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Introduction
The proposed Marshyhope Surface Mine will be a sand and gravel mining operation in Dorchester County, Maryland. It is located along Marshyhope Creek about two miles upstream of the confluence of Marshyhope Creek with the Nanticoke River.

This report is an assessment of the impact of the mining operation on the ground water. It was prepared by C.C. Johnson & Malhotra, P.C. under contract to Buchart-Horn Associates.

Setting
Physiography
The site is located on the Atlantic Coastal Plain on the Eastern Shore of Maryland. A recent physiographic classification puts the site in the Middle Coastal Plain-Mixed Sediment Texture and Alluvial and Estuarine Valleys (Ator et al, 2005).

Geology
The Atlantic Coastal Plain is underlain by a heterogeneous wedge of unconsolidated and semi-consolidated sediments that overlie the crystalline basement rock. At the site, these sediments are approximately 3900 feet thick (Rasmussen and Slaughter, 1957, plate 10).

The crystalline basement rocks are pre-Cretaceous age rocks similar to those that outcrop in the Maryland Piedmont. The basement rocks are overlain by the Cretaceous age sediments. The formations include the Momouth, Matawan, Magothy, and Potomac Group. The Potomac Group contains the Patapsco, Arundel and Patuxent Formations (Ator et al, 2005; Rasmussen and Slaughter, 1957).

The Cretaceous period sediments are overlain by Tertiary sediments including the Aquia, Nanjamo, Piney Point, Calvert, Choptank, and St Mary’s Formations. The top Tertiary sediments are the Pliocene sands and gravels (Ator et al, 2005; Rasmussen and Slaughter, 1957). These Pliocene sands and gravels are overlain by Quaternary sediments which include the Pleistocene age Beaverdam sand and more recent sediments (Ator et al, 2005; Rasmussen and Slaughter, 1957). The mineral resource at the Marshyhope Sand and Gravel mine is likely to be a Pliocene or Pleistocene age sand and gravel. These formations are often confused in Dorchester County (Rasmussen and Slaughter, 1957). The age of the sediments is not a factor in the groundwater assessment.

The geologic map of Dorchester County uses slightly different names for the mineral resource at the Marshyhope Sand and Gravel mine (Owens and Denny, 1986). The surficial sediment is the Parsonburg Sand. This is a Pleistocene (Upper Wisconsin) age deposit underlain by the Beaverdam Sand and Pennsauken Formations which are Pliocene age deposits. Figure 1 shows a surficial geologic map of the site (Owens and Denny, 1986).

The exploration borehole data from the site shows sand, silty sand, and gravelly sand to the depth of over 70 feet. These data are consistent with the geologic reports. All the geological reports agree that the surficial and near surficial sediments are sands and gravels.
Figure 1
MARSHYHOPE SAND AND GRAVEL MINE SURFACE GEOLOGY

Geologic Map of Dorchester County
Owens and Denny, 1986.
Surface Water
The site is bordered by Marshyhope Creek which is a major tributary of the Nanticoke River. A small tributary to Marshyhope Creek, Thomas Creek, forms the northwestern boundary of the site. The Nanticoke River flows into Chesapeake Bay. Marshyhope Creek and the Nanticoke River are tidal at the site. Flow data are not available.

Ground Water
Groundwater at the site exists at shallow depths beneath the land surface. The elevation of the groundwater will be slightly higher than the elevation of the water in Marshyhope Creek. Since Marshyhope Creek is tidal, the site groundwater will also display tidal fluctuations. The flow of groundwater is towards Marshyhope Creek. One would also expect seasonal fluctuations of the groundwater table in response to precipitation and evapotranspiration. Precipitation events will increase the water table elevation. After precipitation, there would be a slow decline in the water table.

The sands and gravels that are the mineral resource to be extracted are very permeable. An aquifer test of the Pliocene and Pleistocene sediments near Hurlock yielded a transmissivity of 155,000 gallons per day per foot (Rasmussen and Slaughter, 1957).

The groundwater quality in these Pliocene and/or Pleistocene deposits is good with low salinity, dissolved solids, hardness and iron (Rasmussen and Slaughter, 1957).

Proposed Mining Operation
A hydraulic dredge will be used to extract sand and gravel. The floating dredge will pump a slurry of sand and water to a wash plant. Sand will be separated from fines at the wash plant and stockpiled. The sand will be then moved by conveyor to barges moored in Marshyhope Creek.

The dredge floats in the mine pit which is filled with water. There is no dewatering of the mine pit. Because the pit is full of water at all times, relatively steep (1 to 2) side slopes can be maintained with no danger of collapse. The pit will be 75 feet deep. Given the high permeability of the sands and gravels at the site, the water level in the pit will be at the same elevation as the water in Marshyhope Creek. The dredge uses a suspended cutter-head with a submersible pump to excavate sand. The sand is pumped up to the dredge and then through a floating pipeline to the shore where a washing operation separates the sand from finer material. The pumped sand slurry is approximately 13 percent sand (U.S. Army Corps of Engineers, 1983).

The sand washing operation will use substantial amounts of water, 3,000 to 4,000 gpm, but this water will be pumped from the pit, used to separate sand and gravel from the fines, and then returned to the mine pit.

A small amount of water will leave the site in the sand mined and shipped. A preliminary estimate of the mine production rate is 500,000 tons per year. When the sand is stockpiled, its moisture content will be close to saturation, but drainage will rapidly reduce that to field capacity. Depending on the amount of time that the sand is on the stockpile, evaporation will reduce the moisture content from field capacity. If we assume, the sand is shipped at field capacity, about 15 percent for a medium sand, and the
Porosity is 40 percent, then the estimated annual production rate of 500,000 tons per year results in shipping of 28,000 gpd of water.

Before the hydraulic dredge can float in the mine pit, the mine pit must be excavated. The area to be mined will be cleared and grubbed. Mechanical equipment will then be used to excavate down to and approximately six feet into the groundwater table. A small suction dredge would then be used to mine. This small dredge would be used for six months to a year until the pit was large enough to accommodate a larger dredge.

It is anticipated that there will be a shallow well on-site supplying water for employees, equipment washing and other uses. It is also anticipated that there will be a septic tank and leach field on-site. Virtually all of the groundwater pumped by the well will be returned to the groundwater by infiltration, either directly on the ground, or through the leach field.

**Impacts on Groundwater**

The proposed sand and gravel operation will have a small impact on the groundwater system, even though large amounts of water are pumped from the mine pit, almost all of this water is returned to the pit resulting in negligible impact on groundwater quantity.

The monthly premining water balance is shown in the following table. The precipitation in excess of potential evapotranspiration becomes runoff and recharge. This table assumes there is no change in the groundwater table elevation or soil moisture storage each month. The table is based on long-term average values so storage changes are negligible. Precipitation is from climate records (NOAA, 2004). Potential evapotranspiration (ET) is assumed to be equal to reference evapotranspiration for grass which was calculated using the Blaney-Criddle formula (REF-ET, 2001). The runoff and recharge is calculated as precipitation minus potential evapotranspiration unless potential evapotranspiration is greater than precipitation in which case there is no runoff or recharge. During the spring and summer, soil moisture is depleted and actual evapotranspiration is less than potential. This table should not be taken as an accurate depiction of the hydrology at the Marshyhope site; daily and hourly variations in precipitation cause runoff to occur in the spring and summer resulting in more runoff and recharge than shown in this table. The purpose of the table is to provide a baseline to compare the impact of mining on the hydrology.
The total precipitation falling on the 392 acre site is $1.25 \times 10^6$ gpd. Runoff and recharge totals 256,000 gpd and actual estimated evapotranspiration is 998,000 gpd.

The following table shows the estimated water usage at the mine and its impact on the post mining water balance. Positive flows are into the pond (mine pit) or groundwater and negative flows leave the pond or groundwater.

<table>
<thead>
<tr>
<th>Month</th>
<th>Precipitation (in)</th>
<th>Evapotranspiration (in)</th>
<th>Runoff and Recharge (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>3.74</td>
<td>0.93</td>
<td>2.81</td>
</tr>
<tr>
<td>Feb</td>
<td>3.33</td>
<td>1.4</td>
<td>1.93</td>
</tr>
<tr>
<td>Mar</td>
<td>4.07</td>
<td>3.1</td>
<td>0.97</td>
</tr>
<tr>
<td>Apr</td>
<td>3.33</td>
<td>4.8</td>
<td>0</td>
</tr>
<tr>
<td>May</td>
<td>3.52</td>
<td>6.51</td>
<td>0</td>
</tr>
<tr>
<td>June</td>
<td>3.72</td>
<td>5.7</td>
<td>0</td>
</tr>
<tr>
<td>July</td>
<td>3.86</td>
<td>8.06</td>
<td>0</td>
</tr>
<tr>
<td>Aug</td>
<td>4.37</td>
<td>6.82</td>
<td>0</td>
</tr>
<tr>
<td>Sept</td>
<td>3.52</td>
<td>5.1</td>
<td>0</td>
</tr>
<tr>
<td>Oct</td>
<td>3.14</td>
<td>3.72</td>
<td>0</td>
</tr>
<tr>
<td>Nov</td>
<td>3.12</td>
<td>2.1</td>
<td>1.02</td>
</tr>
<tr>
<td>Dec</td>
<td>3.28</td>
<td>1.24</td>
<td>2.04</td>
</tr>
<tr>
<td>Annual</td>
<td>43</td>
<td>49.48</td>
<td>8.77</td>
</tr>
</tbody>
</table>

The total precipitation falling on the 392 acre site is $1.25 \times 10^6$ gpd. Runoff and recharge totals 256,000 gpd and actual estimated evapotranspiration is 998,000 gpd.

The following table shows the estimated water usage at the mine and its impact on the post mining water balance. Positive flows are into the pond (mine pit) or groundwater and negative flows leave the pond or groundwater.

<table>
<thead>
<tr>
<th>Category</th>
<th>Annual Flow (gpd)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>$1.25 \times 10^6$</td>
<td></td>
</tr>
<tr>
<td>Evapotranspiration from unmined areas</td>
<td>-$6.93 \times 10^5$</td>
<td>proportioned from premining actual ET</td>
</tr>
<tr>
<td>Evaporation from pit</td>
<td>-$4.42 \times 10^5$</td>
<td>open water evaporation = reference ET</td>
</tr>
<tr>
<td>Hydraulic Dredge Flow</td>
<td>-$8.29 \times 10^5$</td>
<td>calculated from 500000 tons/year and 13% solids</td>
</tr>
<tr>
<td>Return flow from dredge</td>
<td>$8.01 \times 10^5$</td>
<td>Minus the moisture leaving the site with the sand of $2.8 \times 10^4$ gpd</td>
</tr>
<tr>
<td>Wash Plant Flow</td>
<td>-$1.04 \times 10^6$</td>
<td>Estimated 3500 gpm, 300 days/yr, 6 hrs/day</td>
</tr>
<tr>
<td>Return Flow from wash plant</td>
<td>$1.04 \times 10^6$</td>
<td></td>
</tr>
<tr>
<td>Water Supply well</td>
<td>-$300$</td>
<td>calculated from 6 employees @ 50 gpd</td>
</tr>
<tr>
<td>Flow to septic leach field</td>
<td>$285$</td>
<td>95% of well usage</td>
</tr>
<tr>
<td>Runoff and Recharge</td>
<td>$9.16 \times 10^4$</td>
<td></td>
</tr>
<tr>
<td>Consumptive Use</td>
<td>$1.64 \times 10^5$</td>
<td></td>
</tr>
<tr>
<td>Total Withdrawal for Mining</td>
<td>$1.87 \times 10^6$</td>
<td></td>
</tr>
</tbody>
</table>
Runoff and recharge were calculated as the sum of the flows in and off the site. Consumptive use was calculated as the difference in runoff and recharge between premining and postmining conditions. The estimated consumptive use of 164,000 gpd (114 gpm) is 8.8 percent of the total withdrawal for mining and 7.30 percent of the precipitation falling on the site.

The consumptive use consists of an increase in evapotranspiration caused by the open water in the mine pit (136,000 gpd) and the moisture in the sand shipped off-site (28,000 gpd). These are very conservative estimates. The pit area of 120 acres was assumed to be available for evaporation even though this area would only support the estimated rate of evaporation at the end of mining. Open water evaporation was estimated to be equal to the calculated reference evapotranspiration rate. The reference evapotranspiration rate is calculated for a good grass cover that is 12 cm high with an albedo (radiation reflection coefficient) of 0.23. Applying the various versions of the Penman equation in REF-ET resulted in multiple estimates of open water evaporation that were both higher and lower than the reference evapotranspiration. Open water has a smaller albedo than grass, but less resistance to wind and no leaves. Leaves tend to increase the evapotranspiration rate by exposing more area, but decrease air movement because the leaves provide resistance. After multiple simulations, with multiple evapotranspiration formulas, it was decided to use the grass reference evapotranspiration calculated with the Blaney-Criddle formula for open water evaporation.

The impact of this consumptive use may be calculated assuming the mine pit is a large radius well with a pumping rate of 136,000 gpd. Assuming a transmissivity of 155,000 gpd/ft, and a specific yield of 0.1, the drawdown at a radius of 2000 feet and after 30 years of consumptive use is 0.5 feet. This is a negligible impact.

Potential impacts on groundwater quality are similarly negligible for two reasons. First, mining sand and gravel does not contaminate the aquifer in any way. Sand and gravel are inert materials that do not react with oxygen when mined. There are no chemicals used in the mining process. There is some possibility of spills of fuel or cleaning chemicals, however. Potential spills do not represent a threat to groundwater quality, however, for the second reason. The consumptive use of 136,000 gpd causes groundwater to flow towards the mine pit. Hence, any spill or contamination will not move through the aquifer but will travel towards the pit.

Conclusions

The proposed Marshyhope Surface Mine will be a sand and gravel mining operation in Dorchester County, Maryland. It is located along Marshyhope Creek about two miles upstream of the confluence of Marshyhope Creek with the Nanticoke River.

Sand and gravel will be extracted from the site by a hydraulic dredge. The hydraulic dredge pumps a slurry of sand and water to a wash plant that separates fines from the sand and gravel. Both the dredge and the wash plant use large quantities of water, but almost all of this water is returned to the mine pit. The impact of mining on the groundwater system is very small because the water is recycled.
There will be some consumptive use of groundwater. The mine pit creates a pond and an open water surface that will allow evaporation at the potential rate throughout the year. More water will evaporate than would normally transpire from the vegetation. There is also some consumptive use from taking the moisture in the sand from the site. This consumptive use will cause negligible drawdowns around the mine pit.

Impacts on groundwater quality will be negligible. Sand and gravel mining will not contaminate groundwater and any spills will travel into the mine pit because the consumptive use causes a small depression in the groundwater table.

References


NOAA, 2004, Climatology of the United States No. 20 1971-2000, Monthly Station Climate Summaries, Vienna, MD.

Permit Application Screening Form

Tracking No: 200860867
Applicant: Horsey Family LLC/Marshyhope Sand & Gravel Mine
County: Dorchester ADC Map: 17 A 6 Ed: 8
Project Type: Road Crossing
Waterbody: Messick Ditch
Fed. Nav. Channel? No Within 150' of channel? No

Location
State Plane 83 Meters: N 100500 E 508020
Latitude/Longitude 83: N 38° 33' 56" W 75° 45' 38"
DOQQ: RHODESDALE NE
Critical Area/1000' Buffer? Yes
100 yr Floodplain Yes A Floodway? No

Reference Information
FEMA FIRM Index: 2400260250A Taxmap: 35
Watershed: 02130306
Tidal Watershed Boundary Map #: 008 Aerial Photo #: DO1-20RL-54

Reference Information
NWI? Yes PFO1/4A, PFO1E, PFO1S, PFO1R
DNR Wetlands? Yes PEM1Fx, PFO1A, PFO1R, PFO2/1T
MHT? Yes Arch
Sens/Endg Sp? Yes 1287
WSSC? Yes SAV? No

Screened By: ac Date Screened: 3/4/2008