Appendix 3

General Hydrogeological Review for a Planned Sand and Gravel Extraction

Waterloo Township Jackson County, Michigan

Prepared for:
Aggregate Industries - Central Region Kalamazoo, Michigan

June 2008
Project No. G06088C

fTC&h
Fishbeck, Thompson, Carr & Huber
engineers • scientists • architects • constructors

GENERAL HYDROGEOLOGICAL REVIEW

FOR A PLANNED

SAND AND GRAVEL EXTRACTION

WATERLOO TOWNSHIP

JACKSON COUNTY, MICHIGAN

PREPARED FOR:
AGGREGATE INDUSTRIES – CENTRAL REGION
KALAMAZOO, MICHIGAN

JUNE 2008
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LIST OF ABBREVIATIONS/ACRONYMS

amsl above mean sea level
ASTI Applied Science and Technology, Incorporated
bgs below ground surface
ft/day foot or feet per day
ft^2 square feet
ft^2/day square feet per day
ft^3/day cubic feet per day
ft/ft foot per foot or feet per feet
FTC&H Fishbeck, Thompson, Carr & Huber, Inc.
gpd gallons per day
gpd/ft gallons per day per foot
gpd/ft^2 gallons per day per square foot
gpm gallons per minute
gpm/ft gallons per minute per foot
in/day inch or inches per day
in/year inch or inches per year
ft/ft foot per foot or feet per feet
MDEQ Michigan Department of Environmental Quality
MSU Michigan State University
NWI Nation al Wetlands Inventory
USGS U. S. Geological Survey
yd^3 cubic yards

EXECUTIVE SUMMARY

Aggregate Industries – Central Region (Aggregate Industries), Kalamazoo, Michigan, is requesting a Special Use Permit to extract sand and gravel from the Dault Site (subject property) located in Section 12, Waterloo Township (T2S, R2E), Jackson County, Michigan. The subject property is adjacent to an active gravel mine operated by Aggregate Industries. The proposed excavation will extend existing mining operations onto the 20-acre subject property. The proposed limit of mining (resource area) at the subject property encompasses approximately 14.2 acres. Aggregate Industries anticipates mining 1,330,000 gross tons of reserves (887,000 yd^3) at the subject property. Initial plans estimate mining approximately 800,000 tons dry and 530,000 tons wet (below the water table).

The proposed excavation site is situated in a gravel-and-sand aquifer found in a headwater area of the upper Grand River Drainage. Review of available data indicate the aquifer at the subject property is unconfined, with a saturated interval estimated to be between 20 to 45 feet thick. Mining below the water table will ultimately result in the creation of a pond/lake covering an area of approximately 4 acres. The maximum water depths are anticipated to range between 30 to 35 feet.

No mining will occur in the existing wetland found adjacent to the subject property. No aggregate processing will occur on the subject property. All process operations will occur offsite and within the adjacent Chelsea Plant facility. No water will be withdrawn from the created water body at the Dault Site. Wash water used in processing will be taken from ponds located within the existing Chelsea Plant area.

The proposed mining operations and development of a 4-acre pond can alter the local hydrology by changing recharge conditions, increasing evaporative loss by increasing the amount of exposed surface water, and changing groundwater levels as the pond equilibrates with the groundwater surface. The information provided in this report substantiates that there should be no detrimental effect on local hydrological features, including local wells, wetlands, lakes, or streams as a result of these site alterations.

Water levels do change in the subject property's area (rise downgradient and decrease upgradient of the proposed pond). The most sensitive surface waters are the wetland areas located east (upgradient) and north (side or downgradient) and Pond Lily Lake located downgradient of the Dault Site. In the downgradient areas, water levels will increase slightly. Minor water level increases in these areas are likely to be beneficial to the surface water bodies.

INTRODUCTION

Aggregate Industries of Kalamazoo, Michigan, is requesting a Special Use Permit to extract sand and gravel from their property located in Section 12, Waterloo Township (T2N, R2E), Jackson County, Michigan (subject property). This subject property is referred to as the Dault property (subject property, a.k.a., Dault Site). Figure 1 shows the location of the subject property.

The Dault Site is adjacent to the southwestern boundary of Aggregate Industries' existing gravel mine, the Chelsea Plant. Aggregate Industries proposes to extend its existing mining operations into gravel-and-sand surface sediments located on the subject property. An aerial photograph of the subject property, with property boundaries and the proposed Dault Site mine-expansion area is provided as Figure 2. The proposed mine expansion area forms the proposed "limit of mining" at the Dault Site, encompassing approximately 14.2 acres. Mining below the water table will ultimately result in development of a 4-acre pond.

FTC&H was retained by Aggregate Industries to provide a general assessment of the existing conditions and general hydrogeological character of the subject property and adjacent areas. This assessment is based on a review of publicly available information, plus soil boring and water level data gathered by Aggregate Industries. The purpose of this investigation is to evaluate the potential impacts of aggregate excavation at the subject property on the area's hydrologic and hydrogeologic environment.

SITE LOCATION

The subject property encompasses approximately 20 acres located north of Harvey Road and west of the Loveland Road/Harvey Road intersection in Section 12, Waterloo Township (T2N, R2E), Jackson County, Michigan. A legal description for the subject property is provided as Appendix 1.

SITE PLAN

A site plan map showing existing conditions and a conceptual excavation plan for the subject property is provided as Figure 3. Aggregate Industries proposes to access and excavate the resource area from the adjoining existing mine property. Mining on the subject property will only occur in the resource area. Sloping and grading will be completed down from the property lines (or the setback area) to the estimated bottom of excavation at a 1 on 3 slope. As shown, the anticipated bottom elevation for excavation is approximately 990 feet amsl. Mining below the water table is anticipated below 988 feet amsl.

No mining will occur in the existing wetland located on either Aggregate Industries property or on the most eastward northeastern corner of the subject property. Grading and berming along the north and eastern boundary areas that border the existing wetland will be constructed to provide separation from the existing wetland. Silt fencing and erosion control measures will be implemented to prevent any adverse impact to the wetland area by surface runoff or soil erosion. Surface drainage will be inward, toward the excavation.

No aggregate processing will occur on the subject property. All process operations will occur within the existing Chelsea Plant facility. No water will be withdrawn from the proposed created pond/lake at the Dault Site. Any wash water used in processing at the Chelsea Plant will be taken from ponds located off the subject property and within the current active mine area.

UNDERSTANDING OF PROPOSED MINING PLAN

The proposed excavation area (resource area) encompasses approximately 14.2 acres. Aggregate Industries proposes to begin mining near the easternmost property boundary of the subject property. Excavation and dredging will expand generally westward from the adjacent existing mine property. Aggregate Industries anticipates mining 1,330,000 gross tons of reserves (887,000 yd^3) at the subject property. Initial plans estimate mining approximately 800,000 tons dry and 530,000 tons wet (below the water table).

Aggregate Industries proposes to excavate sand and gravel using bulldozers, wheel loaders, and dragline cranes. A dragline will be used for mining saturated soils below the water table elevation. Saturated soils and aggregate materials will be side-cast and stockpiled for gravity drainage along the edges of the excavation area; then the materials will be moved to a processing area, where they will be processed and sorted by material type for sale. The processed aggregate material is stockpiled, awaiting loading and removal by semi-truck.

MINING BELOW THE WATER TABLE

FTC&H anticipates that groundwater will be encountered between approximately 988 to 982 feet amsl within the proposed Dault property excavation area. Mining below the water table will result in the formation of a surface water body (pond/lake) of approximately 4 acres. Figure 4 shows the area of proposed lake development. Maximum water depths are anticipated to range between 30 to 35 feet.

HYDROGEOLOGICAL REVIEW

DATA SOURCES

PUBLICLY AVAILABLE DATA

Public sources of information included, but were not limited to, geologic and topographic maps, federal and state government publications, information from the MDEQ (including water well and pump records), the USGS, U.S. Fish and Wildlife Service, U.S. Soil Conservation Service, Center for Geographic Information (http://www.michigan.gov/cgi), MSU Climatology Program (http://climate.geo.msu.edu/sw-lower.html and http://climate.geo. msu.edu/), plus information collected from Jackson County records.

The MDEQ water well records used for this analysis were valuable in assessing the local hydrogeological conditions. There are numerous water well records available for the area surrounding the subject property. Residential well logs and a map showing the locations of the available water well records for Sections 12 and 13, as entered into the MDEQ mapping systems, are provided in Appendix 2.

SITE-SPECIFIC DATA

Aggregate Industries drilled 27 soil borings at the Dault properties using auger drilling techniques. Six of the 27 borings were advanced at the Dault property located north of Harvey Road (the subject property). Information from all 27 borings was used by Aggregate Industries to evaluate the character of the aggregate deposit at the Dault properties located south and north of Harvey Road. Soil boring data on the north property was used to assess the potential resource area at the subject property. A boring location map, soil sample descriptions, and other data were provided to FTC&H for this review. Figure 5 shows the locations of the Aggregate Industries soil borings at the subject property. The boring records are provided in Appendix 3.

PREVIOUS REPORTS, SITE BORINGS, AND WELL INFORMATION

Five borings/monitoring wells were installed at Aggregate Industries' existing Chelsea Plant by Applied Science and Technology, Incorporated (ASTI) during August 2002. Details of the boring and well installations are reported in the ASTI *Hydrogeologic Investigation Report to Aggregate Industries, Waterloo Township, Michigan,* dated September 25, 2002. Figure 5 shows the locations of monitoring well Nos. 1 through 5 (MW-1 through MW-5). MW-1 was abandoned on November 2, 2006. Logs of the ASTI-installed borings/monitoring wells are provided in Appendix 4.

In response to concerns expressed by members and attendees of the December 29, 2003, meeting of the Waterloo Township Planning Commission, Aggregate Industries commissioned ASTI for a study of the potential effects of mining at the Chelsea Plant property on Pond Lily Lake and other nearby surface water bodies. Results of the study are reported in the ASTI document entitled, *Supplemental Hydrogeological Investigation, Aggregate Industries – Chelsea Plant, in Relation to Pond Lily Lake and Other Waters, Waterloo Township, Jackson County, Michigan,* dated December 16, 2004. The ASTI 2004 report concluded that plant operations had not affected the surface water levels of Pond Lily Lake or other nearby surface water bodies.

Aggregate Industries subsequently installed five borings in the area north of Green Road and four borings on the adjacent Department of Natural Resources property during March 2004. These collective data were used by FTC&H for a hydrogeological study (June 2006 report *Hydrogeological Evaluation Inland Lake Development*) for Aggregate Industries' MDEQ Part 301 Permit Application (Inland Lakes and Streams) to create a lake of approximately 19 acres in Section 1 of Waterloo Township. In response to the MDEQ's query regarding water elevations at Pond Lily Lake, FTC&H developed a basic groundwater flow model using the USGS code MODFLOW and the pre/post processor GroundwaterVistas (Version 4.16). The MDEQ issued a Part 301 Permit No. 06-38-0043-P for the 19-acre lake on March 13, 2007. At the request of Aggregate Industries, FTC&H began collecting monthly water level data at Pond Lily Lake, Clear Lake, the created lake at the north plant, and the Chelsea Plant monitoring wells beginning August 2007. These historic water level data are provided as Table 1.

FINDINGS

TOPOGRAPHY

A copy of the USGS topographic map (Grass Lake and Chelsea, Michigan 7.5-Minute Quadrangles, 1973) showing the subject property and surrounding area is provided as Figure 6. A review of Figure 6 shows the subject property consists of an upland area with gently undulating, low-relief farmland. Elevation at the subject property ranges from approximately 1,045 feet amsl in the southwestern quarter of the subject property to approximately 983 feet amsl in the wetland area located in the northeast corner of the subject property.

GROUNDWATER RECHARGE

Groundwater recharge typically refers to the amount of precipitation, either rainfall or snowmelt, that infiltrates through the ground and reaches the water table aquifer. The amount of water from precipitation

that reaches the water table will vary depending on changes in precipitation, geologic factors, the extent of impervious surfaces, and the extent of storm sewers that can intercept and transfer water. The subject property is largely farmland, with sand-rich soils beneath the topsoil. Jackson County receives approximately 31 in/year of precipitation (MSU, Agricultural Weather Office, 30-Year Record, 1971 to 2000, www.agweather.geo.msu.edu). Precipitation data are provided in Appendix 5.

The approach used by the MDEQ to estimate recharge is based on statistical regression of groundwater discharge (base-flow) estimates derived from stream-gauging records. Groundwater discharge is water that leaves an aquifer through boundaries including rivers, wetlands, and lakes. The assumption is made that recharge to the shallow aquifer system is equal to base-flow. This method is appropriate for the shallow aquifer system (typically in the glacial deposits) that delivers most base-flow to streams and provides a long-term (1 to 80 years) average estimate of recharge for moderate areas (up to 500 square miles). Deeper aquifers generally are recharged with water from shallower systems.

A recharge map showing the Dault Site was downloaded from the MDEQ ground water mapping project site. The map shows recharge is 10 to 11 in/year at the subject property (map provided in Appendix 6.).

GEOLOGY

The regional geologic setting consists of outwash plains, moraines, and till plains (Vanlier, 1968). The MDEQ's Glacial Landsystems and Quaternary Geology Map (Appendix 6) shows the subject property falls within an area of proglacial outwash, with adjacent end moraines of coarse-textured tills characterized as ice-contact outwash. Proglacial and ice-contact outwash is deposited by glacial melt water and stagnant glacial ice. Localized till deposits are associated with area ground and end moraine development. These deposits are a mixed assortment of sedimentary, igneous, and metamorphic rocks that are well to poorly sorted, well stratified, and cross bedded in places. The glacial deposits in Jackson County are generally 100 feet thick or less. Bedrock underlying the area is the Mississippian Marshall Sandstone.

Figure 7 shows the locations of three geologic cross sections constructed across the proposed mining site. Cross Sections A-A' and B-B' (Figure 8) and C-C' (Figure 9) include local water wells that were drilled through the glacial sequence and encountered bedrock, plus Aggregate Industries' monitoring wells and soil borings at the subject property. Lithologic information (sand, clay, gravel, etc.) is shown in symbols characterized in the legend on each drawing. Hydrostratigraphic facies (aquifers - sand and gravel; and aquitards - clay and silt-bearing intervals) are shown shaded in yellow and green, respectively. The cross section view shows the area of proposed excavation in cross hatching. A descriptive log for each boring is provided in Appendix 6. While not drilled to the base of the glacial drift,

Aggregate Industries' five site bo rings encountered the primary gravel-bearing intervals targeted for excavation. The most co mplete record of the glacia l stratigraphy near the subj ect property comes from the residential well located at 14900 Harvey Road (Cross Section C-C'). This well encountered bedrock at 123 feet bgs.

A review of Cro ss Sections A-A', B-B', and C-C' and onsite borings show the aggregate deposit at the subject property closely resembles the reserve that is being mined in the southern area of the existing Chelsea Plant (e.g., compare borings 1 though 5 to MW-3, MW-4, and MW-5). The deposit at the subject property is characterized by a dry, gravel-rich zone, generally above the 1,000-foot elevation, and coarse to fine san d below th at, into the wa ter table. Co mparison of the site bo rings and their sediment descriptions show the deposit on the Dault property is coarsest in the northern areas and becomes finer (higher sand and silt content) moving south of Harvey Road. A review of the cross sections indicate 20 to 45 feet of saturated sand and gravel are found above a silty-clay to sandy-silt unit at the Dault property.

HYDROLOGY

WATERSHED

Figure 10 sh ows the wate rshed and subwatershed boundaries in the vicinity of the subje ct property as mapped by the MDEQ. T he Dault p roperty is loca ted within the upper rea ches of the Grand Rive r Watershed. A small portion of the Chelsea Plant's eastern margin lies within the Huron River Watershed.

SURFACE WATER BODIES

No streams or lakes are present on the subject property. A minor portion of the wetland associated with Pond Lily Lake is present on the most northeastern corner of the subject property.

Surface water bodies on lands surrounding the subject property include Pond Lily La ke, Notten Lake, Lehman Lake, and Clear Lake. These lakes are located within the upper Grand River Watershed. Pond Lily Lake is locate d approximately 600 feet west of the su bject property. Clear L ake is lo cated approximately 5,800 feet northwest of the subject property.

Crooked Lake and Cavanaugh Lake lie east of the subject property and the Chelsea Plant. Both lakes are within the Huron River Watershed.

SURFACE DRAINAGE

Surface drainage follows the general slope of the surface topography. Land surface at the subject property generally slopes toward the existing wetland found along the eastern and northern portions of the subject property.

WETLANDS

Wetlands are common surface water features in southwest Michigan. Wetlands in the area of the subject property that are identified in the NWI database are shown on Figure 11.

Onsite Wetlands

Wetlands associated with Pond Lily Lake lie immediately north and northeast of the Dault property. A small portion of this wetland complex is located on the easternmost northeast corner of the subject property. The NWI database characterizes the wetlands associated with Pond Lily Lake as emergent.

Offsite Wetlands

Wetlands in the vicinity of the subject property include those associated with the Pond Lily Lake. Pond Lily Lake is found west of the Dault property. Portions of the wetlands associated with Pond Lily Lake extend onto Aggregate Industries' Chelsea Plant property and just north of the subject property. Pond Lily Lake's elevation is reported at 985 feet amsl, based on the USGS, Grass Lake, Michigan, 7.5-minute Quadrangle, dated 1973. As previously noted, FTC&H began collecting water level data at Pond Lily Lake in October 2006 at the request of Aggregate Industries (Table 1).

Wetland areas associated with other area lakes, such as Clear Lake, Notten Lake, and Lehman Lake, are present in the region. Wetlands in the area of the subject property that are identified in the NWI are shown on Figure 11.

GROUNDWATER

HYDROSTRATIGRAPHY

A review of Aggregate Industries' site borings and residential water well logs within one mile of the subject property suggests multiple aquifers are present in the shallow subsurface of the subject property area, including both glacial and bedrock aquifers.

The interpretations shown on Cross Sections A-A', B-B', and C-C' show a water table aquifer is present within the proposed excavation area. Confined and/or semi-confined aquifer units are locally present in areas marginal to the excavation site at the subject property.

A review of the cross sections and area well logs and boring data suggests the proposed lake at the Dault Site and the adjacent Pond Lily Lake and wetland are in hydraulic communication with the local water table. Consequently, the surface elevations of these collective water bodies can be considered to be a surface expression of the local water table.

Aquifer Properties

Review of available data indicates the sand-and-gravel aquifer at the subject property is unconfined. Correlations shown on Cross Sections A-A', B-B', and C-C' indicate a saturated interval estimated between 20 to 45 feet thick.

While no aquifer tests were conducted at the subject property, single well aquifer tests (slug tests) were performed on the monitoring wells installed in the adjacent active mine area (ASTI, August 2002). ASTI's slug test results for MW-1, MW-2, and MW-5 were reanalyzed by FTC&H using the Bower and Rice method for unconfined aquifers. Results show a hydraulic conductivity value of 93 ft/day, 29 ft/day, and 122 ft/day, respectively for MW-1, MW-2 and MW-5.

To further assess area aquifer properties, FTC&H utilized local residential well data to estimate ranges in aquifer transmissivity and hydraulic conductivity. The specific capacity (the pumping rate per foot of drawdown in a well) for several local residential wells was calculated at values ranging from 1.6 gpm/ft to greater than 48 gpm/ft. Based on these values, a range of their transmissivity values were estimated at approximately 2,500 to 72,000 gpd/ft using a method described in Driscoll (1986), where transmissivity is estimated by multiplying the specific capacity by 1,500. Noting that the saturated thickness of the upper aquifer at the subject property ranges from 20 to 45 feet, a mean aquifer thickness of 40 feet was used to calculate hydraulic conductivity (K), using the equation for transmissivity as follows:

$$T = bK \qquad (1)$$

where:

T = Transmissivity

K = Hydraulic conductivity

b = Aquifer thickness

Using this method generally results in calculated K-values ranging from 8 to 241 ft/day as follows:

$$K = T/b = 2{,}500 \text{ gpd/ft} / 40 \text{ feet} = 62.5 \text{ gpd/ft}^2 \times (0.134 \text{ ft/day} / 1 \text{ gpd/ft}^2) = 8.4 \text{ ft/day},$$
$$K = T/b = 72{,}000 \text{ gpd/ft} / 40 \text{ feet} = 1{,}800 \text{ gpd/ft}^2 \times (0.134 \text{ ft/day} / 1 \text{ gpd/ft}^2) = 241.2 \text{ ft/day},$$

The range of values calculated are consistent with K-values reported by Fetter (2001) for the hydraulic conductivity (K) of glacial outwash (3 to 284 ft/day [10^{-3} to 10^{-1} centimeters per second]) with storativity values for unconfined aquifers of 0.02 to 0.3 (unitless).

FTC&H used a value of 150 ft/day in our June 2006 report as the estimated hydraulic conductivity and a storativity of 0.15 (unitless) for the unconfined aquifer at the north plant project site. These values are within the range of accepted values for outwash sediments and unconfined aquifers and were approved by the MDEQ in review and approval of Aggregate Industries' Part 301 Permit No. 06-38-0043-P.

GROUNDWATER ELEVATION AND GROUNDWATER FLOW

Aggregate Industries' Dault Site borings (Cross Sections A-A', B-B', and C-C') encountered saturated soils (groundwater) at 28 to 51 feet bgs. Using the estimated ground elevation at each boring location and its depth to saturated soil, an estimate of the water table elevation at the subject property ranges from 982 to 988 feet amsl.

Water Table Contour and Water Table Depth Maps were downloaded from the MDEQ's Groundwater Mapping Project site and are provided as Figures 12 and 13, respectively. Figure 12 shows groundwater elevation beneath the subject property ranges generally between 990 to 1,000 feet amsl. The MDEQ's Water Table Depth Map (Figure 13) indicates depth to groundwater beneath the subject property ranges from 0 to 45 feet bgs. These data are in general agreement with observed water level data (top of saturated soils) from soil borings at the site.

For comparison, FTC&H constructed water table maps for the local area using the February 2006, January 2008, and May 2008 groundwater and surface water elevation data from Table 1. Water table maps for the February 2006 and January and May 2008 sampling events are provided as Figures 14 through 16, respectively. For the January 2008 map, water level data interpreted from the five Dault Site borings were honored in constructing the water table contours at the subject property. Because the estimated groundwater data at the subject property is somewhat subjective, there is a degree of uncertainty regarding site-specific groundwater flow direction and exact groundwater levels.

Comparison of the MDEQ and FTC&H January 2008 water table maps generally indicate a similar groundwater flow direction at the subject property and Chelsea Plant-Clear Lake area. Both the MDEQ and FTC&H January 2008 water table maps suggest the subject property is generally at the crest of a groundwater divide. Collectively, these groundwater maps show groundwater flow direction in the southern portion of the Chelsea Plant and the subject property is generally westward, toward Pond Lily Lake. In the area north of Pond Lily lake and through the Chelsea Plant, groundwater flow direction is north-northwest (generally toward Aggregate Industries' created lake and Clear Lake).

Background Fluctuations in Water Levels

To assess the potential for background groundwater fluctuations in the area, FTC&H plotted a hydrograph (chart showing changes in groundwater elevation over time) of the historic water level data collected at the Chelsea Plant and presented in Table 1. Review of the hydrograph and Table 1 data (Appendix 9) show that water level elevations in the monitoring wells have oscillated upward and downward through their period of record by 3 feet or more. Lake levels have also fluctuated. These fluctuations reflect natural and other background changes in area water levels.

AREA WATER SUPPLY WELLS

FTC&H reviewed the available well reports for area residential wells in the vicinity of the subject property. Many of the area residential wells are screened in a bedrock aquifer. According to the February 2005 Wellogic database (MDEQ), approximately 12% of the wells in Jackson County are completed in the glacial deposits and 74% in the bedrock units. The main bedrock aquifers are the Saginaw and Marshall aquifers (Vanlier, 1968).

Wells within the glacial drift are completed in both confined and unconfined aquifer units. A map showing the location of available well records, as entered into the MDEQ mapping systems, is provided in Appendix 2. The available well records, including historic well records, for Sections 12 and 13 of Waterloo Township, plus Sections 7 and 18 (Sylvan Township, Washtenaw County), are also provided in Appendix 2.

GROUNDWATER QUALITY

No groundwater quality samples were collected for this assessment, since site operations are not expected to affect groundwater quality. MDEQ maps showing nitrate and arsenic results for the local area are provided in Appendix 6. Water quality in the area of the subject property should be typical of water quality throughout a majority of this region of Jackson County.

The only potential impacts to local ground water could result from accidental loss of fuels used to run mining equipment. Aggregate Industries will implement spill plans and procedures for the subject property, as required by state and federal regulations.

ANALYSIS OF POTENTIAL HYDRAULIC CHANGES

Aggregate Industries plans to mine the upland area at the Dault property located north of Harvey Road. The site plan map (Figure 3) indicates the elevation of the proposed lowest excavation is approximately 950 feet amsl. It is the opinion of FTC&H that the water table will be encountered in the proposed excavation area at elevations between 982 to 988 feet amsl. Mining below the water table will result in development of a surface water body (lake, pond). Based on the 988 feet amsl contour shown of the planned excavation (see Figure 3), FTC&H calculates the area of the surface water body (lake) at approximately four acres. It should be noted that, if the water table is encountered at a lower elevation, the resulting water body would have a smaller footprint. Maximum water depths are anticipated to range between 30 to 35 feet during mining.

The proposed excavation pond development can alter the local hydrology by changing recharge conditions, increasing evaporative loss by increasing the amount of surface water, and changing groundwater levels as the lake equilibrates with the groundwater surface. Each of these processes are discussed below.

RECHARGE RELATED CHANGES

Groundwater recharge rates at the subject property are expected to be high due to the sandy nature of the soils, the lack of storm sewers, and the lack of paved surfaces. Mining is expected to slightly increase the recharge rate, since soil cover and crop vegetation will be removed. An increase in recharge could slightly raise groundwater levels. Any increase in recharge is expected to be minor and not result in any significant changes in groundwater levels.

EVAPORATIVE CHANGES

A water budget analysis was conducted to evaluate the potential impact of the proposed 4-acre lake on the hydrologic conditions in the area. The water budget was calculated in accordance with guidelines developed by the MDEQ's Geological and Land Management Division and is attached as Appendix 7.

Evaporation rates from an open water surface were obtained from the National Weather Service. Since evaporation is relatively minor during the colder months, the rates for May through October were used. For this location, the evaporation rate is approximately 25 inches for the 184 days between May and October, for a rate of approximately 0.136 in/day. Using mass balance equations to express the water budget, the calculated net loss to evaporation becomes 0.03 in/day (0.0346 ft/day). This evaporation rate results in a total evaporation loss of 505 ft^3/day or roughly 2.6 gpm over a proposed 4-acre lake. Using a

hydraulic conductivity of 150 ft/day, an aquifer thickness of 40 feet, a flow-path width of 800 feet (based on the maximum width of the proposed lake oriented perpendicular to groundwater flow direction), and a hydraulic gradient of 0.0025 ft/ft, the groundwater flux through the aquifer that houses the proposed lake is approximately 12,000 ft^3/day or 62 gpm. On this basis, the estimated evaporation loss (2.6 gpm) represents a loss of approximately 4% of total flow through the proposed lake area. These collective values are small and thought to be generally insignificant with regard to impacting the local system.

Further, with groundwater flow through the lake calculated to be approximately 62 gpm, based on a 4-acre lake size, turnover of the lake volume will occur in approximately 1.54 years. This rapid turnover will prevent problems associated with stagnation, which generally occur with a turnover time greater than ten years.

THEIS ANALYSIS

The effect of the net evaporative loss on the water table in the vicinity of the subject property can be calculated using a steady-state drawdown model available from the MDEQ. The calculation is performed (modeled) using an excel spreadsheet that computes drawdown at different distances from a pumping well based on the Theis method (1935). The model assumes one-dimensional steady-state flow, with no lateral boundaries or vertical leakage. Model inputs include a pumping rate, time value for the calculations based on the MDEQ water budget guidance document, plus transmissivity and storativity values characterized from the site's aquifer parameters.

In this case, the rate of evaporation loss (2.6 gpm) is assumed as an equivalent pumping well that is located at the center of the proposed lake. The calculation determines the drawdown at various distances from this pumping center. For this calculation, the inputs include a transmissivity (hydraulic conductivity times aquifer thickness) of 6,000 ft^2/day, an unconfined aquifer storativity of 0.15, and a pumping duration of 184 days for the period from May through October. A spreadsheet showing drawdown versus distance from the center of the lake is included in Appendix 8.

A review of the results shows the calculated drawdown, at a distance of 250 feet, 500 feet, and 1,000 feet from the center of the proposed excavation and lake, is 0.45 inch, 0.34 inch, and 0.23 inch, respectively.

EQUILIBRIUM CHANGES

Lake surfaces are level. As such, when superimposed on a sloping water table surface, the groundwater surface needs to equilibrate to the flat surface. This process results in decreased water levels upgradient of the lake and increased water levels downgradient of the lake. Water levels sidegradient to the lake should experience minor, if any, water level changes. The amount of equilibrium adjustment can be

estimated by examination of the water table slope (hydraulic gradient) across the lake. Water table maps constructed using the historic water level data (Table 1) show a possible range of hydraulic gradients from 0.0004 to 0.006.

Using a distance of 400 feet across the pond and a 0.006 ft/ft hydraulic gradient across the water body results in an approximate 2.4-foot change across that distance. This results in an equilibrium change in groundwater levels on the upgradient end of the lake declining by approximately 1.2 feet and a similar increase on the downgradient side of the proposed lake. Bearing in mind that the subject property is thought to be near the crest of a groundwater divide suggests that anticipated hydraulic gradient could be generally less than slope calculations from flanking positions along the water table. Further, the steeper 0.006 slope is thought unrealistic since the estimated water table elevation map from which it is based is taken from the onsite boring data. These data render this portion of the water table map more subjective because the water table depths are not based on site-specific water levels, and the ground elevation for each boring location was estimated from a topographic map. However, while site-specific data were unavailable for determining a more precise estimate of the equilibrium change at the subject property, the above values do represent a reasonable estimation for the anticipated maximum equilibrium change.

Because there is some uncertainty regarding site-specific water levels, a reasonable assumption may be that the proposed lake could equilibrate at an elevation approximately 2 feet higher than Pond Lily Lake. In this case, the hydraulic gradient from the Dault property to Pond Lily Lake becomes approximately 0.0025 ft/ft. Using the hydraulic gradient of 0.0025, results in an 0.5-foot equilibrium change in groundwater levels on the upgradient (east) and downgradient (west) sides of the proposed lake.

Noting that the greatest water level changes will occur in the immediate vicinity of the lake and will become less as you move away from the lake, these changes are considered minor relative to observed fluctuations in water levels recorded in the historic water level data.

WATER QUALITY CHANGES

Groundwater exposed by pond creation could temporarily have an increased level of suspended sediment and increased temperature. Water in the created ponds will infiltrate back into the groundwater system and is expected to quickly re-equilibrate to ambient groundwater quality and temperature. Other water quality changes will be minor.

PONTENTIAL IMPACTS TO HYDROLOGIC FEATUES

IMPACT TO ONSITE WATER BODIES

As noted, a small portion of the wetland associated with Pond Lily Lake is present at the northeastern corner of the subject property. This is approximately 300 feet from the hypothetical pumping center of the proposed pond in the excavation area. Results of the Theis Analysis indicate a 0.42-inch evaporative drawdown as a consequence to developing the 4-acre lake within the proposed excavation area. This calculated drawdown effect is negligible and unlikely to impact the wetland.

The wetland at the property could experience minor changes in water levels related to equilibrium adjustments. The calculations above suggest that equilibrium adjustments could range from 0.5 to 1.2 feet (lowering or rise) at the most upgradient and downgradient shores of the proposed pond. Noting that the greatest water level changes will occur in the immediate vicinity of the upgradient and downgradient lake margin, and will become less as you move away from the lake, these changes are considered minor relative to observed fluctuations in water levels recorded in the historic water level data. These changes due to equilibrium adjustment are expected to result in no adverse impact to the wetland.

IMPACT TO LOCAL WELLS

The nearest residential well is located 700 feet or more from the center of the proposed water body. Results of the Theis Analysis indicate a 0.28-inch drawdown at 700 feet due to evaporative change. This calculated drawdown effect is negligible when considering the available drawdown at this and other residential wells.

The wells closest to the proposed excavation are within the area immediately adjacent to the western boundary area of the subject property. Wells completed in the unconfined aquifer that are located in this area could experience minor changes in water levels related to equilibrium adjustments. Because of the distance to the area wells and the location of these wells generally being downgradient of the proposed pond, any changes in water levels due to equilibrium changes in the groundwater are expected to be undetectable compared to the natural groundwater fluctuations and negligible when considering the available drawdown. FTC&H anticipates that there will be no adverse impact to the wells.

IMPACT TO OFFSITE WATER BODIES

Given the diminutive level of potential drawdown at distances beyond the boundaries of the Dault Site that would result from evaporative or equilibrium changes, no impacts to water levels in offsite wetlands and surface water bodies are expected.

IMPACT TO SURFACE RUNOFF

Site topographic changes will change the character of the landscape and could slightly alter surface runoff at the subject property. Surface elevations will generally be lower and surface runoff will generally be directed inward and constrained to areas within the excavation site. Such volume changes to runoff are expected to be minor and not detrimental to area surface water features.

IMPACT TO GROUNDWATER RECHARGE

Mining operations at the Dault Site have the potential to slightly change (increase) groundwater recharge conditions at the subject property. Such recharge changes are expected to be minor and not result in a negative impact on the local groundwater system, including local wells, or change the interaction of groundwater with surface waters.

CONCLUSIONS

The proposed mining operations and development of a 4-acre pond can alter the local hydrology by changing recharge conditions, increasing evaporative loss by increasing the amount of exposed surface water, and changing groundwater levels as the pond equilibrates with the groundwater surface. The information provided in this report substantiates that there should be no detrimental effect on hydrological features, including local wells, wetlands, lakes, or streams as a result of these site alterations.

Water levels do change in the subject property's area (rise downgradient and decrease upgradient of the proposed pond). The most sensitive surface waters are the wetland areas located east (upgradient) and north (side or downgradient) of the subject property and of Pond Lily Lake, which is located downgradient of the Dault Site. In the downgradient areas, water levels will slightly increase. Minor water level increases in these areas are likely to be beneficial to the surface water bodies.