GROUNDWATER INVESTIGATION OF POTENTIAL QUARRY DEWATERING AND DEPRESSURIZATION IMPACTS ON KELLEYS ISLAND, ERIE COUNTY, OHIO

Tom Tomastik and Tom Benko, Ohio Department of Natural Resources, Division of Mineral Resources Management
INTRODUCTION

Conflicting water uses are a common legal and regulatory issue in Ohio.

Courts and/or regulatory agencies must determine which party’s water rights take precedence and what is the proper compensation.

In a 2005 landmark case, the Ohio Supreme Court ruled “that Ohio landowners have a property interest in the groundwater underlying their land and that government interference with that right can constitute an unconstitutional taking.”
• Carbonate rocks form the primary bedrock aquifers throughout northwestern Ohio and are also extensively quarried by the aggregate industry.

• For quarry mining operations to proceed, some quarries must be kept dry by pumping surface water and groundwater out of the quarry in a process called “dewatering.”

• Dewatering causes a pumping stress on the aquifer which creates an area of decreased hydraulic head known as a “cone of depression.”

• Water wells within a cone of depression of a quarry-dewatering operation can show evidence of decreased water supply, degraded water quality, or can even go “dry.”
QUARRY DEWATERING OPERATIONS
In 2005, 68.9 million gallons of groundwater and surface water was pumped daily by mineral extraction quarry operations in Ohio.

Water rights disputes involving coal or industrial minerals quarrying operations are regulated by the Ohio Department of Natural Resources, Division of Mineral Resources Management.
LOCATION

- Kelleys Island is a 2,888 acre island located in Lake Erie approximately 3-1/2 miles north of Marblehead, Ohio
- Since the 1830’s limestone and dolomite have been extensively quarried on parts of the island
• The island is mainly a resort community with approximately 230 full-time residents.

• About 1/3 of the island utilizes water wells and the remaining portion of the island is serviced by the village water department (water from Lake Erie) or by private cisterns.
Since September of 2004, the Division of Mineral Resources Management has received 10 formal complaints against the current quarry operation alleging loss water, reduced and delayed recharge, and changes in water quality.
Since the initial investigation, the Division has measured water levels in 106 private water wells on numerous occasions.
• Additionally, the Division used its Marks Geovision Jr. color downhole video camera in 16 water wells on the island to further understand the geologic and hydrogeologic nature of the rocks.
Due to the complexity of the geology, transient or seasonal nature of most of the landowners, and the lack of water well data within the central portion of the island, the Division received a NOAA Federal Grant to drill three monitoring wells on state park property within the central portion of the island.
GEOLOGIC SETTING

- Unconsolidated glacial tills and clays deposited on the island are the result of the Illinoian and Wisconsin ice sheets.
- Thicknesses of these tills range from zero to up to 30 feet.
- The bedrock geology is composed of carbonate rocks (limestone and dolomite) from the Middle Devonian period and are exposed at various outcrop locations and in the quarries.
KELLEYS ISLAND GLACIAL GROOVES
## BEDROCK GEOLOGY

**INCLUDES:**

<table>
<thead>
<tr>
<th>GEOLOGIC AGE</th>
<th>GROUP NAME</th>
<th>ROCK UNITS</th>
<th>MEMBERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle Devonian</td>
<td>Columbus Limestone</td>
<td>Venice, Marblehead, Bellepoint</td>
<td></td>
</tr>
<tr>
<td>Middle Devonian</td>
<td>Detroit River</td>
<td>Lucas Dolomite</td>
<td></td>
</tr>
</tbody>
</table>
FRACTURE SYSTEM

- Structurally, the island’s bedrock exposures are highly fractured and jointed.
- Approximately 451 fracture trends were measured by the Division or obtained from a University of Toledo senior thesis.
- The main stress fracture trends on the island are N4-50E and N1-10W, with an average extensional fracture trend of N81E.
HYDROGEOLOGY

• The highly complex carbonate bedrock fracture system as you can see plays an important role in the understanding of the hydrogeologic nature of the island’s bedrock aquifers
BEDROCK AQUIFERS

- There are at least two distinct aquifers on Kelleys Island.
- The upper aquifer is developed in the Columbus Limestone and is a leaky confined system, meaning that some of the groundwater is obtained through percolation of rainfall through the surface fracture system.
- The deeper, confined aquifer is developed in the Lucas Dolomite and is characterized by mineralized water with a higher hydrogen sulfide content.
• Historically, the water levels on Kelleys Island ranged from 570 to 610 feet above mean sea level
• Interestingly, these historic water levels tend to mimic the island’s bedrock topography
HISTORIC MINING OPERATIONS

- Quarrying operations first started on Kelleys Island in 1833 and early operations burned limestone for flux and used it for building stone.
- Today, most of the stone is used for aggregate or cement manufacturing.
- The first modern industrial mineral mining permit was issued to Kellstone, Inc. by the Division in 1980.
KELLSTONE QUARRY IN 1991
• The original permit was valid for 10 years and had an original proposed mining depth of 535 feet above mean sea level.

• In 2001, the Division received a request for modification to mine deeper to an elevation of 480 feet.

• The Division approved the modification, but the new operator did not start mining deeper until June of 2004.

• At an elevation of 531 feet groundwater was encountered flowing from the high walls and ramp.
In September of 2004, the operator received a revised NPDES permit which allows for a discharge of groundwater and surface water into Lake Erie. Discharge rates were between 4.75 to 5 million gallons per day with a maximum discharge rate of 9.2 million gallons per day with the 3 existing turbine pumps.
METHODS OF STUDY

• Used Solinst water level meters to measure water levels
• Garmin GPS to accurately plot water wells onto a DeLorme Xmap base map
• Used Marks Color Geovision Jr. to conduct downhole well evaluations
• Installed 21 Solinst Leveloggers and a barologger in water and the monitoring wells in April and September 2007 to continuous record the water levels
INVESTIGATION

• Initial objective was to try and determine the impact of quarrying dewatering operations on the island’s domestic water wells

• Division measured water levels in 105 private wells on numerous occasions and ran the downhole video camera in 16 wells to determine well bore conditions and to record geologic and hydrogeologic conditions
• Potentiometric surface maps, bedrock topography, cross sections, and drawdown maps were constructed to further understand the effects of the quarry dewatering operations.

• Limited pump tests were conducted on several water wells to determine pumping rates and recovery times.
NOAA GRANT

- Based upon lack of water well data in central portion of the island, the Division applied for and received a NOAA grant to drill three monitoring/observation wells on the Division of Parks and Recreation property.
- Three monitoring wells were drilled in Park property in September of 2007.
- Downhole videos were conducted and three leveloggers were installed and have been measuring water levels every hour since September of 2007.
LEVELOGGERS

• Currently, 21 leveloggers and a barologger are installed in private water wells and in the Division’s three monitoring wells.

• Water levels have been recorded hourly since April and September of 2007.
y = -0.0051x + 562.74
QUARRY ACTIVITY

• Mining operations at the Kellstone Quarry ceased on June 25, 2008 due to economic reasons and the dewatering pumps were shut down on October 2, 2008 and subsequently removed.

• The Division continued to measure water levels in private water wells and collect levelogger data in the 21 wells during groundwater recovery to assist in defining the extent of the Kellstone Quarry dewatering and depressurization impacts.
KELLSTONE QUARRY AS OF AUGUST 25, 2009
Name: Sump

Well depth (ft): __________  Length of saturated zone (ft): __________  Distance from sump (ft): 0  Quad: NW

Legend

× Water elevation (ft amsl) in well, original
● Water elevation (ft amsl) in well, water level meter
--- Water elevation (ft amsl) in well, data logger

Date

08/01/04  02/01/05  05/01/05  08/01/05  01/01/06  05/01/06  08/01/06  11/01/06  02/01/07  05/01/07  08/01/07  11/01/07  02/01/08  05/01/08  08/01/08  11/01/08  02/01/09  05/01/09

Precipitation (in)

Water elevation (ft amsl)

Quary pumping rate (mgd)
Name: MW3

Well depth (ft): 139
Length of saturated zone (ft): 114
Distance from sump (ft): 8.470
Quad: SE

Legend
- Water elevation (ft amsl) in well, original
- Water elevation (ft amsl) in well, water level meter
- Water elevation (ft amsl) in well, data logger

Date
08/01/04 11/01/04 02/01/05 03/01/05 06/01/05 07/01/05 02/01/06 03/01/06 06/01/06 11/01/06 02/01/07 03/01/07 06/01/07 11/01/07 02/01/08 03/01/08 06/01/08 11/01/08 02/01/09 03/01/09

Precipitation (in)
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00

Water elevation (ft amsl)
470 520 530 540 550 560 570 580 590

Quarry pumping rate (mgd)
0 2 4 6 8 10
Name: Collingwood

Well depth (ft): 84  Length of saturated zone (ft): 61  Distance from sump (ft): 10 120  Quad.: SE

Legend

- Water elevation (ft amsl) in well, original
- Water elevation (ft amsl) in well, water level meter
- Water elevation (ft amsl) in well, data logger
Name: Soldner

Well depth (ft): 142
Length of saturated zone (ft): unknown
Distance from sump (ft): 10,940
Quadrant: SW

Legend
- Water elevation (ft amsl) in well, original
- Water elevation (ft amsl) in well, water level meter
- Water elevation (ft amsl) in well, data logger
CONCLUSIONS

• Based upon the Division’s hydrogeologic investigation, a cone of depression was established by the quarry dewatering operations at the Kellstone Quarry.

• The extent and magnitude are still being investigated by evaluation of the water level recovery data, but looks to have impacted the most of Kelleys Island.
• Water rights disputes are becoming more prevalent in Ohio
• Changes to Ohio Administrative Code in 2002 now require groundwater modeling of a projected cone of depression for new mining permits or amendments that may result in dewatering
• These rules may help in resolving water rights disputes or they can be settled in the civil court system