APPENDIX H

REGIONAL EXAMPLE SHOWING BASELINE INFORMATION FOR GEOLOGY AND HYDROLOGY

EASTERN SITE

The number of locations at which site-specific baseline data for geology, overburden, surface water and ground water needs to be collected depends on many variables. Rather than presenting and attempting to rationalize minimum or maximum numbers and locations for surface-water stations, boreholes for overburden data, ground-water observation wells and frequency and duration of water sampling, we have included summaries of baseline information for geology and hydrology as it exists in planned or actual permits. We refer to these summaries as regional examples of baseline data requirements. In this context, regional can refer to hydrologic issues as may exist in one region but not all regions of the country and for which precise kinds and amounts of data are needed to establish, for example, the potential for acid-mine drainage formation. Regional may also refer to differences in philosophy and technical approach to sampling and standards deemed acceptable for baseline geology and hydrology information from one state or region to another.

The three examples of baseline information collection from different regions of the country are presented in Appendices H, I, and J.

- The following eastern permit example represents an area surface mine in a temperate humid region.

- The mid-continent permit example which is presented in Appendix I represents an area lignite mine in temperate continental region.

- The western example which is presented in Appendix J summarizes an actual work plan for baseline data collection for an area mine in a semiarid region. The plan was developed by the operator in close cooperation with the RA. The work plan illustrates how the need for new ground- and surface-water stations and data collection was based on an evaluation of existing information from nearby mines.

The Appalachian Region (AR) Mine is an area mine. The mine is situated in southeastern Tennessee in Sequatchie County about 35 miles northwest of Chattanooga. The area is within the Cumberland Mountains. The site is somewhat hilly with elevations ranging from 1800' to 1960'. The site receives about 54 inches of precipitation per year, and is primarily hardwood forested. The proposed acreage to be mined is 950 acres. Two draglines were proposed to be utilized along with “cast-blasting” techniques to move the overburden. In cast-blasting operations, the overlying 60 - 80 foot sandstone is drilled and blasted in such a manner to cast it into the previous pit. The coal seam has a history of producing acid or toxic mine drainage.

A. Geologic Setting

1. Physiography and Topography

The proposed mine site is located within the physiographic division of Tennessee known as the Cumberland Plateau. It is part of the Appalachian Plateau physiographic province of the eastern U.S. which extends from southern New York to central Alabama. The plateau consists of broad and relatively flat uplands which are capped with resistant Pennsylvanian age sandstones. These sandstones have protected the underlying, less resistant formations from erosion. The plateau is about 1000 feet higher than the surrounding lowlands. Surface elevations range from 1,700 to 2,000 feet in the region with some knobs considerably higher.

The eastern border of the plateau consists of an abrupt escarpment which is slightly dissected by eastern flowing streams. The western edge of the plateau is irregular and deeply dissected by western flowing streams.

The permit area for this operation is situated on the southern half of the Cumberland Plateau which is bisected by the Sequatchie Valley, a northeast-southwest trending valley approximately 180 miles long. The part of the Sequatchie valley which lies in Tennessee is 75 miles long and averages 5 miles wide.

2. Regional Structure

The Cumberland Plateau is bounded on the east by the Valley and Ridge Province which is characterized by imbricate faulting and folding and bounded on the west by the Nashville Dome, a broad arch with gentle southeast dip. The plateau region is divided into well drained sub-provinces of gentle dip which are separated by sharp structural features.

The mine site lies in the sub-province known as the Southern Cumberland Plateau, a broad symmetrical syncline, the axis of which is parallel to and near the western side of Sequatchie Valley. Along the western escarpment of the valley, the rocks dip steeply to the northwest, then gradually flatten out and begin to rise gently to the northwest in response to the syncline. Local variations of the regional dips are present as a result of local structure features but are often obscured due to the lack of detailed mapping.

3. Regional Stratigraphy

The subject area is entirely underlain by rocks of the Crab Orchard Mountain Group of the Pottsville series of lower Pennsylvanian age. This group contains, in descending order, the Rockcastle Conglomerate, Vandever Formation, Newton Sandstone, Whitwell Shale, and the Sewanee Conglomerate. The strata present in these formations are comprised mainly of well-cemented, often conglomeritic sandstones, olive-gray shales, and silty to sandy olive-gray shales. Coal seams of varying thicknesses are found in the shale zones throughout the group. The total thickness of the Crab Orchard Mountain Group in this area is 450 to 550 feet.

The Rockcastle Conglomerate is the youngest formation occurring in the group and it caps many of the higher ridges on the Plateau. This unit is a medium to coarse grained, conglomeritic, massive, cross-bedded sandstone and contains a persistent shale split generally less than 15 feet thick which contains the Nemo coal seam.

The next younger formation is the Vandever Sandstone. It usually consists of a lower shale member, a middle sandstone, and an upper shale member. This formation ranges up to 400 feet thick and usually contains at least 2 coal zones. The lower coal is less than 1 foot thick in the mine area.

The Newton Sandstone underlies the Vandever Formation and consists of a fine to medium grained, sometimes friable sandstone. Its thickness in the area is about 100 feet.

Below the Newton Sandstone lies the Whitwell Shale. This formation varies in thickness from 30 to 200 feet and sometimes contains a sandstone unit which is locally conglomeritic. The Whitwell Shale usually contains one important coal seam, the Sewanee, and often contains the Richland seam which occurs near the base of the formation. In areas where the Whitwell attains its maximum thickness, there can be four coal seams present.

The Whitwell Shale grades downward in the Sewanee Conglomerate. This formation ranges in thickness from 60 to 200 feet on the plateau. It generally occurs as a medium to coarse grained, crossbedded, massive, extremely conglomeritic sandstone, although sometimes the quartz pebbles may be completely absent. This sandstone is generally a very persistent, recognizable marker bed throughout the plateau except in the northwest region of the plateau where it rapidly pinches out.

4. Site Structure

The site structure consists of rocks with a northeast strike between 10 degrees and 25 degrees and a dip to the southeast between 1 and 2 degrees. Local rolls in the Sewanee coal zone are common and may result in slight variations in local dip. No major structural features are present within or immediately adjacent to the permit area.

5. Site Stratigraphy

A typical mining section within the permit area consists of 30 to 100 feet of Newton Sandstone overlying 10 to 50 feet of Whitwell Shale. The Newton Sandstone is a well indurated, micaceous orthoquartzite. Individual quartz grains comprising the sandstone are predominantly held together by silica cement. Occasionally, however, the silica cement will be replaced by sparry calcite.

The Whitwell Shale consists of olive gray thinly bedded shale. Lateral and vertical graduations to silty or sandy shale are present on the site and generally occur below the Newton Sandstone near the top of the Whitwell. Pronounced thickness variations in the two units have resulted from depositional factors and should be expected within the permit area.

The Sewanee coal seam lies near the middle of the Whitwell shale and is 15 to 60 inches thick. It is separated from the Sewanee Conglomerate by an average of 20 to 50 feet of Whitwell shale. The Richland coal seam lies approximately 20 feet below the Sewanee coal and consists of thin, discontinuous stringers.

The operation will mine the Sewanee coal seam, without disturbing the Richland seam. In some higher elevations in the permit area, the Lantana coal seam will be encountered, but the seam is too small and of poor quality to mine.

6. Structural Features from Deformational Processes

The site is relatively flat in comparison to many typical Appalachian mines. This means fracturing from stress relief is not significant. However, where first order streams have dissected the mine area there is some 10 to 40 feet of relief and some stress relief fracturing can be seen. On the eastern end of the property the mine nears Big Brush Creek, a second and third order drainage. Here the relief can approach 200 feet and stress relief fracturing can be significant. For this reason, the operation will remain 200 to 300 feet away from the major stream valley to minimize spoil leakage to the fracture zone.

7. Drilling Program

Much was known about the acid and toxic forming material at the site through experience with adjacent operations. There are three other large area mines adjacent to the site that provided important field data on the spoil water chemistry. The coal seam and overburden have pockets of acid-forming material that in other areas have caused acid mine drainage with pH just below 6 units and elevated iron and manganese concentrations.

Core drilling was conducted at the site. However, the drilling methods, equipment, and recovery techniques were not specified and sample and composite methods were not noted. The coal seams and overburden were analyzed for fizz, paste pH, total sulfur, pyritic sulfur, modified neutralization potential to account for siderite, and potential acidity. About 10% of the coal is not recovered in this type of operation so the acid base accounting model included a 10% coal waste factor. Analysis followed procedures contained in "EPA Field and Laboratory Methods Applicable to Overburdens and Mine Soils." (EPA 600 3.2 and ASTM C-25) The modified neutralization potential procedure consisted of addition of 5 ml of 30% H_2O_2 and then re-boiling before titrating the sample.

Drill hole samples were sent to the lab within 3 days to 18 days. Because samples can weather in a little as 3 days depending on humidity, OSM required future samples to be placed in plastic bags and delivered to the lab within 7 days.

The 60 foot sandstone unit above the Whitwell Shale was not analyzed except for the bottom 12 feet, because this strata normally tests out as net neutral, even when siderite is accounted for. The sandstone strata has been extensively tested at two adjacent mines adjoining this operation. The U.S. Bureau of Mines conducted x-ray diffraction tests on the overburden. The sandstone was subjected to leach tests by Dr. Frank Carrucio that showed that even though the rock has little potential acidity and much potential neutralization, it does not weather and release the stored alkalinity. For this reason, the sandstone was considered inert in the acid base accounting model, a conservative assumption.

In order to evaluate the AMD potential at the AR Mine, the applicant drilled 23 drill holes. This is equivalent to one drill hole per 40 acres. Almost every drill hole showed some acid/toxic forming material, primarily in the Whitwell Shale. There is also acid/toxic material associated with the Lantana coal seam which is present in the west portion of the proposed permit area. A thickness weighted Net Acid Base (NAB) value was calculated for each hole for the Whitwell Shale zone, using total sulfur. Volume weighted calculations were not necessary since the site is flat and the operation will not mine to the outcrop.

Drill hole data from the adjacent AR2 Mine was also evaluated since it was drilled on 500 foot centers (or one drill hole per 5.7 acres). This data showed the shale zone as having the major portion of pyritic material.

OSM used Universal (I) Kriging software to interpolate the data at the AR2 Mine and extrapolate into the adjacent proposed AR Mine. A 500' by 500' grid was created using ARC/INFO software. The Kriging program calculated a predicted NAB value for empty cells based on cells that contained drill hole data. Ninety nine drill holes were used in the simulation. The results showed most of the acid-forming materials is confined to the south 1/3 of the permit area.

OSM also used a statistical technique called Semivariographs, to evaluate the proper drill spacing. The model calculates the semivariance between each pair of drill holes located so many feet apart. The difference is squared and summed, then divided by the number of pairs squared. This produces a semivariance for a distance X. Then another set of drill holes located a slightly larger distance apart is analyzed. The result is a plot of semivariance versus drill hole distance. The line is fitted to one of several distributions for a proper fit. If the plot results in a plateau, the distance at which the semivariance flattens out is deemed to be the optimum drill hole spacing. Drilling closer than this distance results in more holes than needed; drilling farther than this distance results in missing variation in the geochemistry. The basis for Kriging and Semivariograms, including its limitations and assumptions, is the subject of much debate. However, using these two methods did provide an impartial evaluation of drill hole spacing and appeared to confirm an optimum drill hole spacing of about 650 feet.

As a result OSM required the operator to conduct additional drill hole sampling on 650 foot centers as the mining progressed to fine tune the amount of lime to apply on site.

8. Overburden Analysis

The acid-base accounting model was used to determine areas where net acid-forming materials were located that would need lime amendments. The operator assumed that any strata with a net neutralization potential less than zero would be acidic. The coal, floor clay and pit cleanings were found to be acidic throughout the mine area. For this reason, a separate acid base account model was run for these strata. Then a map was created showing zones of how much lime would need to be added to the pit floor to make it net neutral.

The acid base account model used for adjacent mining operations showed the Newton sandstone to be net alkaline throughout the adjacent areas. However, column leach tests also showed that this material does not weather easily and therefore does not release the alkalinity. For this reason, the Newton sandstone was excluded from the acid base accounting model for this mine. This makes the accounting model conservative, as it is expected some alkalinity will be released from the 80-foot sandstone over time.

The remaining shale strata were then evaluated using the acid base accounting model. Acid forming material was found to be non-heterogeneous and non-isotopic within the permit area. In some areas the net neutralization potential (NNP) was above 30, in other areas the NNP was below 20 tons/1000 tons. For this reason, the operator divided the mine areas into zones with similar NNP. A map was developed showing these zones so that proper lime amendments could be determined.

B. Baseline Information On The Hydrologic Balance

In order to make a finding of no “material damage to the hydrologic balance outside the permit area” OSM required the company to discuss and provide baseline information on the hydrologic balance. Part of the information supplied by the operator was a water budget (See Tables H-1 and H-2 below).

TABLE H-1: Annual premining water balance

Land Use = forest
No treatment or practice
Hydrologic condition = good
Soil type = sandy loam

Infiltration = average
SCS runoff curve number (AMC II)=55
Monthly runoff coefficient (AMC II) = 0.3

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Soil depth, inches	24	24	24	24	24	24	24	24	24	24	24	24
Water holding capacity, inches/inches	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Max. soil storage, inches	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Hydrologic Soil Group	B	B	B	B	B	B	B	B	B	B	B	B
Precipitation, inches	4.5	6.8	7.6	4.4	4.7	6.0	4.5	4.8	4.7	3.7	4.4	7.8
Precipitation, number of days	8.0	6.3	8.0	7.7	7.4	9.3	8.4	6.9	6.3	5.4	5.4	7.4
Average number days between events	3.9	4.4	3.9	3.9	4.2	3.2	3.7	4.5	4.8	5.7	5.6	4.2
Precipitation/event	0.6	1.5	2.0	1.1	1.1	1.9	1.2	1.1	1.0	0.6	0.8	1.9
Average Precipitation over 5 days	0.7	1.7	2.5	1.5	1.3	2.9	1.6	1.2	1.0	0.6	0.7	2.2
Antecedent Moisture	2	3	3	2	1	3	2	1	1	1	2	3
Potential Evapotranspiration, inches	0.2	0.3	0.8	2.2	4.8	7.1	7.8	6.0	3.0	1.0	0.3	0.2
AMC-adjusted curve number	55	74	74	55	34	74	55	34	34	34	55	74
AMC-adjusted monthly curve number	0.3	0.4	0.4	0.3	0.2	0.4	0.3	0.2	0.2	0.2	0.3	0.4
Direct Runoff, inches	1.3	2.7	3.1	1.3	0.9	2.4	1.3	0.9	0.9	0.7	1.3	3.1
Previous month soil moisture	2.4	2.4	2.4	2.4	2.4	1.6	0.4	0.1	0.0	0.9	2.4	2.4
Net inflow to soil, inches	3.0	3.8	3.7	0.9	-1	-3.5	-4.7	-2.1	0.9	2.0	2.7	4.5
Accumulated potential loss	0.0	0.0	0.0	0.0	-1.0	4.0	-9.2	-11.	0.0	0.0	0.0	0.0
Current month soil moisture	2.4	2.4	2.4	2.4	1.6	0.4	0.1	0.0	0.9	2.4	2.4	2.4
Change in moisture, inches	0.0	0.0	0.0	0.0	-0.8	-1.2	-0.3	-0.0	0.9	1.5	0.0	0.0
Moisture surplus, inches	3.0	3.8	3.7	0.9	0.0	0.0	0.0	0.0	0.0	0.5	2.7	4.5
Available for recharge, inches	5.9	6.7	7.1	4.4	2.2	1.1	0.6	0.3	0.1	0.5	3.0	6.0
Recharge/baseflow, inches	3.0	3.4	3.6	2.2	1.1	0.6	0.3	0.1	0.1	0.3	1.5	3.0
Detention, inches	3.0	3.4	3.6	2.2	1.1	0.6	0.3	0.1	0.1	0.3	1.5	3.0
Recharge/Baseflow in feet^3 per square miles	2.58	3.23	3.08	1.98	0.96	0.50	0.24	0.12	0.06	0.23	1.34	2.58

Table H-2. Annual water budget summary

Precipitation, in.	**63.9 in.**
Evapotranspiration, in.	**24.9 in.**
Direct Runoff, in.	**19.9 in.**
Recharge, in.	**19.1 in.**
Baseflow in cfs per sq. mile	**1.42 cfs/sq. mi.**

From: AR Mine Permit, PHC, using Thornthwaite.

1. Surface-Water Baseline Flow and Quality Information

The OSM and permittee evaluated three basic data sources for surface water information: (1) regional water resource data supplied by the US Geological Survey (USGS), Tennessee Geological Survey, and EPA Storage and Retrieval Database (STORET); (2) local hydrologic data provided by the US Department of Agriculture (USDA), Forest Service (Dyer, 1982) and the Tennessee Department of Environment and Conservation; and (3) site data provided by the mining company.

The table at the right (Table H-3) shows the watershed area for the three regional streams. In addition, the tables below show comparative flow rates for various recurrence intervals. The USGS regression equations were used to estimate discharge rates for a 24 hour storm. As a check, one stream (Little Brush Creek) that had actual daily discharge records for more than 10 years was evaluated for peak flows. The data was taken from a USGS report (Weaver, 1993, p.10). The peak flow calculations in Table H-4 were made by taking the logarithms of annual peak flow and fitting them to a Log Pearson Type II distribution. The gauge had 28 years of record. The results from both methods showed similar results but the method by Weaver would be expected to be more accurate since it is based on actual data from the gauging station. Also included in Tables H-5. and H-6. are calculated low flows for various flow durations, flow volumes, and monthly flows at various recurrence intervals using USGS procedures (Wetzel, 1986).

Table H-3. Watershed areas for three regional streams

Watershed	**Acres**	**Sq mile**
Big Brush Creek at Little Brush	**30528**	**47.7**
Little Brush Cr.	**9856**	**15.4**
Big Brush Cr. at Sequatchie River	**42304**	**66.1**

Table H-4. Calculated and actual peak flows, in cfs, for three regional streams

Watershed	Qp-2	Qp-5	Qp-10	Qp-25	Qp-50	Qp-100
Big Brush Cr.	3146	4959	6342	8320	9965	11796
Little Brush	1327	2146	2785	3712	4498	5381
(Actual data)	1870	2520	2940	3460	3840	4220
Big Brush at Sequatchie R.	4072	6387	8147	10663	12751	15075
Sequatchie R.	11328	16697	21470	25531	29420	33568

Peak flows; (Wetzel,1986) $Qp = a * Area^{b1} * (Precip\text{-}30)^{b2} * Slope^{b3}$

Table H-5. Mean annual and monthly flow in cfs, for three regional streams

	Year	J	F	M	A	M	J	J	A	S	O	N	D
Big Brush	92	164	185	199	148	80	40	37	25	20	18	53	119
Little Brush	31	53	61	65	49	27	13	12	8	7	6	19	41
Brush at Sequatchie	124	226	255	272	202	108	53	51	34	27	23	71	159
Sequatchie R.	530	999	1108	1179	858	459	228	226	152	114	94	288	645

Flows; (Wetzel,1986) $Qp = a * Area^{b1} * (Precip\text{-}30)^{b2} * Elevation^{b3}$

The USGS methodology was also used to calculate the low flow for a 7-day 2-year, 7-day 5-year, 7-day 10-year, 7-day 20-year, 3-day 2-year, 3-day 10-year, and 3-day 20-year low flows (Wetzel, 1986). Table H-6 below shows the results. The standard error in these calculations is fairly high making interpretations difficult, especially for smaller watersheds.

Table H-6. Low flow (x-day, y-year), for three regional streams

FLOW IN GPM @	Q 7,2	Q7,5	Q 7,10	Q 7,20	Q 3,2	Q3,10	Q 3,20
Big Brush Creek at Little Brush	0.67	.006	.0018	.0018	0.327	.0008	.0007
Little Brush Cr.	0.18	.002	.0004	.0005	.087	.0002	.0002
Big Brush Cr. at Sequatchie River	0.818	.007	.0019	.002	.393	.0009	.0007
Sequatchie River	4.46	.04	.103	.0098	2.14	.0044	.0039

@ Gallons per minute = a Area $Precp^{b3}$ $Slope^{b4}$ $Storage^{b5}$ $Elev^{b6}$ $Cratio^{b7}$, as described in Wetzel, 1980.

Regional water quality data was scarce for the study area. USGS gauging and sampling stations were reviewed as well as EPA's STORET database. The USGS stations are located on Big Brush Creek, Little Brush Creek, and at the confluence with Sequatchie River. Stream water quality data from 1977-1979 was reviewed to evaluate water quality conditions prior to implementation of SMCRA. Table H-7 below compares Big Brush Creek with Little Brush Creek and Sequatchie River upstream at Mt. Airy as well as downstream at Whitwell. Most of the mining in Big Brush Creek watershed has occurred after 1978.

Table H-7. Water quality conditions in Big Brush Creek, Sequatchie River at Mt. Airy and at Whitwell prior to implementation of SMCRA

Big Brush Cr	Q	EC	pH	Tem	Alk	S04	tFe	dFe	Mn	TSS
11/6/79	88	39	7.1	11	10	6.3	.14	.02	.01	<10
3/18/80	700	32	7.4	8	9	5.6	.27	.02	.02	7
Little Brush										
11/6/79	18	38	7.6	9.5	10	7.3	.13	.01	.01	<10
3/18/80	192	40	7.9	7	8	6.6	.18	.01	.02	6
Sequatchie at Mt Airy										
11/6/79	292	200	7.8	12	95	7.9	.44	.06	.04	10
3/18/80	1300	160	7.5	11	84	8.4	2.3	.06	.24	126
Sequatchie at Whitwell										
11/6/79	493	155	7.8	11	66	8.6	.39	.03	.05	86
3/18/80	3420	95	7.4	10	36	7.8	1.2	.06	.11	46

Data in mg/L except discharge (Q) in cfs, electrical conductivity (EC) in mhos/cm and pH in standard units.

The results show a stream system relatively unimpacted by mining as evidenced by the low sulfate values, neutral pH, and low conductivity. Other data from the 1970's show similar results for other times of the year. In addition, data from EPA’s STORET database included data collected by the Tennessee Valley Authority (TVA) on Big Brush Creek just above the confluence with Little Brush Creek. These data also show a stream system little impacted by mining or other land uses. Low alkalinity is typical of undisturbed watersheds in the Cumberland Plateau.

Data from the U.S. Forest Service was reviewed to characterize nearby mined and unmined drainages (Dyer, 1982). The review identified 6 sites within a couple of miles of the Big Brush Watershed. Data was collected June 1977 through August 1979 just after passage of SMCRA.

Table H-8 following lists the sites:

Table H-8. List of U.S. Forest Service Coal Hydrology Stations *

Site	Dates of Mining	Acres	Percent Disturbed	Description
7141	Unmined	217	0	Tributary to Savage Creek
7142	1950-1973	43	40	Tributary to Dry Creek At Cagle
7143	1948-1969	38	42	Tributary to Big He Creek
7152	1948-1974	15	35	Tributary to Big Branch
7153	1948-1972	340	10	Tributary to Big Branch
7156	1955-1970	357	6	Tributary to Spring Creek

* Dyer, 1982

The metal and trace element concentrations were low. Some acidity in the range of 5 to 12 mg/L as $CaC0_3$ was also present. This is not uncommon since stream flow in many undisturbed watersheds is similar to the chemistry of rain water.

The permittee also calculated the 7-day, 10-year low flow; the 3-day, 20-year low flow; and the 30-day, 2-year low flow for each of the major streams. This is because the water quality criteria apply down to certain low flow events, depending on whether the user is a domestic, aquatic, livestock, or irrigation user.

2. Surface Water Data

Table H-9 following shows the dates of sampling by the permittee at the site:

Table H-9. Dates of sampling by permittee at various monitoring sites

Site[1]	Sampling Dates						
SW-1	4/26/95	6/28/95	10/25/95	4/30/96	5/14/96	6/20/96	9/5/96
SW-2	4/26/95	6/28/95	10/25/95	- - -	5/14/96	6/20/96	9/5/96
SW-3	4/26/95	6/28/95 (dry)	10/25/95	- - -	5/14/96	6/20/96	9/5/96
SW-4	4/26/95	6/28/95	10/25/95	- - -	5/14/96	6/20/96	9/5/96
SW-5	1/14/95	4/13/95	10/15/95	- - -	5/14/96	6/20/96	9/5/96
SW-6	- - -	- - -	- - -	- - -	5/14/96	6/20/96 (dry)	9/5/96 (dry)
SW-7	- - -	- - -	- - -	- - -	5/14/96	6/20/96 (dry)	9/5/96 (dry)
BBC	- - -	- - -	- - -	4/30/96	5/14/96	6/20/96	9/5/96
GF	- - -	- - -	- - -	4/30/96	5/14/96	6/20/96	9/5/96
BBC (TS)	- - -	- - -	- - -	4/30/96	5/14/96	6/20/96	9/5/96
BBC (127)	- - -	- - -	- - -	4/30/96	5/14/96	6/20/96 (dry)	9/5/96 (dry)

[1]Site	Description
SW-1	Big Brush Creek (BBC) above the permit area - Perennial Stream
SW-2	Unnamed tributary to BBC - Intermittent
SW-3	Unnamed tributary to BBC - Intermittent
SW-4	Unnamed tributary to BBC - Intermittent
SW-5	Big Brush Creek below permit area - Perennial Stream
SW-6	Unnamed tributary to BBC- Intermittent
SW-7	Unnamed tributary to BBC- Intermittent
BBC	Big Brush Creek upstream of site SW-1 - Perennial
GF	Glady Fork at confluence with BBC - Perennial
BBC (TS)	Big Brush Creek at Trend Station - Perennial
BBC (127)	Big Brush Creek at Highway 127 - Perennial

a. Water Quality

Basic parameters were analyzed quarterly, including field measurements and laboratory analysis. An expanded list of metals and trace elements was analyzed each summer in addition to the standard parameters.

(1) Field Measurements (Monthly)

pH
Temp
Specific Conductivity
Dissolved Oxygen
Discharge

(2) Laboratory - Standard parameters.

Unfiltered samples were taken to allow comparison with Tennessee Water Quality criteria, which are based on total recoverable metals.

pH
Total Acidity
Total Alkalinity
Total Suspended Solids
Total Dissolved Solids
Total and Dissolved Iron
Total and Dissolved Manganese
Sulfate
Specific Conductivity

(3) Laboratory - Expanded Analysis

Total Aluminum
Total Calcium
Total Magnesium
Total Hardness
Total Arsenic
Total Chromium
Total Copper
Total Lead
Total Mercury
Total Nickel
Total Selenium
Total Zinc

(4) Flow Measurements

ASTM Method D3858 (Area Velocity Method) - Using engineer's tape and determining width of stream at sampling point. Stream depth measured at each foot interval across stream section with velocity recorded at 6/10th at each interval using a Mead flowmeter. Total discharge determined by summing the discharges of each partial section.

Low or small discharges where velocity meter could not be used were measured using bucket/stopwatch if a pipe was available or by measuring width and estimating velocity via a partially floating object.

(5) Preservation

All samples were field cooled (wet ice) and delivered to the laboratory in an insulated cooler. Metal samples were field preserved with nitric acid (2 ml or pH 2). Other sample bottles were prepared as appropriate for the analytical parameter. Each sample shipment had a chain-of-custody for the laboratory to accept receipt of samples. The chain-of-custody record contained sufficient information to trace sample possession from collection to analysis.

Samples routinely include:

1) One liter plastic container for general analysis.

2) One liter plastic container, plus nitric acid for metals (total).

3) A 500 ml plastic container, field filtered (.45 micron), plus nitric acid for dissolved metals analysis.

4) One 500 ml plastic container, plus sulfuric acid for ammonia analysis.

(6) Analysis procedures (QA/QC)

All laboratory analysis followed EPA or ASTM methods in accordance with 30 CFR 780.21(a). Likewise, for each set of analysis, a sample duplication, field blank, spikes, and standards were analyzed. A quality control program which conforms to 40 CFR 146 was followed by each lab and was included in the application.

b. Precipitation records and chemistry

Much of the ambient streamflow is from surface runoff and ground-water discharge (soil / bedrock interflow, and fracture flow). In areas undisturbed by mining, the stream water quality can mirror rainfall chemistry. The data on rainfall chemistry included the statistical analysis of 95 weeks of sulfate data, 86 weeks of conductivity data and 87 weeks of pH data from the National Trends Precipitation Network gauge at the Hatchie National Wildlife Refuge rain gauge at Hillville, Tennessee. Data is from October 1993 to September 1995. The pH is about 4.5, the sulfate median is 1.75 mg/L, and the median conductivity is about 19 umhos/cm. These values compare with stream quality in undisturbed drainages in the vicinity of the mine area.

In addition, the permittee included seven years of rainfall records from the adjacent mine site.

c. Biological Data

The permittee was required to conduct an aquatic survey of the first order drainages that flowed within the permit area. The study evaluated physical stream characteristics, such as stream substrate, pool and riffle characteristics, riparian vegetation, stream flow, and evidence of man-made impacts.

Fish populations were sampled at five locations on three separate creeks that were proposed to be mined through. Observations were also made of amphibians, reptiles and waterfowl that were encountered. The traveling kick method (TKM) was used to sample the macroinvertebrate populations. Two TKM's were taken on a transect about mid-riffle. A kicknet with a mesh of 1050 microns was placed on the substrate and moved in an upstream direction for 10 feet in two minutes. Samples were fixed in the field with 5% formalin and preserved in the laboratory with 70% alcohol. Identification was done by standard references by Pennak, 3rd edition; and by Merrit and Cummins, 2nd edition.

The fish community was summarized using the Index of Biological Integrity (IBI) specified by EPA. The macroinvertebrate population used similarity indexes, modified Family Biotic Index, Total taxa and particular taxa diversity (EPT), and Trophic Relationship Comparisons.

d. Sediment Data

The permittee conducted a sediment sampling program at OSM's suggestion to document the physical and chemical nature of stream sediment adjacent to the operation, prior to any mining. Both the physical characteristics, such as color and texture, were evaluated, as well as chemistry. The chemistry was determined using sequential acid-extraction methods on the fine sediments.

e. Ground-Water Baseline

Twelve Ground-Water Monitoring Stations were installed:

- 3 wells were drilled into the Newton Aquifer.
- 3 wells were drilled into the Sewanee Conglomerate Aquifer.
- 3 wells were drilled into the Sewanee Coal seam.
- 3 wells were drilled into the Richland Coal seam.

Regional potentiometric data is also available for the upper reaches of Big Brush Creek. The application included a potentiometric map submitted as part of a prior coal exploration permit that included the AR Mine area. The map was constructed with water level data from more than 16 wells. The exact dates of the water levels used in the map are unknown. The permittee also included four potentiometric contour maps of the mine area using data from on-site wells. These four maps were generated using water elevation data collected during four different quarters to show the seasonal variations in potentiometric head.

Aquifer tests have been conducted in the Newton Sandstone as well as the backfilled spoils at the company's other mines in the area. Data for 7 wells, available from the coal exploration permit previously cited, are summarized in Table H-10 below.

Table H-10. Summary of information derived from aquifer tests at seven well in the Newton Sandstone

Well	Pump Rate (gpm)	Draw-down (ft)	Time (min)	Specific Capacity (gpm/ft)	Transmissivity (gpd/ft)	Storage Coeff.	Est.[1] Hydr. Cond.
801	12	<60	247	>0.20	>400	NA	1.34
802	12	6	242	NA	417	.00066	1.39
802	12	22	8	<0.68	NA	NA	-
803	12	0.12	50	NA	NA	NA	-
804	12	108	10	0.14	<140	NA	.46
805	12	98	15	0.15	<150	NA	.50
806	12	<65	20	<0.23	<230	NA	.77

[1] Hydraulic conductivity, in ft/day, assuming 40 feet saturated thickness

The transmissivity and hydraulic conductivity can only be considered rough estimates. No data were available on saturated thickness which are needed to calculate hydraulic conductivity. The permittee also conducted a pump test in a spoil aquifer at an adjoining mine that had been mined and reclaimed using the same operations plan. The result showed a transmissivity many times greater than the undisturbed sandstones in the area.

(1) Ground-Water Quality

Baseline ground-water quality data are available for the Newton Sandstone in the vicinity of the proposed mine. Well data from April and June of 1995, and from May, June, and September, 1996 were evaluated. There was little variation in water levels. The pH ranged from 6.2 to 6.5 units. Specific conductance (EC) ranged from 56 to 107 with a median value of 71 umhos/cm. Sulfate was always less than 5 mg/L. Dissolved iron ranged from 0.04 to 1.64 mg/L with a median value of 0.54

mg/L. Manganese was less than 0.6 mg/L. A full suite analysis was conducted on one sample dated 9/5/96. Results showed alkalinity of 40 mg/L, TDS 70 mg/L, calcium 10 mg/L, and 2 mg/L of magnesium. None of the metals and trace elements were high except for iron. These data indicate that ground water from the Newton sandstone is similar to the baseline (unmined) surface water quality.

(2) Ground-Water Parameters

The analysis dates and parameters for the twelve monitoring wells were similar to the surface-water baseline data program.

(3) Well Bailing Procedures

The well's static water level and total depth were measured prior to any bailing. Wells were purged using a low capacity variable rate pump mounted on a four wheel mini-ATV. The rate of pumping was maintained slow enough to prevent total dewatering of the well or rapid drawdown that may stir up the well. At least three well volumes were purged prior to sampling. The sample was taken 24 hours later after the sediment in the well was allowed to settle out. A PVC bailer was used.

(4) Sample Preservation

All well samples were field filtered with a 0.45 micron filter to remove any man-induced sediment that may have been stirred up during bailing. Water moving through these ground water systems is so slow that sediment is not transported. All samples were field cooled (wet ice) and delivered to the laboratory in an insulated cooler. Metal samples were field preserved with nitric acid (2 ml or pH 2). Other sample bottles were prepared as appropriate for the analytical parameter. Each sample shipment had a chain-of-custody for the laboratory to accept receipt of samples. The chain-of-custody record contained sufficient information to trace sample possession from collection to analysis.

(5) Data Presentation

Both the surface- and ground-water data were presented using a variety of methods including graphs, trilinear diagrams, stiff diagrams, boxed notch and whisker diagrams, bar charts, and histograms. Over 60 charts were included in the application to allow a visualization of the data.

C. Baseline Data For The CHIA

The Cumulative Impact Area (CIA) for this operation consists of the Big Brush Creek Watershed down to the confluence with Little Brush Creek. All of the operation is contained within and discharged to Big Brush Creek. In addition, the ground water in the shallow fracture system and deeper bedrock aquifers moves to the southeast and discharges into Big Brush Creek about 2 miles downstream of the operation.

For preparation of the CHIA, OSM collected data in cooperation with the State Division of Water Pollution control. Eight surface water sites were sampled for chemistry and seven ground water monitoring wells were sampled. The chemical parameters included:

Field pH
Field Temperature
Field conductivity
Flow or water elevation
Alkalinity
Acidity
Total Suspended Solids
Total Dissolved Solids
Chloride
Sulfate
Fluoride
Phosphorus
Aluminum
Arsenic
Barium
Boron
Cadmium
Calcium
Chromium
Copper
Iron
Manganese
Lead
Magnesium
Mercury
Nickel
Potassium
Selenium
Silica
Silver
Sodium
Thallium
Zinc

OSM evaluated the water quality from other mines in adjacent CIAs that mined the Sewanee coal seam. This was done to determine which metals, trace elements and major ions would be important to look for. Tables H-11 and H-12 show that a number of chemical parameters were found in significant concentrations.

Table H-11. Metals and trace elements of concern (concentrations in mg/L)

PARAMETER	AVERAGE	MAXIMUM	ACUTE WQ[1]	CHRONIC WQ[2]
Al, Total	1.735	11.2	0.750	0.087
Al, dissolved	0.354	2.87		
Cd, Total	0.0035	0.011	0.0018	0.00066
Cd, dissolved	0.0033	0.011		
Cu, Total	0.0141	0.08	0.0093	0.0065
Cu, dissolved	0.0016	0.004		
Fe, Total	19.3	125	1.0	1.0
Fe, dissolved	4.39	51.4		
Pb, Total	0.0078	0.047	0.0344	0.00134
Pb, dissolved	0.0014	0.004		
Ni, Total	0.130	0.63	0.789	0.0877
Ni, dissolved	0.111	0.63		
Zn, Total	0.1726	1.13	0.065	0.0589
Zn, dissolved	0.075	0.411		

Note: A value of 50 mg/L hardness is assumed in deriving criteria.

[1] The acute water quality criteria is usually the 24 hour average.

[2] The chronic water quality criteria is usually the 4-day average concentration.

Table H-12. Major ions found

CATIONS	AVERAGE, in mg/L	AVERAGE, in meq/L
Calcium	65	3.23
Magnesium	31	2.57
Sodium	8	0.35
Potassium	4.3	0.11
Manganese	7.2	0.26
Iron	4.39	0.24
Aluminum	0.35	0.04
ANIONS		
Sulfate	296	6.17
Bicarbonate	87	1.42
Chloride	1.7	0.005
Ammonia	0.27	0.02
Fluoride	0.28	0.015
Nitrate	0.11	0.013

OSM also obtained unpublished pump test data on 7 wells in the CIA along with regional potentiometric maps from the operator.

The State also conducted a biological assessment of the aquatic life in the streams. Four biological survey sites were established to collect ambient aquatic life conditions in the streams adjacent to and downstream of the site. Sampling of benthic organisms was conducted along with fish sampling.

D. References

ASTM Method D3858-95, Standard Test Method for Open-Channel Flow Measurement of Water by Velocity-Area Method; American Society for Testing and Materials, West Conshohocken, PA.

Dyer, K.L.,1982 Stream Water Quality in the Coal Region of Tennessee, USDA, Forest Service, Northeast Forest Experimental Station, General Technical Report NE-77; Berea, Kentucky.

Merritt, Richard W. and Cummins, Kenneth W., 1984, An Introduction to the Aquatic Insects of North America, Second Edition; Kendall/Hunt Publishing Company, Dubuque, Iowa.

Pennak, Robert William, 1989, Fresh-Water Invertebrates of the U.S.: Protozoa to Mollusca, 3rd Edition; John Wiley & Sons.

Sobek, A.A., W.A. Schuller, J.R. Freeman, and R.M. Smith, 1978, Field and Laboratory Methods Applicable to Overburdens and Mine Soils. EPA 600/2-78-054, U.S. EPA, Cincinnati, Ohio.

Wetzel, K.L.and Bettandorff, J.M., 1986, Techniques for Estimating Streamflow Characteristics in Eastern and Interior Coal Provinces of the United States; USGS Water-Supply Paper 2276, 80 p.

Weaver, Jess D. and Gamble, Charles R., 1993, Flood Frequency of Streams in Rural Basins of Tennessee; USGS Water Resources Investigations Report 92-4165.