Attachment 6: Preliminary Evaluation of Hydrological and Hydrogeological Conditions

INTRODUCTION

A hydrogeological investigation of the Vella Pit (Site) is in progress. Current baseline/preliminary information developed to date from this investigation is summarized below. This includes information about the Site setting, surface water, ground water, and preliminary numerical modeling based on publicly-available data from residential water well logs.

Hydrogeological investigation activities in progress or yet to be completed include installation of monitoring wells to observe groundwater conditions at the Site, installation of surface water measurement stations, and collection and analysis of water level observations from these locations. The data from this on-Site investigation will be incorporated with the baseline/preliminary information summarized below to develop findings and conclusions of the hydrogeological investigation.

SITE SETTING

The Site is situated on a topographic high which stands approximately 100 feet higher than much of the surrounding area. The Site parcel encompasses approximately 142 acres of land; the current extent of the mining operates on approximately 75 acres of that parcel. Wetlands exist in the lower-lying forested areas of the Site along the north and northeastern portions of the parcel, as well as an unnamed creek and Massey Lake which are connected to Fleming Creek located to the south of the Site.

Sand and gravel have been mined at the Site since operations began in 1956. Current activities at the Site include mining and production of washed sand and stone. Dewatering of the mining pit is required to facilitate mechanical surface mining. The reserve material is mechanically mined (by excavator or front-end loader) and hauled to the wash plant. The wash plant washes and sizes the material into usable finished product. Finished product is stockpiled on Site and is hauled via truck by the consumer. Water from the wash plant is transferred to the on-site settling pond and recirculated for use at the wash plant.

SURFACE WATER

The Vella Pit is located in the Fleming Creek Watershed (HUC 12-041000130401) in Washtenaw County, Michigan. The low-lying areas to the north and east of Vella Pit contain wetlands with small perennial streams which feed into Fleming Creek. Water extracted from dewatering the active mining pit passes through two settling basins (to remove suspended solids) before being discharged to the wetlands at a National Pollution Discharge Elimination System permitted outfall (Figure 1).

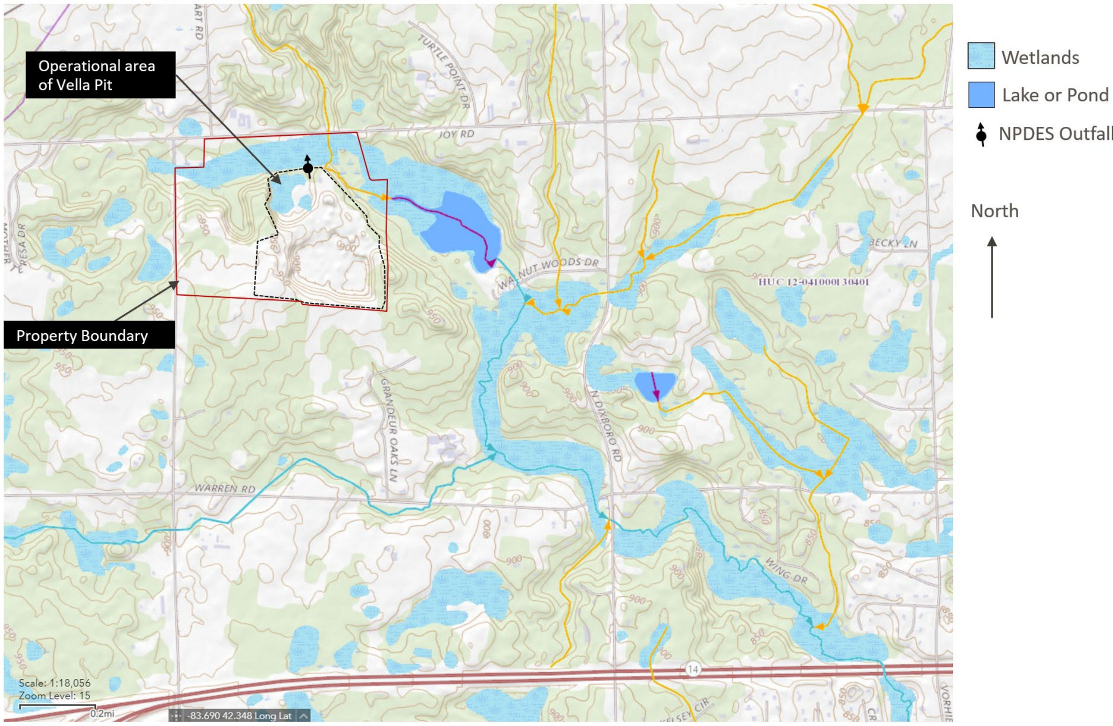

Figure 1. Surface hydrology near Vella Pit. Base map from The National Map (https://apps.nationalmap.gov/viewer/). All other dimensions are approximate.

There are a number of small lakes and ponds in the vicinity of the Site. Some of these are natural, while others are artificial or artificially supplemented by groundwater pumped from residential wells. Massey Lake, the largest in the area, is situated on privately owned property to the east of the Site and receives water from the abovementioned unnamed creek. This lake ultimately drains to Fleming Creek.

GROUNDWATER

Vella Pit is situated in an area of Washtenaw County dominated by fine to medium textured glacial tills and end moraines (Farrand and Bell, 1982). The main gravel and sand body mined at Vella Pit is a localized deposit of coarse glacial outwash surrounded above and below by clay-rich strata. The overlying fine-grained strata is likely clay till based on its heterolithic characteristics, while the underlying fine-grained strata is either a till or lacustrine deposit. For purposes of this study, both fine grained units are referred to as tills. A review of publicly available driller's logs from nearby domestic water wells indicates that this coarse-grained zone is used locally as a drinking water source by several nearby households (referred to as the "Upper Aquifer"). Other nearby residential and community water supply wells withdraw water from a deeper (>200 feet depth) gravel unit (referred to as the "Lower Aquifer"). A schematic cross section through Vella Pit and several of these wells is shown in Figure 2.

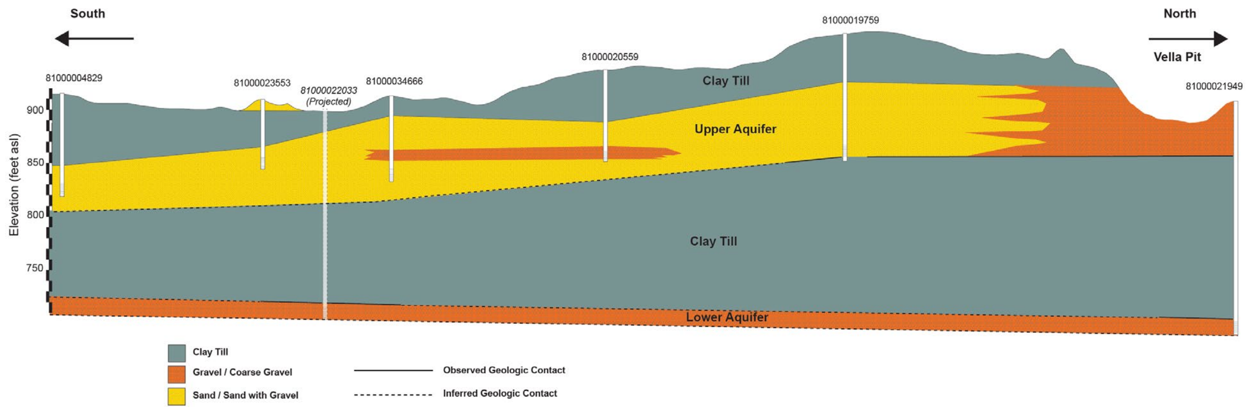

Figure 2. Cross section through Vella Pit and several nearby domestic wells. The topography is from the USGS 3DEP Digital Elevation Model, which does not represent the current depth of excavation in the Vella Pit. All dimensions are approximate. Wells are identified by their Well ID Number, as retrieved from the Michigan Department of Environment, Great Lakes, and Energy ([EGLE], 2023).

The thickness of the Lower Aquifer is unknown as most wells producing from the deep aquifer do not fully penetrate that unit. The Upper Aquifer dips gently towards the South, while the Lower Aquifer appears nearly horizontal. The Upper Aquifer is likely under confined conditions where fully saturated and overlain by clay till, although the static water level in some driller's logs indicates that it may not be fully saturated in all locations. Recharge of the Upper Aquifer probably occurs where the main body of the coarse-grained sediments are at or near the ground surface in low lying areas, such as portions of the wetlands to the north and east of Vella Pit. The Lower Aquifer is confined, and the recharge area has not yet been identified. No evidence reviewed to date suggests the two aquifers are in hydraulic communication. The lateral extent of both aquifers has not yet been fully delineated, although the upper aquifer it is known to be absent in a number of locations.

PRELIMINARY MODELING

To assess the effect of groundwater withdrawal at Vella Pit on the shallow aquifer, a preliminary groundwater model was created using the GMS software package (from AquaVeo). The model framework was based on a 1/3 arc second resolution digital elevation model (DEM) of the ground surface (United States Geological Survey [USGS], 2017) and publicly available driller's logs from the EGLE Water Well Viewer (EGLE, 2023).

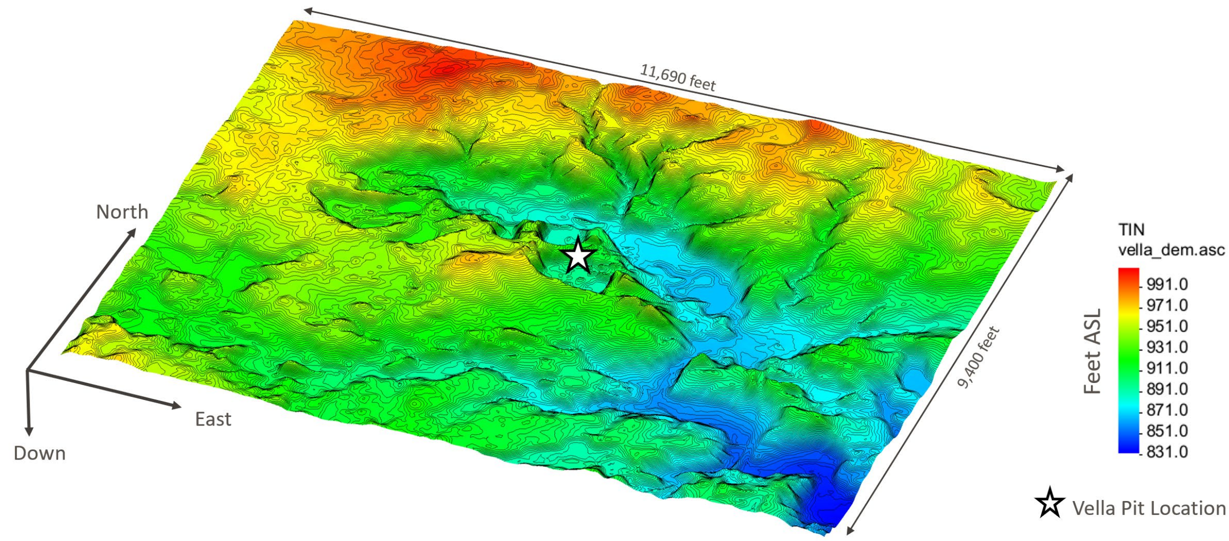

Figure 3. DEM rendered as a surface in GMS (three-dimensional perspective view with 5:1 vertical exaggeration). This topographic surface forms the upper boundary of the model. (ASL = above sea level).

Using the driller's logs and several historical soil borings from Vella Pit, a series of intersecting geologic cross sections was developed to constrain the model framework. Note that domestic water wells are not installed for scientific subsurface investigation, and the quality of the observations is highly irregular and varies with the experience of the driller. Given the strong contrast in soil properties between the upper aquifer and two tills, it was possible to identify those three units with a reasonable degree of confidence in most well logs.

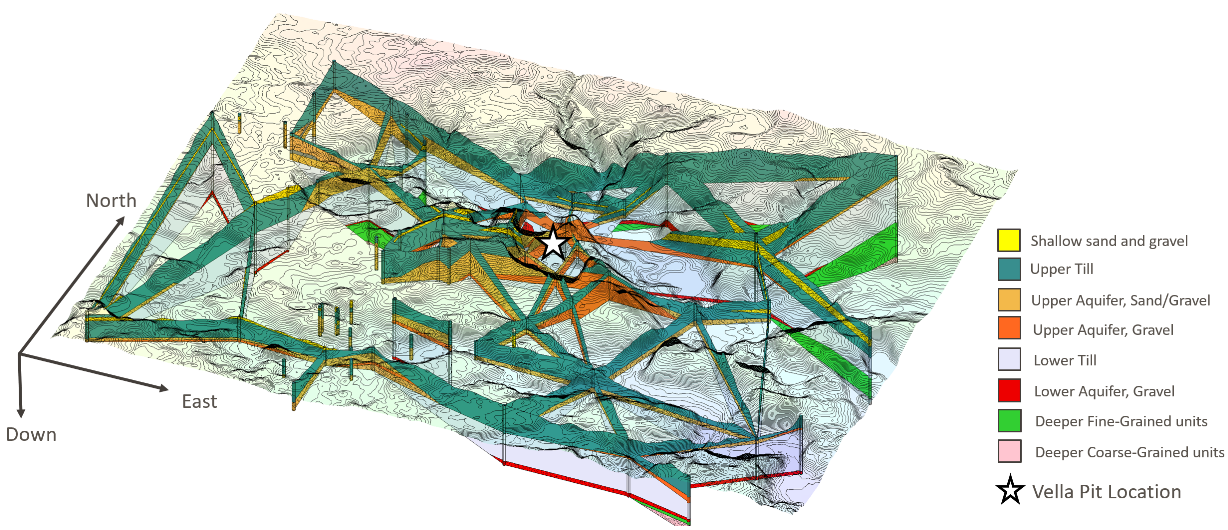

Figure 4. Intersecting cross sections defining model framework (three-dimensional perspective view with transparent DEM surface from Figure 3 for reference).

These cross sections and the DEM were used to generate three solid "geobody" representations of the upper aquifer and two tills (Figure 5, 6):

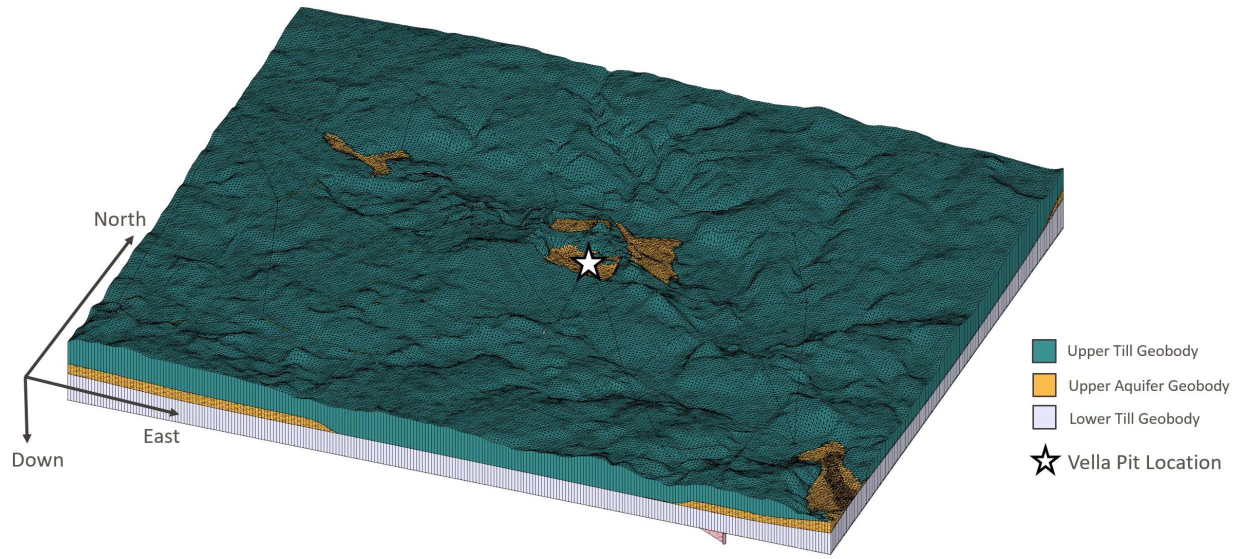

Figure 5. 3D Geobodies representing the upper aquifer and encapsulating tills.

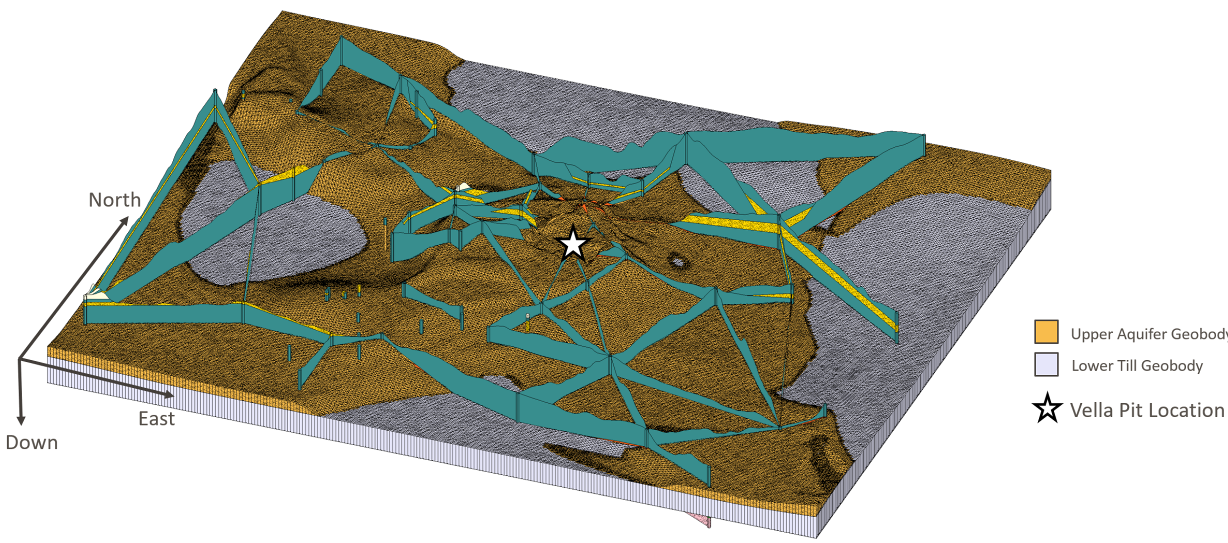

Figure 6. 3D Geobodies representing the upper aquifer and lower till with the upper till removed for visibility.

Figure 6 reflects our current understanding of the geometry of the upper aquifer, which appears to be highly irregular with stratigraphic pinch-outs in all four cardinal directions from Vella Pit. Additional public drinking water well logs examined outside of the model domain indicate that the upper aquifer may extend further to the northwest and southwest. Note in Figure 6 that the upper aquifer is not the only coarse-grained strata embedded in the upper till. Several shallower, small discontinuous sand bodies are also observed. However, these are situated fully above the water table and not a source of groundwater. These unsaturated coarse-grained sediments are not included in the numerical flow model.

To simulate the flow of groundwater in the upper aquifer, the three geobodies shown in Figures 5 and 6 were converted into an unstructured grid with a uniform 50-foot horizontal resolution for use with the

MODFLOW-USG code (Panday et al., 2013). Among other advantages, MODFLOW-USG is numerically stable when recharge must pass through unsaturated cells and allows for discontinuous strata to be simulated more accurately and efficiently than is possible with traditional MODFLOW finite difference grids. The model is initiated with one steady-state stress period (representing pre-development conditions) followed by 12 transient stress periods representing the four years following the initiation of dewatering at Vella Pit (assumed to be April 2022). USGS mapped streams, ditches and wetlands are assumed to be gaining and are modeled with DRN boundary conditions with stage set at the DEM elevation and a high conductance (100 ft^2/day/ft; low impedance to discharge). The main excavation at Vella Pit is represented as a DRN boundary condition with a time-dependent stage and extremely high conductance (10,000 ft^2/day/ft; effectively no impedance to discharge). Massey Lake and other small unnamed ponds are modeled as RIV boundary conditions with stage estimated from the DEM, or in the case of the two settling ponds at Vella Pit, based on surveyed elevations. Conductance of the ponds is treated as a calibration parameter. Note from Figure 3 that the northwest corner of the model sits approximately 200 feet higher than the wetlands in the southeast. To achieve a reasonable solution, it was necessary to add a CHD boundary condition with a head of 900 feet to 8 upper aquifer grid cells at the highest point of the northwest corner of the model domain. This represents a small influx of water from the portion of the upper aquifer that extends out of the model domain to the northwest.

Given the lack of historical data, current monitoring wells, or any domestic wells with surveyed well head reference elevations, the calibration process was preliminary but systematic. First, recharge, hydraulic conductivity and the aforementioned boundary conditions were varied systematically until the initial steady-state solution resembled observed conditions prior to dewatering at Vella Pit. Recharge was varied until the only occurrence of flooded grid cells corresponded to delineated wetlands and the pre-dewatering elevation of the main excavation at Vella Pit (890 feet ASL). The transient model was then run with a rapid lowering of the stage of the main excavation at Vella Pit (from 890 to 858.6 feet ASL) followed by a four-year equilibration period. Storage coefficients were then varied until the modeled head in the aquifer matched as many observations as possible. At the present time, the only observations available to be used in calibration are data points available from recent well driller and service records. Note, again, that domestic water wells are not designed to be used as observation wells and many details of the well construction (type of pump, how the riser pipe is attached to the pitless adapter, etc.) add uncertainty in addition to the lack of surveyed elevations when converting these depths to groundwater head in the aquifer. We estimate that this uncertainty is on the order of ±2 feet. To the extent reasonably possible, this exercise was repeated iteratively until the model reproduced the majority of observations from 2023 (e.g., the date on which particular wells went dry and corresponding water level).

The best-fit model material properties determined by this methodology are summarized in Table 1:

Material	Kh (feet/day)	Kv (feet/day)	Ss (1/feet)	Sy (dimensionless)
Upper Till	0.01	0.001	0.00001	0.01
Upper Aquifer	120	120	0.00001	0.25
Lower Till	0.001	0.0001	0.0001	0.05

Table 1. Preliminary best-fit material properties. Kh is horizontal hydraulic conductivity; Kv is vertical hydraulic conductivity, Ss is specific storage and Sy is specific yield.

MODFLOW uses the specific storage term where the aquifer is fully confined; specific yield applies in unconfined areas such as the Vella Pit property where the overlying clay has been removed. Assigning a

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single hydraulic conductivity to each stratigraphic unit is appropriate for this stage of the assessment. In reality, hydraulic conductivity will vary with changes in geology, but due to the sparsity of constraining data it is not possible to apply spatial variability at this time. These values instead reflect an average or typical value for the upper aquifer. The corresponding recharge rates for these properties are 0.04 inches/year in topographic highs underlain by the upper till; 0.9 inches/year in topographic lows underlain by the upper till and 12 inches/year in areas where the upper aquifer is exposed at ground surface. Recharge in the pre-excavation Vella Pit is estimated at approximately 600 inches/year in a very small area where upper aquifer gravels were exposed by previous mining activities then flooded by a pit lake. Another important fitting parameter is the conductance of the two settling ponds at Vella Pit. The initial groundwater level in areas immediately adjacent to Vella Pit was sensitive to small changes in this value. The best fit was found with a conductance of 0.05 ft^2/day/ft. Modeled potentiometric surfaces for the upper aquifer are shown in Figure 7-9:

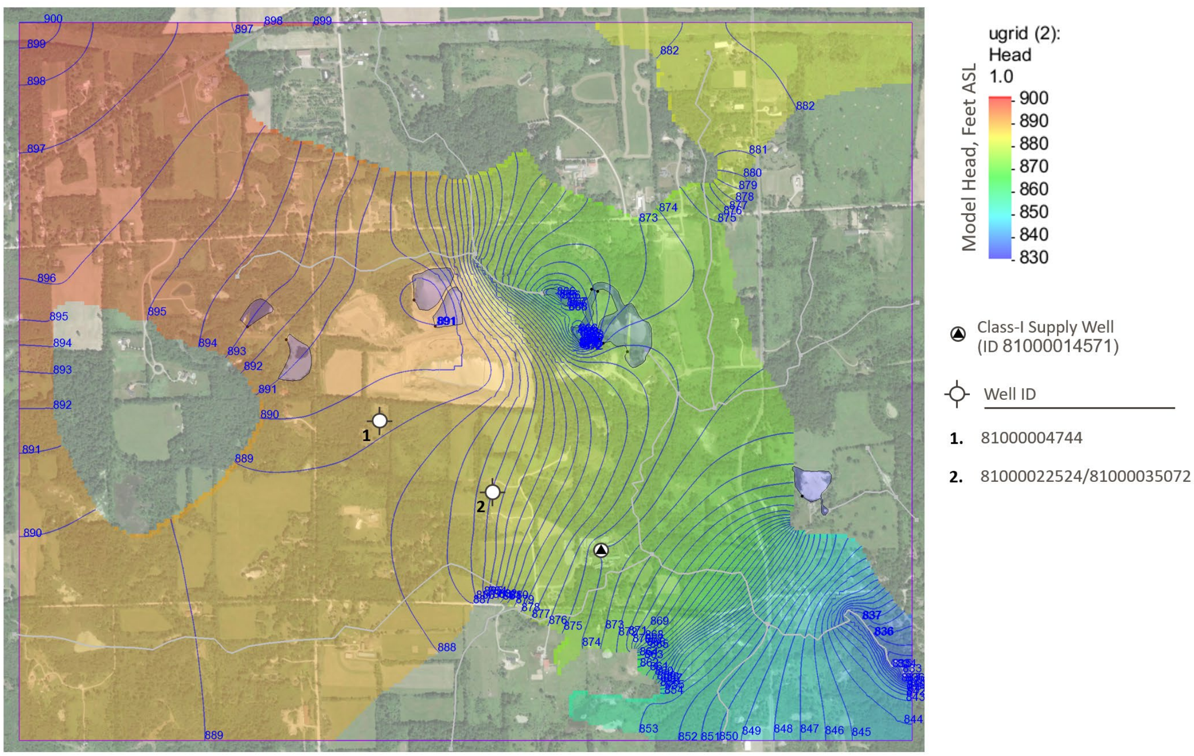

Figure 7. Modeled potentiometric surface, initial condition (steady state solution, stress period 1)

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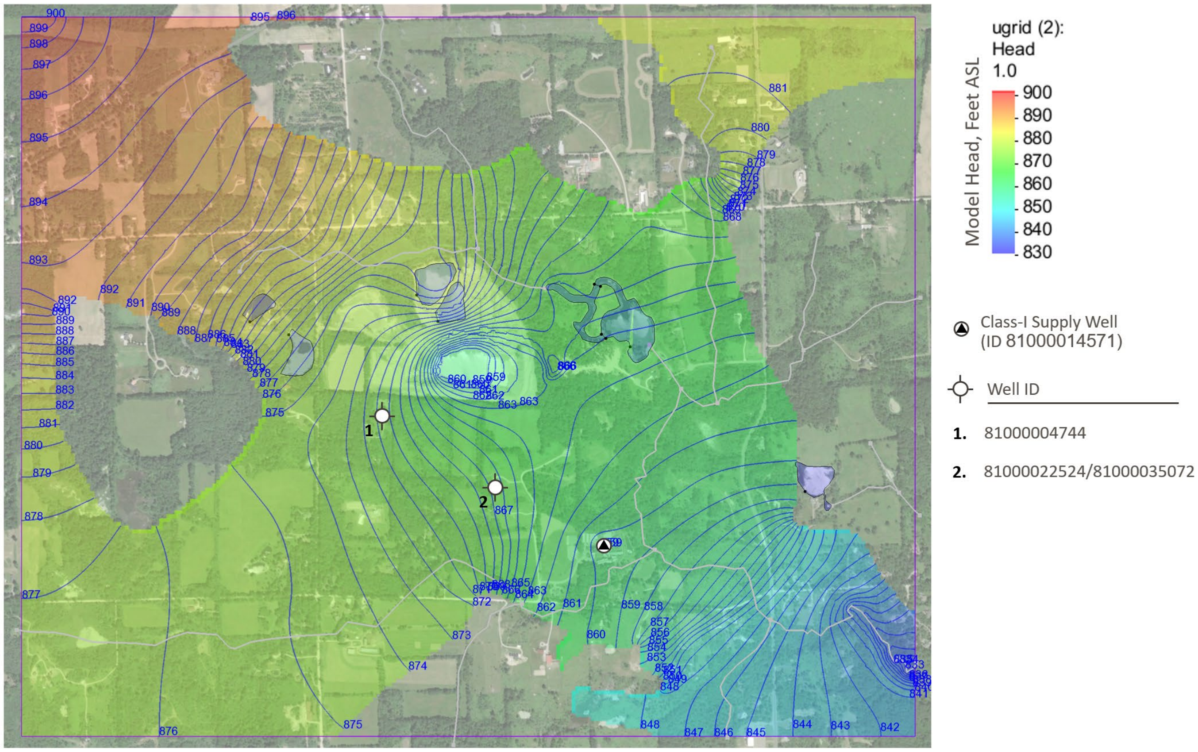

Figure 8. Modeled potentiometric surface, 1 year after start of dewatering.

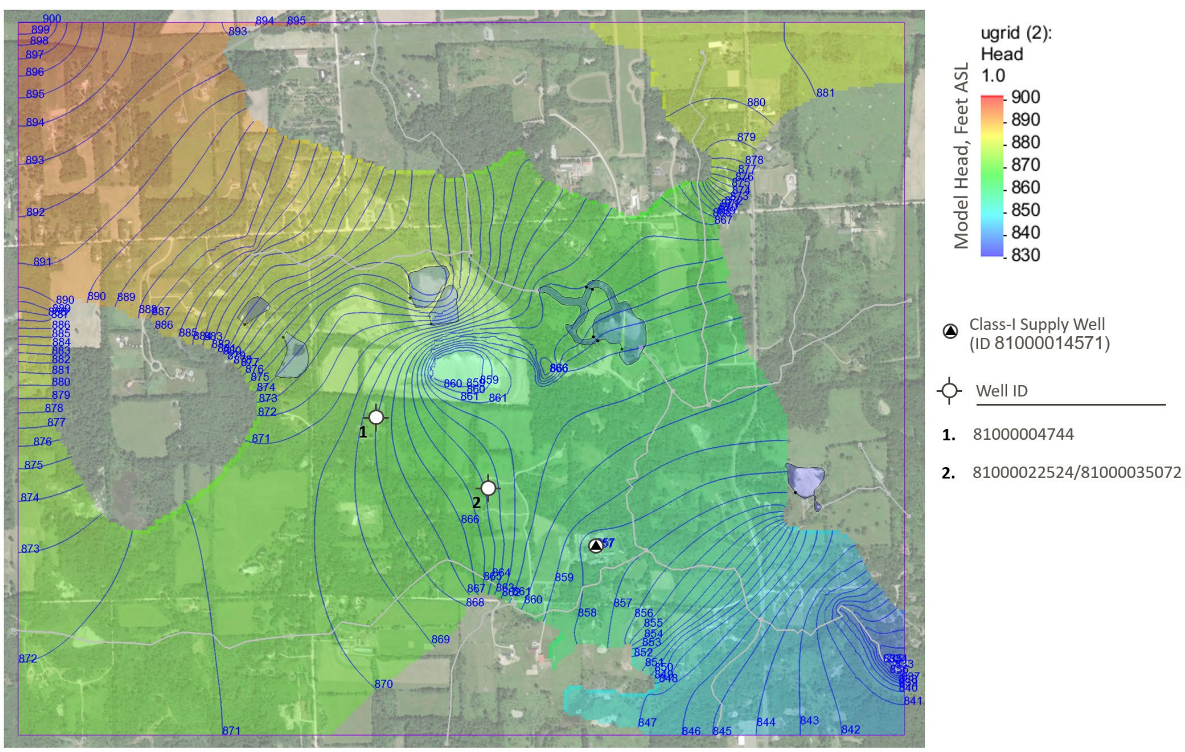

Figure 9. Modeled potentiometric surface, 2 years after start of dewatering.

Note that the single Class-I public supply well in the model area (Well ID 81000014571) is included as a 50 gallons per minute (GPM) pumping stress in the upper aquifer. The log for this well indicates that it was originally tested at 150 GPM, and we are aware that it continues to supply up to several hundred residents of a facility at 4597 Warren Road but are not aware of any record of how much water is actually used.

NEXT STEPS

Findings and conclusions related to the hydrogeological investigation will be provided in the final investigation report after collection and inclusion of the additional data from the in-progress Site investigation.

REFERENCES

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