

WORKPLAN GUIDANCE DOCUMENT FOR MINING BELOW THE WATER TABLE AT LIMESTONE QUARRIES

Currently, mining operators are required to complete a detailed hydrogeological investigation to evaluate the potential for sinkhole development or ground surface subsidence from dewatering when excavating below the water table at limestone quarries. The term “limestone” applies to any carbonate formation where the development of karst features can occur, and the investigation is required when an operator proposes a new pit or any expansion that will advance below the water table. The following workplan guidance document is designed to assist mining operators and their consultants in completing the investigation. Sections I through IV of this workplan can be completed without the Environmental Protection Division’s (EPD) approval. However, EPD must approve the final results of Sections I through IV and a proposed aquifer pumping test before the remaining parts of the workplan can be completed.

EPD recommends that mining operators submit an interim workplan (Sections I through IV and a proposed aquifer pumping test methodology) with the surface mining application and mining land use plans as soon as possible during the mine planning phase. However, the mining operator may submit the application and the interim workplan without the mining land use plans as long as the interim workplan is complete.

Both the interim workplan and the final completed workplan must be prepared, reviewed, and sealed by a Georgia registered Professional Geologist or Professional Engineer. The monitoring and mitigation plans, that are designed based on the information gathered in the final completed workplan, must be provided as part of the mining land use plans. Once approved, the mining land use plan, including the monitoring and mitigation plans, will become part of the permit.

WORKPLAN

I. INTRODUCTION

Provide the location (lat/long, City, County) of the proposed quarry.

Specify the estimated life of the mine or expansion, and if applicable, break down the entire life of the mine into phases.

Show the estimated extent of each individual phase of the quarry on a contour map with recent topographic data and property boundaries. Specify number of acres and quarry excavation dimensions (length, width, depth) for each phase and anticipated duration of quarrying during each phase.

Specify the specific type of limestone to be quarried and the method(s) to remove the limestone.

II. GEOLOGY

A. REGIONAL GEOLOGY (REVIEW OF PUBLICALLY AVAILABLE DATA):

Limit scope of investigation to a physiographic province of Georgia and focus on geologic units impacted by quarry operations (above and below unit to be quarried). Use publically available resources. Cite and reference all sources.

Provide geologic maps and relevant cross sections of regional geology. Identify major formations and units. Identify the types (i.e. oolitic, sparites, etc.) and chemistries (i.e. calcium-rich or magnesium-rich) of any limestone units.

Describe the documented structural and weathering characteristics of units. Highlight any characteristics unique to a unit (karst features, discontinuities, pinnacles, conduit flow, etc.) that may be environmentally sensitive to quarrying and dewatering. Environmental sensitivities include, but are not limited to, subsidence, sinkhole formation, reduction in stream/spring flows, etc.

B. SITE SPECIFIC GEOLOGY

Provide a detailed map of geologic contacts across the project area using borehole data and detailed geologic mapping, as necessary. The map should include geologic contacts above the unit(s) quarried, and if necessary, below the unit(s) quarried. Provide structure contours of the top and bottom of each unit if they can be reasonably determined from geologic mapping and borehole information.

Describe the lithology structurally, mineralogically, and chemically of each unit identified across the project area. Document any karst features and physical or chemical weather characteristics that may be environmentally sensitive to quarrying or dewatering.

III. HYDROGEOLOGY

A. REGIONAL HYDROGEOLOGY (REVIEW OF PUBLICALLY AVAILABLE DATA)

Limit scope of investigation to a physiographic province of Georgia and focus on the aquifer(s) impacted by quarrying operations. This includes units above, within, and below the unit(s) quarried and/or dewatered. Use publically available resources. Cite and reference all sources.

Provide regional geologic maps, identify hydrostratigraphy of the area, and develop regional hydrogeologic cross sections. Provide brief descriptions of regional aquifers. Highlight any known karst aquifers.

Provide meteorological data for the region. Provide potentiometric/water table maps of region showing flow directions, gradients, and average and seasonally high groundwater elevations for each aquifer, if available. Describe groundwater recharge and discharge of the region as it relates to the site. Consider adding hydrologic unit boundaries and their corresponding unit codes.

Consult EPD Publications HA 18 (Most Significant Ground-Water Recharge Areas of Georgia) and HA 20 (Ground-Water Pollution Susceptibility Map of Georgia) to determine if the study area lies within a significant groundwater recharge area.

B. SITE-SPECIFIC HYDROLOGY/HYDROGEOLOGY

If an existing quarry, provide a map showing the current horizontal extent of the quarry, existing surface water diversions, and locations of surface water features on the property. Describe current management of storm water and groundwater seepage into the quarry pit. Provide a list of dewatering rates and schedules. Estimate all inflows, outflows, and storages. Describe any groundwater and surface water interactions using water balance equations.

Provide detailed boring logs and well construction diagrams for all installed monitoring wells. EPD highly recommends that each borehole be cored. Boring logs shall include, at a minimum, the following information: description of each lithology including overburden (color, type, minerals, fossils, etc.), rock quality designation (RQD) values, recovery percentage, and the depths and characteristics of lithologic contacts, fractures/conduits/discontinuities, weathered zones or voids, dissolution features, and any water bearing zone(s). Supplemental techniques such as downhole geophysics and flow meters may be used to determine the depths of water bearing zone(s).

Monitoring wells should extend to a depth that allows for evaluation of the entire vertical extent of the quarry at the quarry's proposed maximum depth, including blast damage at the bottom of the proposed quarry pit. Furthermore, depending on site-specific geology and/or hydrostratigraphy, it may be necessary to extend wells below the bottom of the quarry pit. The mining operator and the operator's consultant should determine the number of monitoring wells necessary to provide an accurate potentiometric surface map across the proposed quarry pit. Likewise, the mining operator and the operator's consultant should determine the optimal type of well construction (i.e. screen or "open hole") for each monitoring well. For sites in which dewatering will affect discrete aquifers (and any potential receptors of each aquifer), EPD would expect to see nested monitoring wells or monitoring wells with multiple screens. For sites in which an "average head" will suffice for analysis, construction of monitoring wells as open-hole wells may provide sufficient information. Do not combine groundwater elevations of different aquifers into a single map (i.e. combining the overburden aquifer with a deep bedrock aquifer) unless there is significant hydraulic communication between aquifers and can essentially be considered a single aquifer.

Using data from onsite monitoring wells and any pertinent site-specific data, provide potentiometric surface maps of aquifer(s) above and within the unit(s) to be quarried and dewatered. In some cases, it may be necessary to provide potentiometric surface maps of aquifer(s) below the bottom of the quarry pit. All potentiometric maps should include:

- Potentiometric surface contours
- Groundwater flow directions & any calculated horizontal gradients
- Groundwater/surface water interactions; recharge/discharge areas

- Observed surficial karst features
- Lateral extent of the proposed quarry pit (include extent at each phase, if possible)

Using data from onsite monitoring wells and any pertinent site-specific data, provide a minimum of two cross sections (long axis and short axis of the proposed quarry pit) that include the following:

- Lithologic units and their contacts
- Hydrostratigraphy
- Average and highest potentiometric surface(s) of aquifers above, within, and if necessary, below the bottom of the pit
- Groundwater/surface water interactions; recharge/discharge areas
- Vertical groundwater flow gradients if present
- Karstic features encountered during drilling
- Horizontal and vertical extent of the proposed quarry pit (include extent at each phase, if possible)

Provide a detailed explanation of how the average and highest potentiometric surfaces were determined.

Provide a table summarizing monthly groundwater elevation readings from all onsite monitoring wells. Provide elevations of any onsite surface water features, if measurements are available. Provide any precipitation data collected at the site during the groundwater elevation monitoring period.

Specify if the removal of rock will change groundwater flow and recharge.

Briefly discuss the project area's groundwater recharge susceptibility by evaluating site-specific data and comparing it to information provided in HA-18 and HA-20. Note any supportive observations or discrepancies.

IV. ENVIRONMENTAL INVENTORY (LITERATURE AND RECORDS REVIEW)

Provide on a map and in a table, the location only of the following environmentally sensitive areas within a two-mile radius of the maximum extent of the quarry:

- Public wells, private wells, permitted and non-permitted surface water intakes
- Streams, springs, ponds, lakes, wetlands
- Karst features (caves, natural and man-made sinkholes, subsidence areas)

It is not expected that each environmentally sensitive area be field-verified. Some available resources to complete the survey include:

National Wetland Mapper: <http://www.fws.gov/wetlands/data/mapper.HTML>

Groundwater Site Inventory: <http://waterdata.usgs.gov/ga/nwis/inventory>

USGS Direct Record Search: <http://ga.water.usgs.gov/about/inforequest-gw.html>

Private Wells/Public Wells/Surface Water Intakes: Review of EPD's Underground Storage Tank Corrective Action files, EPD's Hazardous Site Corrective Action Files,

EPD's Surface Water Withdrawal Permits, EPD's Groundwater Withdrawal Permits, Local Health Department Records

V. AQUIFER PUMPING TEST

EPD will typically require an aquifer pumping test as a basis for consideration of a surface mining permit unless previous investigations were conducted within the study area that accurately predicted the zone of influence and can be used to predict how the proposed new pit or pit expansion may affect this zone of influence.

When proposing an aquifer pumping test, describe in detail the methodology including:

- The criteria for selecting the test well and observation wells (RQD, fracture/lineament trace analysis, identification of major water producing fractures/voids/conduits, etc.)
- The type of aquifer pumping test to be performed (EPD recommends constant-head test)
- The duration of the test and subsequent recovery, and how often data will be collected during pumping and recovery
- The publication source of any equations that will be used to predict the zone of influence. Potential publications to consult include: Army TM 5-818-5, Navy NAVFAC-418, Air Force AFM 88-5 (Chapter 6)
- Describe any assumptions and limitations of the method(s) used to calculate the zone of influence
- If using software, note the type of software used, calibration issues, and model sensitivities

Submit to EPD for review and approval before completing the remainder of the workplan.



Once the aquifer pumping test is concluded, provide potentiometric surface maps and cross sections showing the predicted zone(s) of influence for aquifer(s) above, within, and if necessary, below the units to be quarried and dewatered. Maps and cross sections should show how dewatering will affect groundwater elevations and the corresponding potentiometric surface, flow directions, groundwater gradients, recharge, discharge of the aquifer(s), and surface water interactions. Maps and cross sections should be provided for each phase of quarry expansion, including the quarry's maximum extent and depth.

Again, the number of aquifer(s) evaluated is site-specific. Furthermore, the number of phases is site specific. A relatively small expansion may have only one phase whereas a large greenfield site or expansion, may have five or more phases.

VI. ENVIRONMENTAL INVENTORY WITHIN ZONE OF INFLUENCE

Provide a map and table of all environmentally sensitive areas within the predicted zone(s) of influence, even if the zone of influence is greater than two miles. Provide the following information for each sensitive area:

- Lakes, ponds, wetlands: Water levels
- Streams: Flows, perennial or ephemeral?, trout stream?, gaining or losing?, field parameters including temperature and turbidity (consider pH and dissolved oxygen)
- Private/public wells: Construction details, producing formations, pumping rates, water uses, turbidity
- Surface water intakes: Intake rates, water uses
- Springs: Flows, temperatures, and turbidity (consider pH and dissolved oxygen)
- Karst Features: Description & location

For each of the following environmentally sensitive areas identified within the zone of influence, briefly describe how dewatering may affect:

- Water levels of lakes, ponds, and wetlands
- Flows, turbidity, and temperature of streams (consider pH and dissolved oxygen)
- Temperature of trout streams and their habitat
- Turbidity and water levels of private and public wells
- Quality and quantity of water at surface water intakes
- Temperature, flows, and turbidity of springs (consider pH and dissolved oxygen)
- Ecologies of wetlands
- The impact on existing karst features and the development of new karst features

VII. CONCLUSIONS

The Professional Geologist (PG) or Professional Engineer (PE), in consultation with the mining operator, should choose one of the following:

1. Proposed quarry (or expansion) can proceed below the water table. No environmentally sensitive areas were identified within the zone of influence. Confirmation monitoring is required*. <Propose a confirmation monitoring program. Annual reporting is required unless a trigger requires immediate notification to EPD.>
2. Proposed quarry (or expansion) can proceed below the water. Environmentally sensitive areas were identified within the zone of influence. Confirmation monitoring and monitoring of sensitive areas within zone of influence are required. <Propose both a confirmation monitoring program and a monitoring program for any sensitive areas identified within the zone of influence*. Annual reporting is required unless a trigger requires immediate notification to EPD.>
3. Additional investigation is needed. <Provide a proposal outlining why additional data and analysis are needed, a plan to collect and evaluate that data, and a date in which the report will be submitted to EPD.>
4. Proposed quarry (or expansion) should not proceed below the established water table. <The mining operator will continue with the previously approved monitoring program to ensure there is at least a five (5) foot separation between the bottom of the quarry and the highest potentiometric surface or the mining operator will propose a monitoring plan that ensures at least a five (5) foot separation between the bottom of the quarry and the highest potentiometric surface.>

*The confirmation monitoring program and the monitoring program for sensitive areas should include a list of what will be monitored, the locations of all monitoring points, a description of how data will be collected, the frequency of data collection, and mitigation triggers and a mitigation strategy for any significant change in the data collected. Confirmation monitoring shall include, at a minimum, groundwater elevations from each onsite monitoring well (to confirm the predicted zone of influence from the aquifer pumping test), turbidity readings of groundwater in each onsite monitoring well and groundwater seeping into the pit, inspection of the area around the active pit for subsidence or sinkholes (where it can be done safely; survey area to be determined by PG or PE), precipitation amounts at the site, and groundwater flow into the pit derived from water balance equations. EPD's recommendations for the initial monitoring frequency:

- Groundwater elevations: (Daily with transducers, quarterly confirmation via water level indicator)
- Turbidity readings: Quarterly
- Inspection for the development of subsidence or sinkholes: Quarterly or semi-annually
- Precipitation amounts: Daily
- Groundwater flows into the pit: Quarterly
- Data collected at sensitive areas within zone of influence: Quarterly