Chapter 8
Groundwater Issues

Introduction

As the population continues to expand and grow, once isolated mining operations will become a part of the urban landscape. As part of this new community the operation will need to understand its potential hydrological effects on the surrounding community.

Senate Bill 83 has instituted new guidelines to deal with the resolution of complaints regarding cases dealing with diminution, contamination, or interruption of the water supply. In the new guidelines, the time line and procedure for complaint resolution are dependent upon whether the complaint is located inside or outside of the regulatory cone of depression. The regulatory cone of depression must be delineated through the compilation of a three-dimensional groundwater flow model that is generally accepted in the local scientific community. If no model exists the foregoing complaint is treated as if the concern is outside the cone of depression. In each case, the operator must understand the new law as it relates to hydrogeology, the time line, and appropriate actions. At the same time, the operator must weigh the potential cost of the complaint process compounded with potential negative public relations versus determining the cause before a complaint is filed with ODNR. In many instances, the concern is not related to the operation.

Finally, the operator needs to understand when a model is necessary. This will be dependent upon whether the operation is viewed to be dewatering, the expansion of an existing dewatering operation, or whether a new permit has the potential to dewater. This chapter tries to address these concepts and tries to provide the industrial mining operator with guidelines on the construction of groundwater models, the resolution of complaints, and dewatering issues.

Are you dewatering?

An operator must decide first if an operation is dewatering thus resulting in a lowering of the water table or the potentiometric surface. ODNR defines dewatering as “the withdrawal of ground water from an aquifer or saturated zone that may result in the lowering of the water level within the aquifer or saturated zone or a decline of the potentiometric surface within that aquifer or saturated zone.” Depending on climatic conditions, the potentiometric surface or water table may fluctuate 5 to 10 feet in a given season.

Terminology associated with dewatering may include: drawdown, cone of depression, static water level, specific yield, hydraulic conductivity, transmissivity, and specific capacity. Each term is more clearly defined in the appendix. The main terms an operator needs to understand are drawdown, cone of depression, and static water level. These are defined below.

- “Static water level is the level of water in a well or unconfined aquifer with no water being removed. It is usually expressed as the distance from the ground surface.” ORC 1514.
- “Drawdown is the distance between the static water level and the water level due to pumping or discharge of water.” ORC 1514.
- “Cone of depression means the depression of the static water level around a location due to the withdrawal of groundwater.” ORC 1514.

In most instances, if no pumping or discharge of water offsite is occurring on the property then the operator is not dewatering. Any withdrawal of water from either a highwall, pumping or discharge of water has the potential to dewater depending on the situation. The question is what is the influence or potential drawdown from the withdrawal of water?

For example, a sand and gravel operation may be pumping to supply water to wash aggregate. This may have the potential to dewater. But, if the water then re-circulates back into a lake next to the operation this may surcharge the water table. This may have the effect of offsetting any dewatering occurring through the effects of pumping.

On the other hand, a limestone operation mining into a hillside and not pumping any water may still have water seeping from an existing highwall. This water then naturally drains off the property. Although the operator is not pumping the operation may have the effect of lowering the potentiometric surface on the surrounding property.

For an understanding of the potential to dewater or if dewatering is occurring to any significant degree, an existing operation needs to understand the pre-mining static water. This may be accomplished through well logs obtained from the Ohio Department of Natural Resources’ Division of Water or from measuring existing wells to create a potentiometric map.

Finally, an operator may be dewatering, but due to surrounding conditions the dewatering has limited, if any, effect on the surrounding properties. For instance, if a sand and gravel operation is pumping for the purposes of obtaining a greater extractive depth this is considered dewatering. However, if a river is situated between the offsite structures and the operation the river may negate any effect beyond the property line boundary.

Each operation will have a different set of criteria in order to determine if dewatering is occurring. By understanding the local geology, pre-mining static water levels, and current water levels, and operator will be able to determine if the operation is dewatering. Some of this information will also be critical in determining the potential to dewater for purposes of modeling.

Hydrology Background

The following paragraphs deal with the two main types of aquifers in Ohio and the hydrologic cycle in relation to mining.
The hydrologic cycle is the condensation of water in the form of rainfall, and the movement of this water through a combination of surface flow, infiltration and subsequent groundwater flow. The final step in the cycle is the eventual evaporation or transpiration of the water back into the sky. This relates to mining because an operator must understand that more than groundwater alone affects an operation. An operation is also affected by surface water through runoff, direct precipitation, and possible runoff from ongoing operations. Additionally, operations are affected by the type of geology, recharge, and local topography. Each of these may affect the amount of water that is discharged from an operation or the potential to discharge from an operation. An understanding of how the hydrology of the area affects an operation is critical to understanding the effects the operation may have on the surrounding landscape.

Identifying these other sources of water is important in determining the amount of water that is being discharged due to groundwater flow. For example, a quarry is discharging 195 million gallons per year and the quarry floor is approximately 50 acres in size. Direct precipitation can account for approximately 25% of the water that is being discharged (50 acres * 43560 feet/acre * 3 feet precipitation * 7.48 gallons/feet). Evaporation is not considered in the previous equation. The listing of precipitation data can be found through the Ohio Department of Natural Resources' Division of Water. Or the National Oceanic and Atmospheric Administration website. Other factors that may account for additional pumpage include runoff due to topography, drainage tiles that empty into the quarry, and plant water that filters back into the quarry or is discharged into the quarry. Each of these may affect the amount of water that is attributed to groundwater. By understanding the amount of groundwater inflow an operator should be able to extrapolate the amount of additional water due to either lateral or vertical expansion of the operation. Additional information may be necessary through nearby onsite pumping tests to confirm the calculations.

For the purposes of this chapter two main types of aquifers are situated in Ohio in relation to mining. They are sand and gravel and limestone/dolomite. Present day sand and gravel aquifers were created with the onset of glaciations. From 1,200,000 yr. BP to 14,000 yr. BP, at least four major glaciations occurred covering the Ohio region with ice, gravel, and clay. In the process, the glaciers controlled the course and direction of our present day valleys. The Wisconsin glaciations (70,000 yr. BP to 14,000 yr. BP) in the process of retreating and advancing coupled with its final retreat, filled the valleys with permeable sand and gravel interspersed with clay and till (Spieker, 1968). Such buried valleys make up our present day aquifers. These buried valleys are also referred to as valley train deposits, valley fill, or glacial outwash (Spieker, 1968). Listed below are various hydraulic conductivities of unconsolidated materials.

Material	Hydraulic Conductivity (cm/s)
Clay	10^{-9} - 10^{-6}
Silt, Sandy Silts	10^{-6} - 10^{-4}
Silty Sands, Fine Sands	10^{-5} - 10^{-3}
Well Sorted Sands	10^{-3} - 10^{-1}
Well Sorted Gravel	10^{-2} - 1

* Applied Hydrogeology - C.W. Fetter

Limestone aquifers were mainly formed while Ohio was a shallow inland sea. As the sea level changed from shallower to deeper, the types of sediments that were deposited changed as well.

Usually deeper seas or a rise in sea level result in an environment favorable to shale deposition. On the other hand, shallower seas or a fall in sea level result in carbonate or limestone deposition. Depending on the depositional platform, from marine shelves to moderately deep seas, would dictate what type of characteristics were deposited as part of the limestone. Listed below are various hydraulic conductivities of consolidated materials.

Material	Hydraulic Conductivity (cm/s)	Hydraulic Conductivity (gpd/ft2)
Shale	10^{-9} - 10^{-13}	10^{-4} - 10^{-8}
Sandstone-Well Cemented	10^{-8} - 10^{-10}	10^{-3} - 10^{-5}
Limestone Unjointed Crystalline	10^{-6} - 10^{-10}	10^{-1} - 10^{-5}
Sandstone-Friable	10^{-5} - 10^{-8}	1 - 10^{-3}
Karst Limestone	10^{-2} - 10^{-6}	10^{-3} - 10^{-1}

*Groundwater and Wells - Fletcher G. Driscall

Anytime an operator plans to open or expand an operation that requires a permit through ODNR a model may need to be completed to determine the possible extent or influence on dewatering. As stated above, the operation must first decide if the mining permit will result in dewatering. If no dewatering is to occur then a model is not necessary. In addition, if the proposed expansion will not result in any increase in the lateral extent of the current dewatering a model may not be necessary.

The following is a list of when a model may be needed for the ODNR:

- New permit is applied for that will necessitate pumping in order to extract minable material.
- Amendments to existing permits for minable areas in either a vertical or lateral extent that are viewed as significant under the current ORC 1514 regulations.

Time Frame

There is no time frame mentioned for completion of the model in ORC 1514 or the draft 1514 Hydrologic Rules. If ODNR completes the model to determine the cone of depression and operator should expect a minimum of three months delay. This is provided that the information listed below is complete and given to ODNR for modeling purposes. If the company completes the model, a similar time frame may be expected. Additional time will then be required for the ODNR to review the model for accuracy.

Model Requirements

The overall goal of the model is to determine the cone of depression for purposes of regulation. From this determination, the operator may or may no be required to perform certain tasks dependent upon whether a complaint is located within or outside the cone of depression.

The operator has the options of completing the groundwater model, either in- house or using a consultant, or of allowing the ODNR to complete the model. All models must be 3 dimensional groundwater flow models utilizing finite difference modeling. MODFLOW, originally developed by the U.S. Geological Survey, is one example of a scientifically accepted computer model. An applicant may submit a 2 dimensional model provided the chief determines that the model will accurately represent groundwater flow in the hydrologic area. In designating the cone of depression, the chief shall look at availability, seasonal variations, and other water use in the hydrologic area. Unless otherwise determined, the 10-foot contour line shall be used for determination of the cone of depression.

The applicant may also stage the cone of depression to be consistent with the progression of the mining operation. The cone of depression applied to water replacement responsibilities will be based on the cumulative boundary of the cones of depression for the quadrants of the permit area affected at the time of the complaint. This allows the operator to more accurately define the projected cone of influence as the operation progresses, thus reducing the overall risk. A maximum of four vertical or horizontal sump locations within the proposed permit area is allowed.

If ODNR completes the model, the following list of items needs to be provided by the operator. If the information is unavailable a statement to that effect, including the reasons for the lack of information, must be submitted. For a complete list of requirements see the draft of the 1514 Hydrology Rules.

1. Hydrologic map from a four-mile radius boundary from the proposed permit area.
    - Location of cross sections.
    - Location of selected water supply wells and other water sources for domestic, agricultural, or industrial use.
    - Any well, well field, reservoir, water source used for public water supply.
    - Chief may require additional information beyond the hydrologic area if such identification is necessary, based on site-specific conditions.
2. A hydrogeologic description in sufficient detail to determine the hydrologic cone of depression for the proposed operation.
    - The description shall include a general statement of the geology within the proposed permit and hydrogeologic study area down to and including the deeper of either the first stratigraphic unit below the lowest mineral seam to be mined or any aquifer below the lowest mineral seam to be mined. It shall also include the area and structural geology of the permit and hydrogeologic study area and other parameters which may affect the occurrence, availability, movement, quantity, and quality of potentially affected ground waters and shall be based on information available to the applicant from test borings, core drillings, well logs, and geologic literature and practices.
    - Groundwater information available in the public domain (lithology and extent of thickness of the aquifer, uses, water bearing elevations,

      transmissivity, storativity, hydraulic conductivity, specific yield (unconfined aquifer), location and elevation of dewatering sumps, and the rate of discharge of any currently registered water withdrawals).
    - Listing of published and unpublished information and data used in preparation and description of data.
    - Water supply inventory listing drilled wells with the hydrologic area. The wells shall represent all aquifers and be uniform in geographical distribution. The list shall not exceed 300 wells. Included in the inventory shall be the location and type of any public water supply sources. (Water supply inventory may be reduced upon written determination that reduction in the number of submittals will not affect the accuracy of the hydrologic model.)
    - Two perpendicular hydrogeologic cross sections in uniform vertical and horizontal scale.

As stated above, the operator can submit a model as long as the model is consistent with ASTM standards, contains a detailed explanation of the geologic and hydrologic parameters used to construct the model, and contains the plans of long-term development of the operation.

Complaint Resolution

The type of complaint resolution required by the ODNR is dependent upon whether the complaint is located inside or outside of the cone of depression. If no cone of depression is determined, the procedure is considered to be outside the cone of depression.

Inside the Cone of Depression

If the complaint is within a predetermined cone of depression the following outlines the timetable that must be adhered to:

- If the operator receives a complaint informing him/her that there is a diminution, contamination, or interruption of the owner's water supply the complaint needs to be sent immediately to the chief.
- The operator shall immediately send the chief a written statement explaining how the operator will resolve the complaint.
- A temporary water supply, comparable in quality and quantity to water supply prior to interruption, shall be provided within 72 hours to the owners. This shall be maintained until a permanent water supply is established or the operator provides evidence that they are not the cause of the interruption of the water supply. This evidence must be supplied within 14 days of receipt of the complaint.
- Within 14 days the operator may rebut the presumption that the operator is the cause of the diminution of water supply. If the operator rebuts the presumption the Division shall immediately notify the owner that the operator has rebutted the presumption and upon receipt of that notice, the operator may cease providing water to the owner.
- If the operator rebuts the presumption and the ODNR determines the operator is the cause of diminution from an investigation the operator will supply the owner with a permanent water supply within 14 days of that notice.
- If no rebuttal is received within 14 days the operator must provide the complainant with a permanent water supply within 28 days of the receipt of the original complaint.

Outside the Cone of Depression

If the complaint is outside the cone of depression or no cone of depression has been determined the following is the list that an operator must adhere to:

- If the operator receives a complaint the operator shall send a copy of the complaint to the chief immediately.
- The ODNR will complete an investigation to determine the cause of the diminution of the water supply and upon completion shall send the results immediately to the operator and the owner.
- If the operator is determined to be at fault for contamination or interruption of the owner's water supply the operator is encouraged to replace the well. This is not required. The homeowner may commence a civil action utilizing the information provided by the ODNR against the operation for replacement of the water supply.

Recommendation to Operators

Gathering information on the existing hydrogeologic conditions at your sight is a very good idea prior to the development of a new mining operation or the expansion of an existing operation. Whenever possible, observation wells should be installed and regularly monitored to determine what potential effect your mining operation will have on the aquifer in which you operate.

Observation wells do not have to be terribly sophisticated. Test borings or core holes drilled for exploration purposes can be cased with PVC pipe for a relatively small additional cost and converted into observation wells for future use. Observation wells are especially valuable when placed around the entire periphery of the mining property, or at a minimum between your operation and the nearest adjoining wells.

Measuring and recording the water levels in observation wells on regular intervals, such as once a month, can provide important information on seasonal trends and the effects of increased or decreased pumping rates. Periodic, maybe once a year, sampling and water quality testing can provide invaluable protection in the event of allegations of groundwater contamination. The costs of this type of regular monitoring and testing is minimal when compared to the potential cost of litigation or replacement of neighboring wells that were not affected by your operation.

Test borings that penetrate confined aquifers may result in artesian flow of groundwater, and can depressurize aquifers below the quarry floor. If these wells are not converted to monitoring wells, they should be plugged with cement immediately after drilling/coring operations are completed.

Even if you do not intend to dewater, monitoring observation wells can provide insurance against future allegations of diminution, contamination, or interruption of water supply.

Glossary

Cone of Depression: "A depression or low point in the water table or potentiometric surface of a body of groundwater that develops around a location from which ground water is being withdrawn." ORC 1514.

Confined Aquifer: "An aquifer that is overlain by a confining bed. The confining bed has a significant [ly] lower hydraulic conductivity than the aquifer." Fetter, W.C., 1994.

Dewatering: "The withdrawal of groundwater from an aquifer or saturated zone that may result in the lowering of the water level within the aquifer or saturated zone or a decline of the potentiometric surface within that aquifer or saturated zone." ORC 1514.

Drawdown: "The distance between the static water level and the water level due to pumping or discharge of water." ORC 1514.

Groundwater: all water occurring in an aquifer.

Hydraulic Conductivity: "A coefficient of proportionality describing the rate at which water can move through medium." Fetter, W.C., 1994.

Potentiometric: "A surface that represents the level to which water will rise in tightly cased wells. If the head varies significantly with the depth of the aquifer the there may be more than one potentiometric surface. The water table is a particular potentiometric surface for an unconfined aquifer." Fetter, W.C., 1994.

Specific Capacity: "An expression of the productivity of a well obtained by dividing the rate of discharge of water from the well by the drawdown of the water level in the well. It will generally decrease with time as drawdown increases." Fetter, W.C., 1994.

Specific Yield: "The ratio of the volume of water a rock or soil will yield by gravity drainage to the volume of rock or soil." Fetter, W.C., 1994.

Static Water Level: "The level of the water in a well or unconfined aquifer with no water being removed. It is usually expressed as the distance from the ground surface." ORC 1514

Transmissivity: "The rate at which water of a prevailing density and viscosity is transmitted through a unit width of aquifer or confining bed under a unit hydraulic gradient." Fetter, W.C., 1994.

Unconfined Aquifer: "An aquifer with no confining bed between the zone of saturation and the surface." Fetter, W.C., 1994.

References

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