3.0 SITE GEOLOGY AND HYDROGEOLOGY

3.1 SITE GEOLOGY

The geologic conditions at the AI Chelsea Plant and vicinity have previously been investigated during more than four phases of hydrogeolgic investigation (see Section 1.2, above). During the preparation of this hydrogeological report addendum, AI drilled and sampled fourteen additional soil borings. The locations of the additional sol borings are illustrated on Figure 2, and the boring logs documenting the hydrogeological observations from each new soil boring are presented in Appendix 4.

The geologic deposits in the vicinity of the Chelsea Plant consist of outwash plains, moraines, and till plains (Vanlier, 1968). The MDEQ's Glacial Land Systems and Quaternary Geology Map (see Appendix 3) shows that 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 the area's ground moraine 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.

Detailed evaluations of the site geology are contained within the previous hydreogological reports presented in Appendices 2 and 3. To illustrate the site topography and geologic conditions beneath the proposed mining operations at the State of Michigan lease area, a new geologic cross-section has been prepared (Figure 6). Figure 2 shows the location of the geologic cross section constructed across the proposed mining site.

Additional geologic cross-sections illustrating the subsurface conditions are contained in Appendix 3. The cross-sections 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 units (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 4. While not drilled to the base of the glacial drift, Aggregate Industries' fourteen site borings encountered the primary gravel-bearing intervals targeted for excavation.

A review of Figure 6, cross sections A-A', B-B', and C-C' (Appendix 3), and onsite borings (Appendix 4) 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. The deposit at the subject property is characterized by a dry, gravel-rich zone and coarse to fine sand below that, into the water table.

3.2 SITE HYDROGEOLOGY

3.2.1 AQUIFER CHARACTERISTICS

The hydrogeologic conditions at the AI Chelsea Plant and in the vicinity have previously been investigated during more than four phases of investigation (see Section 1.2, above). The investigations conducted at the site determined that groundwater is present below and adjacent to the site in a water table (unconfined) aquifer. Additional aquifer zones are present beneath clay rich soil that may represent confined or partially confined water-bearing zone. Regional bedrock aquifers (the Saginaw and Marshall aquifers) are present at a depth greater than 120 feet below ground. At the Chelsea Plant, the elevation of the water table is generally between 977 feet amsl and 981 feet amsl. Pond Lily Lake was evaluated and determined to be hydraulically connected to the adjacent water table aquifer beneath the Chelsea Plant.

Clay-rich soils are present in some intervals in the subsurface that may serve, or partially serve, as a confining layer to separate aquifer zones.

The previous investigations conducted at the site determined that the hydraulic conductivity of the water table aquifer is approximately 150 feet per day, the water table gradient is approximate 0.002 foot per foot, and the porosity of the aquifer is approximately 30%. Based on these values, the groundwater flow velocity at the Chelsea Plant is approximately one foot per day or 365 feet per year to the northwest, toward Clear Lake.

3.2.2 GROUNDWATER LEVELS FLOW DIRECTION

Water levels have been recorded at the AI Chelsea Plant in both groundwater and surface water since August 2002 to determine the groundwater flow direction and the range of variation in the water elevations. Table 1 presents a summary of all water levels measured, and Figure 7 presents the water elevation data graphically to illustrate the range and timing of groundwater and surface water level variations.

The maximum range of water level variations in monitoring wells throughout the monitoring period were MW-2 (3.24 feet), MW-3 (3.92 feet), MW-4 (4.24 feet), and MW-5 (3.65 feet), with the average groundwater elevation range of 3.76 feet.

The maximum range of water level variation in AI's Freshwater Lake was 3.60 feet, which is very consistent with the range of the groundwater level fluctuation (3.76 feet) at the site.

The maximum range of water level variation in Pond Lily Lake was 2.28 feet, slightly less than the range of variation observed in the groundwater at the site and in Freshwater Lake.

The timing of the variations of the water level changes described above show a clear annual cycle. The water levels described above exhibit the lowest water levels after the end of summer and the end of the growing season, while the highest observed water levels occur after the end of winter and near the beginning of the growing season. The observed seasonal cycles are very common for natural groundwater surface-water interactions.

The range of water level variation in Clear Lake, only 1.22 feet, are much less than those observed at, and adjacent to, AI's Chelsea Plant. The limited range of water level fluctuations and the lack of strong seasonal/cyclic water level changes are consistent with the water levels in Clear Lake being largely controlled by the outflow hydraulics of Clear Lake, more so than groundwater level fluctuations. Many of the soil borings at the AI Chelsea Plant identified the presence of clay-rich soil below an elevation of 960 feet amsl, while the surface water elevation of Clear Lake is approximately 966 feet amsl. Clear Lake appears to drain toward the west-northwest through a series of poorly developed wetland drainages that are consistent with low permeability clay-rich soils. Water levels in Clear Lake above an elevation of approximately 966 feet amsl are expected to result in increased surface water or wetland water flow, so that the surface elevation of Clear Lake cannot effectively rise above approximately 966 feet amsl. Water levels in Clear Lake during drought conditions can, however, fall below 966 feet amsl due to lack of rainfall, evaporation, and increased irrigation (lawn sprinkling) by lake area residents.

Figures 8, 9, and 10 illustrate the water levels measured during March 2012, September 2012, and December 2012 to update those submitted in previous hydrogeological reports (see Section 1.2, Appendix 2, and Appendix 3). The groundwater elevations are very consistent with those identified previously. The resulting groundwater flow direction is generally to the northwest, and the groundwater gradients are uniform indicating no significant geologic variations across the study area. Groundwater flow directions near the southern-most end of the Chelsea Plant area are influenced by the proximity to Pond Lily Lake, and groundwater flow adjacent to Pond Lily Lake is expected to discharge into Pond Lily Lake.

3.2.3 WATER BUDGET ANALYSIS

The water budget related to the operation of the Chelsea Plant was previously evaluated as part of the FTC&H 2006 and 2008 hydrogeological evaluations (see Appendices 2 and 3). The analysis presented in Appendix 2 was related to the proposed development of a small inland lake (Freshwater Lake) that would be used to provide source water for the sand and gravel washing operations at the site. The analysis concluded that evaporation from the surface water of the lake would amount to approximately 12.5 gallons per minute during the period of May through October of each year. The very small evaporative losses were determined to have no significant effect to the hydrologic environment in the area. The development of Freshwater Lake was permitted by the MDEQ under MDEQ Inland Lakes and Streams Permit No. 12-38-0010-P. No negative effects have been identified from the development of Freshwater Lake, confirming the 2006 conclusion that no significant effects were expected.

Following methods similar to those used during the 2006 hydrogeological investigation (Appendix 2), a water budget analysis was conducted during 2008 (Appendix 3) to evaluate the planned sand and gravel extraction formerly proposed for the "Dault Property." The analyses concluded that "there should be no detrimental effect on hydrological features including local wells, wetlands, lakes, or streams as a result of the (proposed) site alterations." The proposed lake was never developed.

The present day proposed sand and gravel operations on the land that will be leased from the State of Michigan will be conducted entirely "in the dry." No sand and gravel mining on the land leased from the State of Michigan will be conducted below the water table; therefore, sand and gravel mining will have no adverse impact on the groundwater at the site or in the vicinity of the site. The proposed sand and gravel mining will not adversely impact the water level in Clear Lake or in water wells. It should be noted, however, that the proposed sand and gravel mining on the State of Michigan-owned property will result in tree removal over an area of up to approximately 50 acres. Each mature tree is expected to use between 50 and 200 gallons of water per day during the growing season. The removal of these trees during the mining process will eliminate the transpiration losses of rain water, thus allowing more precipitation to infiltrate and recharge the groundwater. The proposed sand and gravel mining on the State of Michigan owned land is expected to increase the quantity of groundwater that recharges the aquifer and results in groundwater flow towards Clear Lake.