Appendix B
Water Data Collection and Analysis

Basic Water Data Collection

Water quality, streamflow, and groundwater level data that are presented in permit application packages are to be collected, analyzed, and presented in a manner consistent with requirements. Generally, these data are in a format that makes them readily available to the public. Use of such a format may minimize data collection requirements for future permits. Applicable procedures for data collection, data processing, and laboratory analyses are described in the Office of Water Data Coordination's National Handbook for Water Data Acquisition (U.S. Geol. Survey 1977).

The recommended minimum duration of basic data collection for specific parameters includes appropriate seasonal high and low flow periods characteristic of the region under study. Because this short period of data collection may not reflect long-term variations in hydrologic conditions, the representativeness of the hydrologic data is evaluated by standard hydrologic statistical techniques or by comparison with long-term regional hydrologic norms.

It is recommended that an elevation datum at each monitoring station be established by level altimeter survey or other approved method, and be referenced to mean sea level. Determining the longitude and latitude of all monitoring stations facilitates storage and retrieval of data for future use, whether for the same permit or for others in the same area. Longitude and latitude are required if the data are to be entered into the national data base.

Surface Water

Surface water quantity and quality are normally measured on streams draining the area to be mined, as well as adjacent areas that may be affected by mining. For small operations these measurements may be made downstream from the mine plan area. Where perennial or intermittent streams transect the mine plan area, it may be appropriate to take additional measurements upstream from the proposed mine area.

Monitoring sites in and near the mine plan area that are to provide data used to estimate seasonal characteristics of the surface water should be chosen so that the following characteristics of surface water can be evaluated:

Surface Water Parameters and Frequency

Seasonal streamflow characteristics can be estimated from site-specific peak flow and low flow data collected during the pre-mine inventory. If models applicable to the area are not available, partial record stations equipped with crest-stage gages and staff gages for correlation (by graphical or statistical methods) with long-term flow data from nearby stations are often used.

Peak or Flood Flows

Peak flows during the sampling period can be determined by direct measurements or by indirect methods such as slope area, culvert computation, contracted opening, or other appropriate method. They should involve storm events. The return periods for these peak flows can be developed from flow frequency relationships, which may have to be indirectly estimated as described below. The storm runoff volume should also be estimated from peak flow and precipitation data.

Estimates of pre-mining flood flows may be available from published sources such as the statewide flood frequency reports of the U.S. Geological Survey. McCuen and others (1977) published a literature evaluation of techniques for determining flood flow frequency for ungaged natural watersheds. In addition, appropriate regional hydrologic models or techniques, including Soil Conservation Service methods described by Haan and Barfield (1978), may be useful to develop flood flow characteristics for desired frequencies.

Low Flows

Low flow is normally coincident with base flow and is highly dependent upon groundwater discharge into streams. Flow information is often collected at the surface-water monitoring sites. Flow calculations can be made using a standard current meter to determine velocity at a known cross-section. Estimates derived from open channel flow models or with a flume, weir, or similar device with an established rating can also be used. For very low flow situations, a calibrated container and a stop watch may be the most appropriate equipment. Flow data can be estimated from baseflow relationships of a nearby watershed for which long-term streamflow data are available. It is best if the nearby watershed is similar in area as well as topographic and vegetative characteristics.

Flow Duration

Flow duration estimates for the surface-water monitoring sites show the percentage of time that any flow may be equaled or exceeded. If sufficient data cannot be gathered at the monitoring sites to produce a flow duration curve, then data that are collected can be compared to duration curves of nearby gaged streams, and a duration curve can be synthesized for the monitoring sites. Where available, an appropriate regional model may be used to synthesize flow duration curves. Also, flow duration estimates can be calculated using regression equations based on basin characteristics and streamflow statistics for the state or the general area.

Models

Models may be useful to predict post-mining surface water conditions. Models may be calibrated for pre-mining conditions with data from nearby areas. Independent variables can be changed to reflect post-mining values and the models used to predict post-mining conditions. Another approach is to use nearby watershed studies and apply the ratio of pre-mining to post-mining effects to the pre-mining parameters in the mine plan area to predict post-mining effects on the watershed.

Modeling may be used to *estimate* impacts of mining upon aquatic biota. However, because modeling is an emerging art, models may not yet be available for *predicting* the consequences of mining on aquatic biota. At present, predictions are normally made on the basis of actual measurements of streams in the region, where water quality and flow regimes are similar to those in the area to be mined.

Chemical Water Quality

Field Measurements. The following parameters are normally measured at each surface-water monitoring site:

- Temperature, in degrees C
- pH, in standard units
- specific electrical conductance, in micromhos per centimeter at 25°C
- acidity titrated to pH 8.3, in mg/l as $CaCO_3$
- alkalinity titrated to pH 4.5 in mg/l as $CaCO_3$

Appendix D contains a quick reference guide for water quality sampling.

Laboratory Measurements. Samples are submitted for laboratory analysis for total dissolved solids, total iron, total manganese, dissolved iron, and total suspended solids. The results are expressed in milligrams per liter.

The samples are often analyzed for the major inorganic constituents (dissolved calcium, magnesium, sodium, potassium, chloride, nitrate, bicarbonate, and sulfate) and other relevant chemical constituents. These data can be used to aid in characterizing the chemical water type and the buffering and assimilation capacity of the streams.

On-site Erosion and Sediment

On-site erosion before mining should be evaluated for the same storms during which the peak flows are determined. Suspended solid samples should also be collected for these storms at the surface-water monitoring sites. Runoff volume, discharge peaks, and sediment loads could then be estimated for each of the storms.

Two approaches to erosion and sediment prediction and measurement are often used, one to estimate the average annual onsite erosion rate, the other to estimate the stream sediment loads resulting from a selected individual storm.

Onsite erosion rates can be estimated for the monitored storms using a modified universal soil loss equation (USLE) as described by Williams (1975). The watershed LS factor should be determined by the technique of Williams and Berndt (1976). The K and T factors are described by the Soil Conservation Service (1975a). Erosion estimates for the interior U.S. are discussed by the Environmental Protection Agency (1977); see also Wischmeier and Smith (1978). After the onsite erosion estimate is made, it should be compared with the suspended solids data to see whether a relationship can be demonstrated and the USLE parameter values validated. Data for the average annual erosion rate should then be developed for the same site for which the storm erosion estimates were made.

There are several approaches to predicting average annual on-site erosion. The USLE procedures were originally developed for agricultural use. A modification of the USLE has been developed for nonagricultural land use by Wischmeier (1975). Additional coefficient modifications pertinent to forest land management use were made by the U.S. Forest Service. Before these modified equations are used, the appropriate State or Federal forestry agency should be contacted for a copy of the appropriate guidelines.

An alternative approach to evaluating average annual onsite erosion that utilizes the USLE, but without the complex measurements, is described by the Soil Conservation Service (1975). Haan and Barfield (1978) also summarized the USLE approaches. Once the estimates of the parameters in the USLE have been validated for the premining conditions, certain of these parameters can be estimated for future conditions, and predictions can be made. If these predictions are to be translated to other locations, a sediment delivery ratio will have to be considered. This approach to sediment delivery must be used with caution because adjustments must be made for differing stream locations, changes in terrain due to mining, and the destruction of ground cover between the minesite and the stream.

Aquatic Biology

High flows may carry large volumes of sediment and organic matter, cause channel scour and redeposition, lower the dissolved oxygen concentration, and thereby change the habitat for fish and the organisms they eat. Disruption of continuous flows or frequent low flows containing acid or other toxic substances can also impair the aquatic (biologic) balance of the stream. Thus, to understand the complete hydrologic balance of an area, elements of the aquatic biologic community must be determined before mining to estimate what changes will occur as a result of mining. The macroinvertebrate population is considered a good indicator of a stream's "health."

The aquatic biology in perennial streams is identified by sampling. Sampling during low flows (preferably in early summer) can be used to estimate communities of biota. Considerations in defining the sample area include width, depth, riffle and pool areas, and sinuosity of the stream. Standard techniques for collecting macroinvertebrate samples allow for species identification, diversity, and density. The following physical parameters are normally recorded and considered in the analysis of the biologic community: streamflow, type of substrate, past or present watershed disturbance that may contribute effects to the sample site, and vegetative canopy over the stream. Biological sampling is often coordinated with routine monthly water quality sampling.

Groundwater

The effects of mining on the groundwater system can be estimated with appropriate groundwater flow and solute transport models, or from data collected before and after mining operations at nearby watersheds or research watersheds. Bachmat and others (1978) summarize many available models that simulate groundwater systems. Changes in groundwater characteristics can affect the water quality and flow characteristics of surface water streams. Baseflow characteristics are particularly susceptible to impact.

Groundwater Inventory

During an inventory of groundwater wells and springs the following information, if available, is usually collected:

- Depth of well
- Diameter of well
- Depth of casing and location of perforated or screened intervals
- Date drilled
- Use of water
- Static water level
- Yield of well
- Formation name and rock type of the aquifer(s)
- Location (elevation or depth below surface) of water-yielding zones
- Land surface elevation at well site
- Water quality
- Type of water treatment, if applicable
- Estimated amount of water used daily
- Permission to use the well for monitoring purposes or to test for hydraulic characteristics.

Groundwater Monitoring

Groundwater monitoring sites may consist of a combination of observation wells (appropriate existing wells or wells drilled specifically to monitor groundwater conditions) and existing springs.

For groundwater quality monitoring, emphasis should be on locating sites generally downgradient from the mine area because this is where the impacts of mining generally will be detected. The number of monitoring sites will depend upon the number of aquifers, whether they are present above and below the coal to be mined, and on the size of the mine area. Where coal seams are themselves aquifers, it may be necessary to install observation wells in the coal seams and to sample any water discharged from underground mines.

At least one observation well should be drilled for quality and water level monitoring unless sufficiently detailed information on groundwater is available or existing wells can be utilized for groundwater monitoring. The need for additional wells can be judged from the first well. Generally, the areal distribution and number of groundwater monitoring sites should be such that gradients and directions of flow can be defined. Under certain conditions, such as in fractured bedrock, these points of measurement may be quite variable. Unless there is no hydraulic connection between the proposed disturbed area and the underlying aquifer, it will be necessary to monitor groundwater in the first aquifer beneath the coal. The importance of wells above the coal is to document any dewatering of the aquifer as a result of mining. Further, where observation wells are drilled, those wells completed above the coal seam to be mined may have to be located close to those wells completed in the first saturated stratum below the coal seam so that potential vertical movement between aquifers can be evaluated.

Groundwater Parameters and Frequency

Water Level Elevations. Water levels are measured in observation wells. A well may be equipped with a continuous recorder or measured on a schedule so that a hydrograph of water levels can be prepared.

Field Water Quality. Samples for groundwater quality determinations are normally collected at times that correspond to seasonal high and low water levels and an intermediate time during the sampling period. Observation wells should be pumped or bailed until a representative sample of aquifer water can be obtained for water quality analysis as described earlier in this section.

Aquifer Characteristics. Aquifers are tested through observation wells. There are several types of tests: a standard pump test, instantaneous injection or withdrawal test, or bailer test. Water level data are analyzed to provide values of transmissivity, hydraulic conductivity, and specific capacity. Field tests may be required to determine storage coefficients. Existing boreholes or coreholes may be used for observation wells in storage coefficient tests.

Data Analysis. The observed data are tabulated and described relative to high and low water levels and water quality variations. Aquifers are classified according to the presence of unconfined (water table) or confined (artesian) conditions. Recharge and discharge areas for the aquifers are normally described on maps and cross sections showing groundwater levels, horizontal extent during seasonal high and low water levels, and other observed water level information. If more than one aquifer is present, groundwater level relationships and vertical movement between aquifers are usually described for seasonal high and low water levels. Also, a description of the present or potential future use of any aquifer is usually prepared.