elongated bedrock valleys of coarse glacial material are severed by the pit. Impacts may not be discernable from natural variation.
- **Beyond 3500' from the pit**: no impacts expected.

References:

Barr, 2011. Comparison of Hydrogeologic Setting – Canisteo Pit, MinnTac Pit near Kinney and NorthMet Mine Site