



**IESI – SENECA MEADOWS, INC.
SENECA MEADOWS SOLID WASTE MANAGEMENT FACILITY**

APPENDIX N

HYDROGEOLOGIC MODELING

MEADOW VIEW SURFACE MINE

PREPARED FOR

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TABLE OF CONTENTS

1	HYDROGEOLOGIC MODELING.....	1-1
1.1	INTRODUCTION.....	1-1
1.2	GEOLOGY.....	1-1
1.3	HYDROGEOLOGY.....	1-3
1.3.1	<i>Surface Water.....</i>	<i>1-3</i>
1.3.2	<i>Water Level Measurements.....</i>	<i>1-4</i>
1.3.3	<i>Hydraulic Conductivity Measurements.....</i>	<i>1-4</i>
1.3.4	<i>Groundwater Flow.....</i>	<i>1-5</i>
1.4	GROUNDWATER MODELING.....	1-6
2	FILL TIME CALCULATIONS.....	2-1
2.1	INTRODUCTION.....	2-1
2.2	GROUNDWATER FLOW.....	2-1
2.3	PRECIPITATION AND RUNOFF.....	2-2
2.4	NORTH POND CALCULATION DETAILS.....	2-2
2.5	SOUTH POND CALCULATION DETAILS.....	2-3
2.6	ADDITIONAL FILLING CONSIDERATIONS.....	2-4
3	REFERENCES.....	3-1

TABLES

Table N-1	Stratigraphic Summary
Table N-2	Static Water Level Measurements, June and August 2005
Table N-3	Summary of In-Situ Hydraulic Conductivity Testing
Table N- 4	Geotechnical Laboratory Results
Table N-5	Summary of Hydrogeologic Properties of the Fractured Rock
Table N-6	Monitoring Well Water Level Readings
Table N-7	Fill-Time Calculations (North Pond)
Table N-8	Fill-Time Calculations (South Pond)

FIGURES

Figure N-1	High Groundwater 4/22/2010
Figure N-2	Low Groundwater 8/5/08
Figure N-3	Estimated Drawdown in the LGL
Figure N-4	Estimated Drawdown in the Bedrock

1 HYDROGEOLOGIC MODELING

1.1 Introduction

As described in Section 2.1.3 of the DEIS, the soil units identified on the Meadow View Mine property consist of alternating layers of glaciolacustrine and glacial till deposits which are similar in composition to each other and are referred to as the Upper Glaciolacustrine (UGL), Upper Glacial Till (UGT), Lower Glaciolacustrine (LGL), and the Lower Glacial Till (LGT). These units are similar in origin and character to those identified at the nearby Seneca Meadows Solid Waste Management facility (the SMI Facility), which has been studied extensively as part of the 6 NYCRR Part 360 permitting process. Hydrogeologic information from the SMI facility has thus been used to supplement the information obtained from the test pits, soil borings and piezometers installed on the Meadow View Mine property and to assist in evaluating the potential impacts associated with the proposed mining operation. This additional information is summarized below and is obtained from the Seneca Meadows Landfill Expansion Site Investigation Report, HydroQual Inc., November 2006 (SIR).

1.2 GEOLOGY

The geology underlying the Meadow View Mine and SMI facility consists of unconsolidated glacially derived sediments underlain by bedrock. Soils were deposited by the advance, retreat, and re-advance of ice sheets. Four overburden and three bedrock units have been characterized as follows:

Overburden

- Upper Glaciolacustrine (UGL)
- Upper Glacial Till (UGT)
- Lower Glaciolacustrine (LGL)
- Lower Glacial Till (LGT)

Bedrock

- Onondaga Limestone
- Cobleskill Dolostone
- Bertie Dolostone

Table N-1 summarizes the stratigraphic information related to the top and bottom elevation and thickness of each of these units as determined from borings completed on the SMI property. Information from borings completed on the Meadow View Mine property are provided in Appendix C and described in Section 2.1.3 of the DEIS. These units are described more fully in the following sections.

Unconsolidated (Overburden) Geology

The site lies within a glacial lake plain area typified by low permeability silt and clay deposits. This is evident by the relatively flat topography of the surrounding area and the prevalent silts

and clays identified in the borings completed throughout the area. The thickness of the overburden soils at SMI ranges from approximately 10 to 70 feet, which is generally consistent with the thickness of 30 to 56 feet reported in borings completed on the Meadow View Mine property (Section 2.1.3 of the DEIS). As reported in the SIR, the overburden thickness throughout most of the SMI facility is on the order of 40 to 50 feet thick. Large scale maps illustrating the overburden and individual unit thicknesses and depth below ground surface are provided within the SIR.

The individual stratigraphic units comprising the overburden are described individually below, in their order of occurrence from the ground surface to the top of bedrock. These descriptions are consistent with those presented in Section 2.1.3 of the DEIS for soils underlying the Meadow View Mine site.

Upper Glaciolacustrine (UGL)

The uppermost stratigraphic unit is the UGL. This unit ranges from not present near the southern end of Tantalos near Salcman Road to 5 to 20 feet thick throughout the remainder of the site. The upper-portion of the UGL can generally be described as a yellowish-brown silt and clay, in areas where the UGL is thicker than 10 feet, and as a reddish-brown varved lean clay with frequent silt partings at greater depth.

Upper Glacial Till (UGT)

Underlying the UGL is the UGT, which is continuous across the SMI site. The UGT ranges in thickness from approximately 3 to more than 35 feet, with the greatest thickness found along the western side of the SMI facility. The UGT is generally a soft to stiff, red-brown sandy silt and clay, containing a trace of fine to coarse gravel.

Lower Glaciolacustrine (LGL)

The LGL is generally a thin unit over most of the site with thicknesses generally in the 0 to 10 foot range, but thickens significantly south of the intersection of Salcman Road and Route 414. The LGL varies in character consisting of brown to gray-brown, very thinly to thinly varved lean clay, silt or silty sand throughout the majority of the site. Thicker layers of sand or silty sand are present in the area south of the intersection of Salcman Road and Route 414, where the LGL thickens.

Lower Glacial Till (LGT)

Immediately overlying the bedrock is a low permeability, lodgment till identified as the LGT. The LGT is absent near the southern portion of Tantalos and the area immediately to the southwest. Elsewhere across the site, thicknesses of this unit generally range from 5 to 15 feet, with the thickest deposits near the north end of the existing landfill. The LGT is generally a dense to hard, sandy clay or clayey sand with gravel, and is brown to gray-brown in color.

Bedrock Geology

Bedrock elevations beneath the SMI site range from approximately 410 to 484 feet. The highest elevations are encountered in the vicinity of monitoring well cluster T -22 southwest of Tantalos along Salcman Road. This localized bedrock high is known as the "bedrock knob" and represents the highest bedrock elevation at the SMI site. The bedrock surface slopes radially downward

from this high, with typical elevations around the perimeter of the knob on the order of elevation 440 to 450.

The bedrock beneath the site consists of the Onondaga Limestone, principally associated with the bedrock knob, and the Bertie/Cobleskill Formation, which underlies the remaining area of the site beyond the perimeter of the bedrock knob. The Cobleskill and Bertie Formations are combined because the contact is gradational at the site. The Cobleskill is a massive fine-grained brownish gray dolomite. The Bertie Formation consists primarily of units of massive dolostones, limestone beds, and shaley dolostone with wavy interbedded layers of argillaceous or siliceous material, rehealed fractures filled with gypsum, anhydride, and calcite or occasional pyrite crystals. Underlying the Bertie Cobleskill is the Camillus shale, which is described as a brownish gray dolostone. The Camillus shale was not encountered in the borings at the site.

1.3 HYDROGEOLOGY

The regional groundwater framework for the site is characterized as predominantly bedrock controlled, superimposed on which are low permeability glacial till and glaciolacustrine soils consisting predominantly of silt and clay. Given these low permeability soils and the relatively humid climate, these overburden soils are saturated close to the ground surface (i.e., high water table). The underlying bedrock is comprised of limestone and dolostone, which exhibit hydraulic conductivity values one or more orders of magnitude greater than those observed in the overburden. Given these conditions and the relative lack of topographic relief in the area, the bedrock serves as a groundwater sink or discharge point for overburden groundwater. The site specific hydrogeologic characteristics, and the interaction between groundwater and surface water at the site, are discussed in the context of this regional framework below.

1.3.1 Surface Water

Surface water features at and within the vicinity of the site are generally man-made and range from the channel conveying Black Brook across the central portion of the site, to retention ponds associated with the active solid waste facility, and finally to ponds south and west of the office building related to soil borrow operations. Black Brook, the only flowing body of water, originates about 1 mile west of the site, and flows in an easterly direction through a man made channel that traverses SMI's property. Approximately 1.5 miles east of the site, Black Brook turns northward and drains into the Montezuma Refuge located approximately 5 miles to the northeast.

Retention ponds associated with the SMI site are used to collect surface water runoff from the existing landfill. Retained water in the ponds is sampled to confirm that water quality meets discharge limits, and is then pumped into Black Brook.

The nature, elevation, and location of surface water features at the site are such that they do not serve as significant groundwater sinks. The hydraulic heads in the overburden and bedrock are generally lower than surface waters indicating that groundwater discharge to surface water is generally negligible. However, some groundwater discharge is expected from the UGL, in close proximity to Black Brook and to the Retention Ponds when the water level in the ponds is

pumped down. Shallow groundwater also discharges to the underdrains constructed as part of the landfill waste cells.

1.3.2 Water Level Measurements

Water levels have been measured as part of various investigations at wells screened within each of the unconsolidated geologic units and the underlying bedrock at locations throughout the Site. Wells designated as UL or UGL, UGT or UT, LGL or LL, and LGT, or LT provide head data from the upper glaciolacustrine, upper glacial till, lower glaciolacustrine, and lower glacial till units, respectively. Wells designated as SB, IB, MB, and DB monitor the bedrock with SB wells screened within the upper 20 feet of the bedrock surface and IB, MB, and DB wells monitoring deeper bedrock intervals.

As part of the 1997 SIR, water level measurements were obtained on a monthly basis for 24 months in 1995 and 1996. These data, collected from wells located throughout the Site, indicated that seasonal high water levels occur in the spring when the higher recharge events (precipitation and snow melt) contribute to the groundwater flow regime. Conversely, seasonally low water elevations occur in the fall. Both the increases and decreases occur synchronously in the different overburden units and bedrock, with limited localized exceptions. Site wide water levels collected at the SMI facility in June and August of 2005 are summarized in Table N-2. Water levels collected at the Meadow View mine property are summarized in Table N-6.

The collected data also illustrate predominantly downward gradients from the overburden to the underlying bedrock. While this condition dominates, there are occasional, transient reversals where heads at a given well cluster in the bedrock are higher than those in the adjacent UGL well. These gradient reversals are attributed to seasonal variability in recharge and appear to be a localized condition that does not affect the site wide groundwater flow regime. With respect to bedrock, vertical gradients are downward within the bedrock knob area while similar head levels within the shallow and deep bedrock wells are observed throughout the remainder of the Site. The collective effect of these observed gradients on Site wide groundwater flow is discussed further below.

1.3.3 Hydraulic Conductivity Measurements

The hydraulic properties of the overburden and bedrock geologic units underlying the site have been evaluated through slug testing at individual overburden and bedrock well locations, laboratory tests of Shelby tube samples collected from the overburden, and packer testing and aquifer tests completed within the bedrock.

Slug test results provide an estimate of the horizontal hydraulic conductivity of the tested interval and are summarized in Table N-3. The geometric mean hydraulic conductivity for the UGL, UGT, LGL and LGT were calculated at 1.8×10^{-5} , 2.7×10^{-6} , 2.4×10^{-5} and 1.4×10^{-6} cm/s respectively. Vertical hydraulic conductivity of the overburden soils has been estimated through laboratory testing of Shelby tubes and these results, along with the geotechnical properties, are summarized in Table N-4. These data indicate a range of vertical hydraulic conductivity from 2×10^{-8} to 6×10^{-6} with the UGL deposits typically exhibiting a higher vertical permeability relative to the other overburden units.

Bedrock horizontal hydraulic conductivity, also derived from slug testing and summarized in Table N-3, was generally in the 10^{-2} to 10^{-4} cm/sec range with a few values at 10^{-5} cm/sec. These values are consistent with packer testing completed at locations SE-100DB and SE-105DB, which illustrated horizontal hydraulic conductivity within the bedrock on the order of 1×10^{-3} cm/sec. Finally, aquifer testing (Eckenfelder Inc. August 1998), completed at PW-100R (adjacent to the SE-100 well cluster), also indicated horizontal hydraulic conductivity within the bedrock of 3×10^{-3} cm/sec. Hydrogeologic properties for the underlying bedrock, derived from the aquifer test, are summarized in Table N-5. These data indicate that the vertical anisotropy of the bedrock below approximately 430 feet msl (i.e. the bedrock beneath the proposed Meadow View Mine) is negligible and equates to a vertical hydraulic conductivity of roughly 3×10^{-3} cm/sec). The aquifer test also yielded a specific storage of 2×10^{-6} ft⁻¹ and an effective porosity of 0.0025.

Collectively, the hydraulic conductivity data consistently demonstrate that the overburden soils are represented by low hydraulic conductivity values on the order of 10^{-5} to 10^{-6} cm/sec (on average) while the hydraulic conductivity of the bedrock is typically two to three orders of magnitude higher at approximately 10^{-3} cm/sec. As discussed in further detail below, this results in groundwater flow that is predominantly vertically downward through the overburden with significant horizontal flow restricted to the bedrock water-bearing zone.

1.3.4 Groundwater Flow

Site wide potentiometric surface maps and hydrogeologic cross sections for the SMI facility were prepared for the overburden and bedrock water-bearing zones as part SIR and are not reproduced herein due to their size. This mapping, however, provides additional insight into the hydrogeologic flow system as summarized below and the reader is referred to the November 2006 SIR for additional discussion and copies of the maps and cross sections. Potentiometric surface maps for the Meadow View Mine property are illustrated in Figures N-1 and N-2.

The most noticeable feature on the SMI facility overburden potentiometric surface maps is the depression in the water table surface beneath the Southeast Landfill (SELF) as a result of operating the porewater depression system. This indicates that the SELF porewater depression system now serves as the localized discharge point for shallow groundwater within the eastern portions of the site. However, the areal extent to which this discharge point affects groundwater flow is limited as a result of the low hydraulic conductivity of the overburden deposits and the strong downward vertical gradients. This is supported by the hydrogeologic cross sections, which illustrate vertically downward gradients within the overburden throughout the site. The strong vertical gradients within the overburden deposits, as illustrated by the nearly horizontal equipotential lines on the cross sections, are a result of the low hydraulic conductivity of the overburden deposits, which overlie bedrock of higher hydraulic conductivity. As a result, groundwater flow within the overburden is predominantly vertical, with discharge to the underlying, higher permeability bedrock.

Groundwater flow in the lower bedrock water-bearing zone, which essentially encompasses the area beyond the limits of the bedrock knob and below an elevation of approximately 430 feet msl, is characterized by low vertical and horizontal gradients. These conditions are indicative of

the permeability and negligible vertical anisotropy observed during the PW-100 aquifer test, and result in predominantly horizontal flow paths to the south-southwest, consistent with the regional groundwater flow regime.

Collectively, the potentiometric surface maps and hydrogeologic cross sections illustrate a groundwater flow system dominated by downward vertical flow paths through the overburden, which behaves as an aquitard, with discharge to the underlying bedrock water-bearing zone, which behaves as a confined aquifer. Horizontal flow paths dominate within the bedrock (beyond the localized limits of the bedrock knob) with flow to the south, consistent with the regional groundwater flow regime. Localized variations in the groundwater flow direction are also present as a result of anisotropy within the bedrock water-bearing zone.

Representative seasonal high and low potentiometric surface maps within the overburden underlying the Meadow View Mine property are illustrated in Figures N-1 and N-2 based upon four piezometers constructed on the property. Consistent with the conditions observed on the SMI property, the data indicate little, if any, discharge of groundwater to surface water and in most cases, indicate that the surface water is associated with accumulation of precipitation and run-off within the low permeability soils. In other words, the surface water is typically at higher elevations than the surrounding groundwater. Both maps illustrate consistent flow patterns suggesting that seasonal changes result in changes in the depth to groundwater but not to the overall flow patterns. More importantly, and again consistent with the SMI site, the generally low permeability of the overburden soils will result in predominantly vertical flow paths. Therefore, while there is a horizontal component of shallow groundwater flow away from the topographic high in the southeast corner of the property as illustrated in Figures N-1 and N-2, there is a pronounced vertical component of flow that discharges to the underlying bedrock water-bearing zone.

1.4 Groundwater Modeling

In order to assess the effects of the mining operation on the surrounding groundwater levels, a conceptual level groundwater flow model was constructed to simulate the dewatering activities. The intent of the modeling was not to create a detailed site specific groundwater flow model, but rather to use the understanding of groundwater flow obtained from the detailed hydrogeologic work completed on the nearby SMI property to assess how the groundwater flow regime would respond to the dewatering of the proposed mines.

Stratigraphic and hydrogeological information for the model were specified based upon information presented in the *IESI – Seneca Meadows, Inc. Seneca Meadows Solid Waste Management Facility 6NYCRR Part 360 Landfill Expansion Application Site Investigation Report* (HydroQual, 2006), on borings completed within the proposed mine area (Appendix C of the DEIS), and limited water level readings in off-site wells. The details of the data taken from the site investigation report are discussed above (see Geology and Hydrogeology sections).

Five layers were included in the model domain to represent the Upper Glacial Lacustrine (UGL), Upper Glacial Till (UGT), the Lower Glacial Lacustrine (LGL), and the Lower Glacial Till (LGT) units and the underlying bedrock (BR). Layer thicknesses were generalized based upon

information in the site investigation report. Table 1-1 of this narrative summarizes the layer thicknesses as well as the horizontal and vertical hydraulic conductivities used in the analysis.

Table 1-1. Details of Simplified Site Model

Stratigraphic Unit	Model Layer	Thickness (ft)	Generalized Layer Top Elevation (ft)	Horizontal Hydraulic Conductivity, K_H (ft d ⁻¹) ¹	Vertical Hydraulic Conductivity, K_V (ft d ⁻¹)
Upper Glaciolacustrine (UGL)	1	5	200	5.1×10^{-2}	2.6×10^{-3}
Upper Glacial Till (UGT)	2	25	195	7.7×10^{-3}	1.2×10^{-4}
Lower Glaciolacustrine (LGL)	3	5	170	6.8×10^{-2}	2.3×10^{-4}
Lower Glacial Till (LGT)	4	5	165	4.0×10^{-3}	2.7×10^{-4}
Bedrock (BR)	5	>125	160	9.07	9.07

¹ Values from HydroQual, 2006

Table 1-2 lists wells within 2000 feet of the Meadow View Mine excavation. Most of these wells are screened in the relatively permeable BR (see Table below). Wells 2 and 2A are completed within the overburden and is most likely screened in the LGL, which is the most permeable soil unit. Therefore the drawdown analysis focused on water levels changes within the LGL and BR due to dewatering operations.

Table 1-2. Well Details for Selected Wells

Well Number	Approx. Dist. to Mine (ft)	Depth of Well (ft)	Local Aquifer	National Aquifer
1	1870	75	Onondaga Limestone	Carbonate
2	580	39.6	Glacial Delta Deposits	Sand and Gravel
2A	500	27.4	Glacial Delta Deposits**	Sand and Gravel
2B	580	73.0	Onondaga Limestone**	Carbonate
3	550	168	Onondaga Limestone	Carbonate
4	770	88	Onondaga Limestone	Carbonate
5	10	68	Onondaga Limestone	Carbonate
11	1850	75	Onondaga Limestone	Carbonate
16	870	72	Bedrock**	N/A

** Assumed based on the depth of the well

In Visual MODFLOW, a model domain was created for the analysis measuring 20,000 feet by 20,000 feet by 200 feet. A total of 80 rows and 80 columns were used resulting in 250' x 250' cells (in the x-y plane). The ground surface was placed at an elevation of 200 feet and the bottom of the BR was placed at an elevation of zero in the model. The following points summarize additional details of the modeling analysis:

1. An excavation depth of 35 feet below ground surface (bgs) (elevation = 165 feet in the model) was used for the analysis. Based on the thicknesses of the units in Table 1-1, this

represents removal of the UGL, UGT, and LGL units. The separation between the excavation bottom and the BR is 5 feet (i.e, the thickness of the LGT).

2. Data and mappings from the site investigation report suggest that the water table is up to 10 feet below the ground surface. The water table in the model was placed within the UGL at a depth of 3 feet bgs (model elevation = 197 feet).
3. To maintain a downward vertical gradient in the model domain, constant head nodes were placed at the westernmost and easternmost extents of the UGL, LGL, and BR. A 1-foot head differential (west to east) was used to produce some horizontal water movement.
4. Data and mappings from the site investigation report indicate the potentiometric surface of the LGL is generally 15-25 feet below the groundwater table and the potentiometric surface of the BR is typically 2 feet lower than that of the LGL. To produce the maximum difference between the unperturbed head in the LGL and the excavation bottom, the head in the LGL was specified at 15 feet below the groundwater table (i.e., at an elevation of 182 ft in the model). The head in the BR was specified at 180 ft in the model. This is 2 feet lower than the LGL potentiometric surface and 15 feet above the top of LGT layer (Table 1-1).
5. The head values used for the constant head nodes (see number 3 above) are as follows: water table in UGL (197 – 196 ft), potentiometric surface in LGL (182 – 181 ft), and potentiometric surface in BR (180 – 179 ft).
6. Drains were used in the model to simulate the effect of dewatering. This type of boundary condition removes water from an aquifer at a rate proportional to the difference in head in the aquifer and the elevation of the drain itself. Drains were placed in the model within the footprints of the two excavations and the drain elevation was set at the bottom of the LGL (at an elevation of 165 feet in the model). The conductance value was set at an arbitrarily high value to facilitate direct hydraulic communication between the drain and the surrounding aquifers. Based on the unperturbed head in the LGL (181 – 182 ft) and the drain elevation (165 ft), dewatering activities were manifested in the model as a 16-17 foot decrease in the LGL potentiometric surface within the footprints of the two excavations.
7. A recharge of 1 in/yr was used to maintain saturated conditions in the UGL.
8. Observation wells were added to the model domain to indicate drawdown at the location of the wells listed in Table 1-2 of this narrative.
9. A steady-state simulation was used for the modeling analysis to illustrate the maximum drawdown conditions that result from the specified input conditions. Steady state simulations are not time dependent and therefore, storativity values for the various model layers are not required.

Figures N-3 and N-4 indicate contour maps of steady-state drawdown in the LGL and BR. In general, drawdown predicted by the model is minor and ranges from 0.23 – 0.40 feet. It should be noted that with the exception of Wells 2, 2A, 2B, 3 and 16, the other wells depicted on the plan are either owned by SMI or are located in areas serviced by public water. The model prediction of minor changes in the surrounding area is consistent with the changes observed in response to the SELF pore water depression system described above. The modeling indicates that effects of de-watering the mine will be limited to within a few thousand feet of the mine and that the overall groundwater flow directions outside this radius are not impacted. The analyses thus indicate that the dewatering at the mine would not result in significant impact to adjacent well users. Because of the extensive controls that are included in the design, construction, and operation of the mine, and based on the results of the groundwater modeling, the Project will not have significant adverse impacts on groundwater resources. Impacts to groundwater flow patterns in the vicinity of the SMI landfill site are also anticipated to be negligible. Due to the distance of the excavation to these groundwater monitoring points and the inconsistency of the thickness and presence of the more permeable LGL layer, drawdown as a result of the excavation dewatering will be negligible. The southern limits of the SMI landfill, in particular, are not anticipated to see any impact as the LGL layer is not present.

2 FILL TIME CALCULATIONS

2.1 Introduction

To assess the longevity of hydrogeologic impacts from mining activity, the time required to fill the Meadow View Mine North and South Ponds with water was estimated. The calculations considered inflow from three sources: 1) groundwater flow, 2) precipitation, and 3) surface runoff.

2.2 Groundwater Flow

Groundwater flow into the excavations was estimated by considering both horizontal flow in the overburden and vertical flow in the bedrock. A radial inflow analysis was used to describe the horizontal flow contribution. The follow equation was applied:

$$Q = -K_{h,ave} i A \quad (2.1)$$

Where Q is the groundwater flow, $K_{h,ave}$ is the average horizontal hydraulic conductivity, i is the gradient in head, and A is the area through which flow occurs. Based on the conceptual model for the Visual MODFLOW drawdown estimate, the average horizontal hydraulic conductivity can be calculated as follows:

$$K_{h,ave} = \sum_{i=1}^n \frac{K_{h,i} b_i}{b} \quad (2.2)$$

Where b is the total saturated thickness and $K_{h,i}$ and b_i are the horizontal hydraulic conductivity and thickness of the different overburden units, respectively. Based on the hydraulic conductivities and thicknesses presented in Table 1-1, included in this narrative, the calculated average horizontal hydraulic conductivity is 0.072 ft/d.

The gradient at some distance, r , from the mine center is given as:

$$i = \frac{z_{pond} - h_{wt}}{2r} \quad (2.3)$$

Where z_{pond} is the elevation of the water surface in the pond forming in the mine excavation and h_{wt} is the head at a distance $2r$ away. This head represents the unperturbed water table elevation (i.e., free from drawdown associated with mining activity). The area, A , through which flow occurs at r is given by:

$$A = 2\pi r \left(\frac{z_{pond} + h_{wt}}{2} \right) \quad (2.4)$$

Substituting 2.3 and 2.4 into 2.1 gives

$$Q = -\frac{K_{h,ave}\pi}{2} (z_{pond}^2 - h_{wt}^2) \quad (2.5)$$

This last result allows one to estimate the horizontal component of groundwater discharge to the mine excavations as a function of the water stage.

The vertical component of groundwater inflow was estimated using Equation 2.1 with the following modifications. The vertical hydraulic conductivity of the till layer ($K_{v,LGT} = 9.4 \times 10^{-8}$ cm/s or 2.7×10^{-4} ft/d) was used in the calculation since this is the limiting conductivity value between the bedrock potentiometric surface and the water surface in the ponds. The gradient, i , was specified based upon the water surface of the ponds, z_{pond} , the potentiometric surface of the bedrock, and the 5 foot separation between the bedrock and the excavation bottom (i.e., the thickness of the LGT). The potentiometric surface of the bedrock was set at an elevation of 15 feet above the top of the LGT to be consistent with data and mappings from the site investigation report (HydroQual, 2006). The area, A , used in Equation 2.1 was the surface area of the pond.

2.3 Precipitation and Runoff

Estimates of the precipitation and evaporation rates at the location of the excavations were taken from maps prepared by the USGS (1996) for the period 1951-1980. The mean annual precipitation amount is approximately 33 in/yr. The mean annual evaporation amount is approximately 20 in/yr. Therefore, the net annual inflow from precipitation is 13 in/yr or 1.08 ft/yr. This inflow was applied to the water surface area of the ponds during filling.

The USGS (1996) maps were also used to estimate a mean runoff value of 13.5 in/yr at the location of the excavations. The runoff was applied to the drainage area (excluding the water surface) associated with each of the mine excavations. The drainage area values were established by subtracting the water surface area of the completed pond from the overall drainage areas presented in the stormwater calculations.

2.4 North Pond Calculation Details

Fill-time calculations were performed for the 11.3-acre North Pond and the 61.6-acre South Pond separately due to differences in shape and operations. For both ponds, the design life of the mine is 11 years.

For the North Pond, the lowest elevation of excavation is approximately 455 ft above mean sea level (amsl); the maximum water level is the pond outlet elevation of 478.6 ft. In terms of operation, excavation with dewatering will occur for the first three years. Then dewatering will cease and the North Pond will transition to filling. Based on data and mappings from the site investigation report (HydroQual, 2006), the water table is generally 5-10 feet below the ground surface. The ground surface in the vicinity of the North Excavation is at an elevation of 480 ft. To incorporate a measure of conservatism into the fill-time estimate, the water table in the North Pond, h_{wt} , was specified at 10 feet below the ground surface at 470 ft. Accordingly, the last nine feet of water entering the pond were due solely to precipitation and run-off. The fill-time estimate for the North Pond does not consider explicitly the detailed bathymetry of the excavation: the surface area of the pond at the elevation of the outlet was applied in the calculations for the entire time the pond was filling. The drainage area (not including the pond surface) used in the calculation was 7 acres (approximately 62% of the North Pond area). This area was also used to calculate the vertical groundwater inflow component. As indicated above, the potentiometric surface of the bedrock was specified as 15 feet above the till layer or, equivalently, 15 feet above the bottom of the excavation.

The results of the fill-time analysis for the North Pond are presented in Table N-7, which represents a printout of the Excel spreadsheet used for the calculations. Following cessation of dewatering in year 3, an estimated 12.3 years is required to fill the North Pond. This is 4.3 years beyond the life of the mine. Calculations indicate that ground water inflow contributes approximately maximum of 26% of the total inflow to the North Pond. Precipitation contributes 45 – 61% of the total inflow. Recharge contributes 29 – 39% of the total inflow.

2.5 South Pond Calculation Details

For the South Pond, the lowest elevation of excavation is 441 ft; the maximum water level in the South Pond is the outlet elevation of 480.2 ft. In terms of operation, excavation will proceed in multiple phases. During the first phase (year 0 – 3), the deepest portion of the excavation (i.e., the western edge) will be dewatered. During the second phase (year 3 – 6), dewatering will be used to maintain an approximate water level below 449 ft. During the third phase (year 6 – 8) dewatering will maintain an approximate water level below 454 ft. During the final phase of operations (year 8 – 11), dewatering will maintain an approximate water level below 458 ft. At the end of the final phase, dewatering will cease and the pond will be allowed to fill above 458 ft. A water table depth, h_{wt} , of 480 ft was used for the fill-time calculation based on the general water table relation to ground surface noted above, and the fact that the ground surface ranges from roughly 480 ft along the northern perimeter of the South Pond to 500-505 ft along the southern perimeter of the South Pond.

The bathymetry of the South Pond is more complex than that of the North Pond. Therefore, South Pond fill-time calculations considered variation in surface area with depth and inflows were calculated on a volumetric basis. The volumetric inflow due to net precipitation varies with the surface area of the water surface. The drainage area use to calculate runoff inflow was related to the water surface area using the drainage area to pond area ratio (0.61) for the final water surface elevation. It was assumed that the surface area through which vertical inflow from the bedrock occurs is the mine surface area at an elevation of 458 ft (26 acres). Bedrock elevations in the area of the South Pond range generally from 436 to 457 ft. Based on a 5-foot LGT thickness and a 15-foot separation between the top of the till and the bedrock potentiometric surface, the elevation of head in the bedrock ranges between 456 and 477. A value of 467 ft was used in the analysis.

The results of the fill-time analysis for the South Pond are presented in Table N-8, which represents a printout of the spreadsheet used for the calculations. These calculations indicate that only 3.5 years are required to fill the excavation to an elevation of 458 ft. This result suggests that the lower elevations of the pond will fill rapidly and dewatering will indeed be necessary to maintain the water levels at the elevations associated with the various phases indicated above. Accordingly, at the end of operations in year 11, the water surface will be at an elevation of 458 ft. The time required to fill the remainder of the South Pond after operations cease (i.e., between an elevation of 458 ft and 480.2 ft) is 12 years. Between elevations of 441 and 450, groundwater inflow is the dominant component of the total inflow. Above 458, the net precipitation and recharge terms make up most of the total inflow.

2.6 Additional Filling Considerations

Although calculations indicate that the filling operations for the North and South Ponds are estimated at 4.3 and 12 years, respectively, it is anticipated that additional surface water sources will be available for more rapid filling. These sources could include; stormwater runoff from adjacent roadways or adjacent construction projects. The stormwater runoff that could potentially be used from other sources would consist of runoff that would normally enter Black Brook, but would be temporarily diverted. Additionally, the agricultural ditch that runs along the north and west limits of the excavation, is connected to Black Brook and regularly backs up every spring. Excess water from this ditch will be siphoned or diverted into the Ponds as available. During dewatering operations for the south pond, water will be pumped to the north pond if it has not yet been filled. Furthermore, excess water available in the North Pond after it is filled, will be diverted as it is available to fill the South Pond. It is anticipated that filling using additional available sources will allow the ponds to be filled within 2-4 years after the completion of mining operations.

3 REFERENCES

United States Geological Survey (USGS), 1996. Mean Annual Runoff, Precipitation, and Evapotranspiration in the Glaciated Northeastern United States, 1951-80, USGS Open File Report 96-395.

TABLES

FIGURES
