

XVI. STAGES OF A GOAL EXPLORATORY PROGRAM AS RELATED TO GEOLOGY AND HYDROLOGY INFORMATION

Pertinent 30CFR¹ Sections:

- Maps
- Operation Plan

Mining companies collect geologic, hydrologic, and geochemical data on pre-mining conditions in a proposed permit area to:

1. define the quality and quantity of the coal resources,
2. determine how to minimize unexpected ground-water inflows to the proposed mining excavation,
3. provide information for the water-supply design for the mining and plant operations and support facilities, and,
4. satisfy the requirements of the regulatory authority to predict the potential geohydrologic impacts of the mining operation on the ground-water flow system(s) of the general area, by quantitative analysis, and (or) by ground-water modeling.

The four stages of a coal-mining exploratory program include mine feasibility, information evaluation, mine design, and mine operations (Coates and Yu, 1977). At the conclusion of mining, ground-water quantity and quality data are monitored to satisfy the requirements of the regulatory authority until bond release, which is granted when the monitoring data indicate the quality of the ground water and base flow are suitable to support the approved postmining land uses and that the water rights of other users have been protected or replaced (as described in chapter II herein).

1. Feasibility

The mine-feasibility stage starts with regional and local studies to collect geologic, hydrologic, and geochemical information. The first step is a comprehensive literature search (as described in chapter XV) and an examination of topographic maps, geologic maps, and aerial photographs of the general area. (These photographs are generally available from various Federal and State agencies.) From the information, the geologic setting (chapter IV) and hydrologic setting (chapter VI) can be estimated.

The maps and recent aerial photographs show the water and terrain features near and within the permit area that might influence the economic success of a mining venture. The water features include reservoirs, lakes, rivers, creeks, and swamps. If these features are adjacent to the permit area and are at a higher elevation than the coal bed(s) to be mined, inflow of water into the mining excavation is possible. Conversely, mining operations higher than surface-water features have a potential for surface-water contamination. Terrain features include active mine operations, abandoned mine areas, and landslides. If these features are adjacent to the permit area, water-quality problems and geologic hazards are possible.

¹CFR = Code of Federal Regulations

2. Evaluation of geohydrologic information

The second stage in the initial investigations of the exploratory program for mining is the detailed evaluation of the information collected in stage 1, within the general area, which also includes a field-reconnaissance trip. This step includes:

1. verification of the information compiled,
2. an examination of geologic and hydrologic activities within the general area, such as active mining, petroleum exploration and development, water-resource development (wells and reservoirs for water supplies), and water-treatment facilities, and,
3. a preliminary determination of water quantity and quality.

Other activities include:

1. Location of water wells and oil or gas wells and spotting them on the topographic maps. With this information, additional geologic and hydrologic data such as driller's logs (chapter VIII), and maps showing the occurrence of coal (section III) and ground water (chapter VI) can be obtained from State and Federal agencies.
2. Examination of outcrops to determine rock types, the presence of acid-forming minerals (pyrite, marcasite, siderite), neutralizing rocks (limestone and dolomite), and geologic structures (such as dipping beds, folds, faults, and fracture zones). This information, together with the drillers logs, forms a basis for a. preliminary geologic map and geologic cross sections.
3. Planning and implementation of:
 - (a) a drilling program including the layout of exploratory test-hole sites,
 - (b) the siting of geophysical survey lines, and
 - (c) the siting of hydrologic monitoring stations upgradient and downgradient of the proposed permit area.

If little or no hydrologic information is available, the drilling program and the geophysical surveying will be necessary to determine the geologic setting (chapter IV), the hydrologic setting (chapter VI), and the feasibility of the proposed mining.

4. Collecting and chemically analyzing ground-water samples and base flow samples (chapter XII) at the monitoring stations. This provides information on the chemical character of ground water.
5. Water-level monitoring (chapter IX) and aquifer testing (chapter X-2). Ground-water samples are collected and analyzed along with this testing.

The geohydrologic tasks of an exploratory program are listed in table XVI-1. The completion of these tasks is mandatory to satisfy ground-water regulations of the State regulatory authority for the proposed permit application. The end of the feasibility and information evaluation stages is determined by a management decision on the economic soundness of the proposed mining venture.

3. Design

This stage includes the collection and analysis of additional geologic and hydrologic field data, which are necessary to:

1. refine the coal-reserves estimate,
2. define the water-inflow problems (if any),
3. finalize the water-supply design, and,
4. quantify the impact of the mining operation on the aquifer systems and thereby satisfy the regulation requirements.

Activities in this stage include:

1. Aquifer testing in selected exploratory test holes within the permit area and adjacent area (chapter X-2).
2. Borehole geophysical logging to aid in aquifer delineation.
3. Interpretation of hydraulic properties for the impacted aquifer systems within the permit and adjacent area (chapter X-1), in terms of the above activities.
4. Delineation of confining beds adjacent to the coal seams to be mined.
5. Chemical analysis of water samples from base-flow sites and wells and springs (chapter XII).
6. Detailed well and spring inventory in the general area, which includes the investigation of ground-water pumpage and use (chapter VII).
7. Establishment of base-flow sites upgradient and downgradient of the permit site. Low-flow measurements are made within the permit area and adjacent area (chapter XI).
8. Drafting and implementation of ground-water monitoring plan in the permit area and adjacent area, including selected springs (if any), selected exploratory test holes for observation wells, and selected suitable inventoried wells.
9. Final water-supply design for the mine-plant operations and the support facilities.
10. Estimation of the potential hydrologic impacts (chapter XIII) of mining on the aquifer systems within the adjacent area through quantitative analysis and (or) digital computer ground-water-model analysis (chapter XV-7).
11. Completion of the products listed in table XVI-1 and as required by the State regulatory authority (chapter II).

4. Operations

At this stage, the mining-operations strategy has been resolved, the orientation of the adits has been defined, the water-supply facility has been constructed, the ground-water monitoring plan is operational, and the potential impact of the operations on the aquifer systems has been estimated.

The hydrologic data obtained from the monitoring system are compiled and submitted to the regulatory authority at least every 3 months, or more frequently if required. The authority may also require additional monitoring stations (chapter II), such as the conversion of core-test holes into observation wells. Additional observation wells will also need to be installed within and adjacent to waste-disposal (spoil) piles.

As the exploratory program continues to refine the coal-reserve estimates before mining the geohydrologic tasks (listed in table XVI-1) are also performed and refined on a continuing basis. Engineering evaluations include:

1. comparison of predicted water-level changes in the adjacent area against the observed water-level changes;
2. comparison of predicted ground-water pumpage from mine-dewatering operations against the actual pumpage; and,
3. comparison of predicted precipitation against actual precipitation data.

If the comparisons show little difference, the assessment of probable hydrologic impacts is satisfactory. If the estimates differ from the observed values by orders of magnitude, however, additional aquifer testing and computer-model analyses are necessary. Additional aquifer testing will improve the hydraulic properties data array in the ground-water model, and corrected pumpage data will also improve the results. The addition of updated hydrologic data in the model will yield a new estimate of the hydrologic impacts of mining. The regulatory authority should be kept informed of the changing projected conditions from the analytical or model runs.

Table XVI.-1– Geohydrologic investigation tasks for exploratory program, and resulting products and digital-computer modeling.

	Reference Chapter	Product
<u>Geologic Information</u>		
determination of Geologic Setting	IV	
literature search and bibliographic reference listing	XV	list of references
outcrop mapping for geologic map	XIX	map
underground/subsurface mapping for selected subsurface maps		map
measuring geologic sections to be shown on geologic map and cross section	VIII XIX	cross section cross section
surficial geophysical very low surveying - shallow seismic frequency		map
electrical resistivity techniques for definition of buried channels in bedrock (glacial terrain)		
downhole geophysical logging - contributing to geologic cross section		cross section
analysis of driller's logs borings test holes and cores for geologic cross section (s); also defines presence of pyrite and carbonate minerals in overburden	VIII XIX XIX	map cross section cross section
photogeologic analysis of structural geologic features (faults fracture traces folds and lineaments)	IV	map cross section
'well sitting' for the collection and analysis of driller's samples identifying aquifers and confining beds relative to the coal seams to be mined	VIII VI	cross section cross section
<u>Hydrologic Information</u>		
determination of Hydrologic Setting	VI	
literature search and bibliographic reference listing	XV	list of references
compilation of water-level data from driller's logs borings test holes downhole geophysical logging and 'well sitting' information.	IX	cross section table
definition of potentiometric surfaces for individual aquifers	IX	map
water well and table spring inventory for well and spring location map	VII	map
streamflow monitoring information (hydraulic boundary)* - existing streamflow information	X XI	map graph, table
base flow determination from existing information or from temporary gaging stations.	XI	graph, table
losing streams determined from seepage measurements	XI	map, table
demands for existing water supplies (surface-water use)		table
surface-water diversions such as for irrigation purposes		map
precipitation*		graph, table
define aquifers and confining beds	VI	cross section
aquifer recharge areas (hydraulic boundary)*	X	map
hydraulic properties of aquifers* from aquifer tests	X	table
laterally and vertically	X	table
ground-water use* including irrigation, industrial, commercial, domestic stock	VII	map, table
ground-water pumpage-rate inventory* including historical and time and space distribution	VII	table
ground-water monitoring plan (observation-well network) from existing hydrograph information* (for model calibration) and nested piezometers in borings	XIV IX	map graph, table
active- and abandoned-mine water discharge and mine pool information *		table
digital computer ground-water model analysis with input data tabulated for estimation of probable hydrologic consequences of proposed mining	XV(7)	tables cross section
<u>Geochemical Information</u>		
determination of water quality in time and space		
literature search - bibliographic reference listing	XV	list of references
water well and spring sampling	XII	map, table
stream base -flow sampling	XII	map, table
determination of alkalinity and acidity	XII	map, table
active- and abandoned-mine discharge water quality table information	XII	map, table
ground-water monitoring plan analysis of existing water quality	XIV	map
overburden analyses - analysis of acid-forming minerals	XIX	table
		cross section

* hydrologic data input for digital computer ground-water modeling, for areal drawdown effects.