Tennessee Valley Authority
Resource Stewardship

Aquatic Ecological Health Determinations for TVA Reservoirs--2000
An Informal Summary of 2000 Vital Signs Monitoring Results and Ecological Health Determination Methods

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AQUATIC ECOLOGICAL HEALTH DETERMINATIONS
FOR TVA RESERVOIRS--2000

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Section 1. Reservoir Monitoring -- Overview of Approach, Methods, and 2000 Results

Introduction

The Tennessee Valley Authority (TVA) began a program to systematically monitor the ecological condition of its reservoirs in 1990. Previously, reservoir studies focused on reservoir specific assessments to meet specific needs as they arose.

Reservoir Monitoring is one of five components of TVA's overall river and reservoir monitoring effort, termed Vital Signs Monitoring. Objectives of Reservoir Monitoring are to provide information on the "health" or integrity of the aquatic ecosystem in major Tennessee Valley reservoirs. Ecological monitoring activities provide the necessary information from key physical, chemical, and biological indicators to evaluate conditions in reservoirs and to target detailed assessment studies if significant problems are found. In addition, this information establishes a baseline for comparing future water quality conditions in TVA's reservoirs. Other components of Vital Signs Monitoring include: (1) examination of ecological conditions in tributary streams to the Tennessee River to evaluate their influences on observed conditions reservoirs and to provide a snapshot of overall watershed conditions; (2) monitoring of toxic contaminants in fish flesh to determine their suitability for consumption; (3) evaluating the number and size of important game fish species to help ensure their populations remain abundant and robust; and (4) sampling of bacteriological concentrations at recreational areas to evaluate their suitability for water contact recreation.

This document describes the monitoring and data evaluation process used to evaluate the overall ecological health of reservoirs. It summarizes 2000 data as an example of the mechanics of the ecological health scoring system used in the process. This document is prepared annually with the most recently published report covering 1999 (Dycus and Baker, 2000).

The reservoir ecological health evaluation process has been in use since 1990.. The scoring system is reviewed each year seeking opportunities for improvements. Initially, numerous improvements were made based on experienced gained from working with this new system and input from other professionals. Each year, progressively fewer changes have been needed.

Study Design Considerations

This monitoring program was designed based on several fundamental premises.

1. Ecological health evaluations must be based on physical, chemical, and biological components of the ecosystem.
2. Monitoring must provide current, useful information to resource managers and the public.
3. Monitoring program design must be dynamic and flexible, rather than rigid and static, and must allow adoption of new techniques as they develop.
4. Monitoring must be sustained for several years to document the status of the river/reservoir system, determine its year-to-year variability, and track changes through time.
5. Addressing specific cause/effect mechanisms is not the primary purpose of monitoring. While monitoring may provide information to identify cause/effect relationships, more detailed assessment investigations usually are required.

With these premises in mind, our challenge has been to develop a sustainable monitoring effort that collects the right kinds of physical, chemical, and biological data to provide enough information to reliably characterize ecological health. Study design must carefully consider selection of important ecological indicators, representative sampling locations, and frequency of sampling, all in light of available resources. Following are some of the basic study design decisions made in developing this program.

Ecological Indicators--Physical, chemical, and biological indicators (dissolved oxygen, chlorophyll, sediments, benthos, and fish) were selected to provide information from various habitats or ecological "compartments". For example, the open water or pelagic area in reservoirs is represented by chlorophyll and dissolved oxygen (DO) in midchannel. The shoreline or littoral area is evaluated by sampling the fish assemblage. The bottom or benthic compartment is evaluated using two indicators: quality of surface sediments in midchannel (determined by chemical analysis of sediments) and examination of benthic macroinvertebrates from a transect across the full width of the sample area (including overbanks if present).

Sampling Locations--Three areas were selected for monitoring: the inflow area, generally riverine in nature; the transition zone or mid-reservoir area where water velocity decreases due to increased cross-sectional area, suspended materials begin to settle, and algal productivity increases due to increased water clarity; and the forebay, the lacustrine area near the dam. Overbanks, basically the floodplain which was inundated when the dam was built, are included in transition zone and forebay areas. Embayments, another important type of reservoir area, also were considered. Previous studies (Meinert et.al., 1992) have shown that ecosystem interactions within an embayment are mostly controlled by activities and characteristics within the embayment watershed, usually with little influence from the main body of the reservoir. Although these are important areas, monitoring of hundreds of embayments is beyond the scope of this program. As a result, only four, large embayments (all with drainage areas greater than 500 square miles and surface areas greater than 4500 acres) are included in this monitoring effort.

Sampling Frequency--Sampling frequencies (indexing periods) must consider the expected temporal variation for each indicator. Indicators which vary in the short term (dissolved oxygen and chlorophyll) are monitored monthly from spring to autumn. Other indicators better integrate long-term variations and are sampled once each year. Sediments are monitored once in mid-summer. Fish assemblage sampling is conducted in autumn (September-November). From 1990 through 1994 benthic macroinvertebrate sampling was conducted in early spring (February-April) to avoid aquatic insect emergence. Beginning in 1995, sampling was switched to late autumn/early winter (November and December). The problem with spring benthos sampling was that results were reflective of conditions from the previous year. This caused results for this indicator to be out of synch with those from the other indicators. This change is more thoroughly discussed in Dycus and Meinert (1996).

Another design issue dealing with sampling frequency is year-to-year variation. Meteorological conditions (particularly runoff from rainfall and its influence on flows) have a great effect on reservoirs and can vary substantially from year-to-year. To account for this variation, our design specifies that a reservoir be sampled for five consecutive years. Following that, sampling occurs on an every other year basis.

Data Evaluation Considerations (Reference Condition and Classification Issues)

Like most evaluations, results for ecological integrity studies must be compared to some reference or yard stick to determine if monitoring results are indicative of good, fair, or poor conditions. In streams this is usually accomplished by studying a site that has had little or preferably no alterations due to human activities. Observations at that site provide the **reference conditions** or expectations of what represents a site with good/excellent ecological health. Given that reservoirs are not natural systems, this approach is inappropriate. Other potential approaches include historical or preimpoundment conditions, predictive models, best observed conditions, or professional judgment. Preimpoundment conditions are inappropriate because of significant habitat alterations. For the most part, models are of limited value for many indicators because of spatial and temporal variations within and among reservoirs. Spatial variation exists within in the multiple zones (e.g., forebay, transition zone, inflow, and embayments) of a reservoir. Further, each zone responds differently to different stimuli. Temporal variations are introduced because reservoirs are controlled systems with planned annual drawdowns in elevations ranging from only a few feet to close to a hundred feet. This leaves best observed conditions and professional judgment as the most viable alternatives for establishing appropriate reference conditions or expectations for reservoirs. Our process uses a combination of these two approaches.

A preliminary step to developing reference conditions is to examine the need to separate the reservoirs under study into separate **reservoir classes** so that appropriate , "apples-to-apples" comparisons can be made. Like streams, important considerations for classifying reservoirs include size, gradient/depth, ecoregion, etc. In addition, reservoirs are managed systems and management objectives must be considered.

A lesson we learned early in this process was that the issue of classification and its influence on determining reference conditions differed among the environmental indicators. A fundamental question that had to be addressed separately for each indicator was – Should reservoir ecological health evaluations be based on:

1. ideal conditions (basically a subjective determination; for example, a very low DO concentration is an unacceptable ecological condition regardless of any classification issue); or
2. the best conditions expected/observed given the environmental and operational characteristics of the dam/reservoir (for example, very low DO concentrations are acceptable in many tributary reservoirs because they are expected due to water management practices, withdrawal schemes, stratification, etc.)?

Our response (opinion) was that ideal conditions should be expected for DO and Sediment Quality. That is, poor DO is unacceptable regardless of type of reservoir or dam operation. Sediments should not have high concentrations of metals, should have no or at most very low concentrations of pesticides, and should not pose a toxic threat to biota. In this situation, there is no need for classification because the same conditions are desired for all reservoirs.

For chlorophyll, the classification scheme that has evolved is somewhat of a combination of the two approaches. First the geological characteristics (primarily erodablility and nutrient level of soils) of the watershed were examination. Then a conceptual/subjective decision made as to the concentrations indicative of good, fair, and poor conditions. Two classes of reservoirs were developed – reservoirs in watersheds draining nutrient poor soils, basically those in the Blue Ridge Ecoregion (i.e., expected oligotrophic reservoirs); and reservoirs in watersheds draining soils which are not nutrient poor (i.e., expected mesotrophic reservoirs).

For benthic macroinvertebrates and fish assemblage, the "best expected/observed conditions" approach was selected initially. Basically, this means the data base from the existing population of reservoirs is examined to determine the range of conditions for each community characteristic or metric (e.g., number of taxa). The process is to first omit outliers (defined as more than three standard deviations from the mean), then trisect the remaining range of values (including zero if appropriate for a particular metric – see Sections 5.0 and 6.0 for details). These three ranges represent good, fair, and poor conditions and form the reference conditions or expectations for each metric. This is still the basic approach used for these two indicators, but experience has shown best results can be obtained by including professional judgment in the process. Cutoff points are examined closely and adjusted, if appropriate, based on professional judgment. This approach is discussed in detail in Dycus and Meinert (1998).

Reservoirs were divided into four classes to evaluate the benthos and fish. One class includes the reservoirs on the Tennessee River plus the two navigable reservoirs on tributaries to the Tennessee River (loosely termed run-of-river reservoir). This group of reservoirs has relatively short retention times and little winter drawdown. The remaining tributary reservoirs were separated into three classes: those in the Blue Ridge Ecoregion, those in the Ridge and Valley Ecoregion, and those on the Interior Plateau Ecoregion. The run-of-the-river reservoirs were not subdivided by ecoregion because most of the water flowing through them comes from upstream and does not originate within the ecoregion where the reservoir is physically located.

Ecological Health Rating Methods

We developed a methodology to evaluate the ecological health of reservoirs included in this program because none were available when the monitoring program began in 1990. The ecological health evaluation system examines each of five key indicators separately and then combines these ratings into a single, composite score for each reservoir.

Dissolved oxygen – The rating criteria represent a multidimensional approach that includes dissolved oxygen levels both throughout the water column (WC_{DO}) and near the bottom (B_{DO}) of the reservoir. The DO rating (ranging from 1 "poor" to 5 "good") at each sampling location is based on monthly measurements during April through September for the run-of-the-river reservoirs and May through October for the tributary reservoirs. This is the six-month period when maximum thermal stratification and maximum hypolimnetic anoxia are expected. The WC_{DO} Rating is the six-month average of the proportion of the reservoir cross-sectional area at the sample location that has a DO concentration less than 2.0 mg/L. The B_{DO} Rating is the six month average of the proportion of the reservoir cross-sectional bottom length that has a DO concentration less than 2.0 mg/L. The final DO rating is a combination of the WC_{DO} and B_{DO} results. (See Section 2.0 for details.)

Chlorophyll – Scoring criteria were developed separately for each of the two classes of reservoirs. Reservoirs expected to be oligotrophic receive highest ratings at low chlorophyll concentrations. Reservoirs expected to be mesotrophic receive highest ratings for an intermediate range of concentrations. For reservoirs expected to be mesotrophic, the rating is reduced at high chlorophyll concentrations and at low chlorophyll concentrations if an environmental factor (e.g., turbidity, toxicity, retention time) inhibits primary production. A sliding scale is used to evaluate the seasonal average chlorophyll concentration for each reservoir class. (See Section 3.0 for details.)

Sediment quality – Initially, the scoring criteria for sediment quality was based two components: sediment toxicity tests and sediment chemical analyses for ammonia, heavy metals, pesticides, and PCBs. Since 1995, the sediment quality scoring criteria have been based only on sediment analyses for metals (As, Cd, Cr, Cu, Pb, Hg, Ni, and Zn), organochlorine pesticides, and PCBs. Sediment toxicity tests were discontinued primarily because of budget reductions, but also because frequent changes in toxicity testing methods made year-to-year comparisons difficult. The sediment quality rating compares results for metals analyses to sediment guidelines we adapted from EPA Region 5 (EPA, 1977). Presence of any of the organic analytes is deemed undesirable so results are compared to laboratory detection limits. If none of the metals exceed these guidelines and no PCBs or pesticides are detected, the site would receive the highest sediment quality rating. Occurrences of analytes above these standards lowers the rating. (See Section 4.0 for details.)

Benthic Macroinvertebrates – Seven metrics or characteristics are used to evaluate the benthic macroinvertebrates in all reservoirs. Scoring criteria for each metric were developed from the data base on TVA reservoirs. The benthic macroinvertebrate score is the total of these seven metrics. Some specific metrics vary between run-of-river reservoirs and tributary reservoirs due to differences in thermal stratification and dissolved oxygen concentrations. (See Section 5.0 for details.)

Fish Assemblage – Twelve metrics or characteristics are used to derived the Reservoir Fish Assemblage Index (RFAI) described in Hickman and McDonough (1995). The same 12 metrics are used for all classes of reservoirs although specific scoring ranges for each metric varies by reservoir class. (See Section 6.0 for details.)

The ecological health scoring process is designed such that four of the indicators (DO, chlorophyll-a, benthos, and fish) are given equal weights with each indicator assigned a rating ranging from 1 (poor) to 5 (excellent). The fifth indicator, sediment quality, is given half the weight of the other indicators and assigned a rating ranging from 0.5 (poor) to 2.5 (excellent). (Note: Prior to 1995, sediment quality had been rated on the 1 to 5 range, same as the other indicators. But, discontinuance of sediment toxicity testing, which had contributed half the sediment quality rating, resulted in the rating for this indicator being reduced by one half). Ratings for the five indicators are summed for each site. Thus, the maximum total rating for a sample site would be 22.5 (all indicators excellent) and the minimum 4.5 (all indicators poor).

To arrive at an overall health evaluation for a reservoir, the sum of the ratings from all sites are totaled, divided by the maximum possible rating for that reservoir, and expressed as a percentage. It is necessary to use a percentage basis because the number of sites monitored varies according to reservoir size and configuration. Only one site, the forebay, is sampled in small tributary reservoirs, and up to four sites (forebay, transition zone, inflow, and embayment) are sampled in selected run-of-the-river reservoirs. Also, the number of indicators varies from three to five at different sites. Chlorophyll and sediment quality are excluded at the inflows on run-of-the-river reservoirs because in situ plankton production of chlorophyll does not occur significantly in that part of a reservoir and because sediments do not accumulate there. As a result, the number of scoring possibilities may be as few as 5 indicator ratings for a small reservoir sampled only at the forebay. Or, as many as 18 indicator ratings for a large reservoir sampled at the forebay, transition zone, inflow, and embayment. The total score for the small reservoir would be 22.5 if all indicators rated excellent, whereas, the total score for the large reservoir would be 82.5 if all indicators rated excellent. Hence, using a percentage basis allows easier comparison among reservoirs.

This approach provides a potential range of scores from 22 to 100 percent and applies to all reservoirs regardless of the number of indicators or sample sites. To complete the ecological health scoring process, the 22-100 percent scoring range must be divided into categories representing good, fair, and poor ecological health conditions.

As with other elements of this program, this has proven to be a challenging issue. The obvious approach would be to follow the same process as that used for individual indicators. Basically, this would mean trisecting the range between 22 and 100 and designating the three categories that result as good, fair, and poor. In attempting to use this approach we found that virtually all our reservoirs fell into the fair category — none rated poor and only a few rated good. This was not acceptable because there was such a large difference between reservoir conditions at the upper and lower ends of the fair range. We carefully examined the conditions which existed in each reservoir and were generally comfortable with the separation between fair and good categories, with only minor adjustment. However, the reservoirs at the lower end of the range exhibited conditions which we felt were truly representative of poor reservoir conditions. As a result, we initially made a subjective decision and adjusted the low end of the fair range up so that reservoirs with poor conditions actually rated poor. Originally, this adjustment differed between run-of-river reservoirs and tributary reservoirs.

The scoring ranges which resulted from this initial effort were used with slight modification from 1991 through 1997 and are shown below.

Run-of-the-River Reservoirs		
Poor	Fair	Good
<52	52-72	>72

Tributary, Storage Reservoirs		
Poor	Fair	Good
<57	57-72	>72

A slightly difference approach to determine reservoir scoring ranges was instituted prior to evaluating the 1998 results and continued in 2000. One of the primary factors driving this change the absence of a justification for the difference in the poor range between the run-of-river reservoirs and tributary reservoirs. The scoring system itself should account for any differences if appropriate adjustments are made to scoring criteria for individual metrics for each indicator. If this is accomplished, final ecological health scores for reservoirs should be comparable, regardless of whether they are run-of-the river reservoir or tributary reservoirs.

The approach used was to first obtain a five-year average ecological health score for each reservoir. The average scores were then plotted and examined for natural breaks which coincided with known lake condition and which did not differ substantially that the previously used scoring ranges. The trisection of these average scores is shown in Figure 1 and summarized below. Incorporation of 2000 results and refiguring the five-year average did not change the trisection points.

Scoring Ranges for All Reservoirs in 1998, 1999, and 2000		
Poor	Fair	Good
<59	59-72	>72

An example that illustrates the overall reservoir health evaluation methodology is presented in Table 1 for Fort Loudoun Reservoir.

Reservoir Ecological Conditions--2000 Results

Description of Meteorological and Hydrological Effects on Reservoir Conditions in 2000 – Meteorological conditions (sunlight, cloud cover, and the amount, frequency, and seasonal distribution of rainfall) significantly affect the hydrology (flows and retention times) and ecological conditions in reservoirs. As meteorology varies from year to year, so do its effects on reservoir hydrology and ecology.

Figure 2 shows the relative flow contributed by each of the major tributary rivers to the Tennessee River. Water quality characteristics vary greatly among these tributaries because of differences in geology, rainfall, and land use patterns among watersheds. For example, the French Broad and Holston rivers are moderately hard and rich in nutrients; the Little Tennessee and Hiwassee rivers are soft and nutrient-poor; the Clinch River is hard with moderate nutrients; while the other two large tributaries, the Elk and Duck rivers, are relatively hard and nutrient-rich, especially in phosphorus.

Meteorological conditions in 2000 continued the hot and dry weather patterns which had plagued the Tennessee Valley beginning in July 1998. Most months were warmer (Figure 3) and dryer (Figure 4) than normal. January, February, March, May, and October were warmer than normal by 2 to 6°F. The summer months (June, July, August, and September) were slightly warmer than normal by 1°F or less. The three remaining months were cooler than normal – April and November by about 2°F, and December by 8°F. Numerous cold weather temperatures were set in December making it the third-coldest December in 100 years of record.

Although several months were warmer than normal, the reduced amounts of rainfall was the meteorological influence which had the greatest effect on reservoir ecological conditions in 2000. Total precipitation for the year averaged only 38 inches across the Tennessee Valley. This was 13 inches below the 100-year mean of 51 inches. There have been only four years out of the last 111 which had lower rainfall amounts.

The dry pattern in 2000 was a continuation of lower than normal rainfall amounts which had begun in summer 1998. The year 1999 was among the driest 10% in the last 110 years. As shown in Figures 4 and 4a, rainfall amounts in all but two months of 2000 were lower than the long-term average. Only April and November had higher than average rainfall amounts. April, which normally is one of the wettest months of the year, had over 6 inches of rain in 2000. A storm event the first week of April dropped significant amounts of rain throughout the Tennessee Valley. This was the largest storm event of the year with some areas receiving over 9 inches of rain. Despite the higher than normal rainfalls amounts for April, cumulative rainfall for 2000 through April was still almost 3 inches below normal. The ensuing May through October period was dry with rainfall deficits of about 2 inches in May and July and almost 3 inches in October.

Rainfall amounts in November were slightly above normal, but over two inches below normal during the extremely cold month of December.

As stated above, the cumulative rainfall deficit for 2000 alone was 13 inches. When added to the total deficit since the drought began in July 1998, the cumulative rainfall deficit in the Tennessee Valley was about 30 inches

Although rainfall is an important consideration in evaluating meteorological influences on reservoir condition, what really matters is the runoff which actually reaches the streams and reservoirs. Runoff is greatest in high intensity rainfall events, especially if the ground is already saturated and spring growth of foliage has not yet occurred. Foliage increases surface area which enhances evaporation, and significant amounts of water move back to the atmosphere via plant transpiration.

On an average annual basis, runoff is highest January through early April and lowest August through October (Figure 5). The naturally low summertime runoff usually results in reduced stream flows which in turn decrease flows in the receiving reservoirs and thereby increase retention times. Retention time has a direct influence on physical, chemical, and biological conditions in reservoirs. Some of these effects are stressful to aquatic life. For example, lower reservoir flows allow stronger thermal stratification to develop. This in turn limits mixing of the water column diminishing reaeration and causing lower dissolved oxygen concentrations in bottom waters. Naturally warmer summer water temperatures further lower oxygen concentrations due to lower solubility of oxygen and higher rates of respiration and decomposition. In addition, low stream flows help to diminish turbidity and increase water clarity. In reservoirs in which algal productivity is not nutrient limited, which is typically the case for reservoirs on the main stem Tennessee River, greater water clarity means more light available for photosynthesis and higher algal populations.

As would be expected, the lack of rainfall described above resulted in much less runoff than normal for the Valley during 2000. Total runoff for the year was only 12.6 inches which is 10 inches below the 100 year mean of 22.7 inches (Figure 5a). As a result, reservoir flows were much lower than normal and retention times were much longer in 2000 than in years with more normal amounts of rainfall (Table 5). For example, the long-term average flow through Kentucky Dam (the downstream-most dam on the Tennessee River) is 66,255 cfs, whereas the flow in 2000 was only 32,780 cfs. Comparable low flows and increased retention times were experienced in reservoirs throughout the Tennessee Valley.

Periodicity of rainfall and resultant runoff is also an important factor. Of particular interest are strong, localized storms which produced substantial runoff. These storms provide much needed water to help fill the reservoirs and augment flows throughout the system, however they also introduce substantial nutrients to stimulate algal growth.

Clearly, the hot dry conditions in 2000 compounded by periodic heavy rainfall set the stage for potentially undesirable ecological conditions – too much algal productivity and low dissolved oxygen levels. As seen below, these conditions were manifested in several reservoirs. Some had the highest chlorophyll levels found to date. Also, some reservoirs which usually do not suffer from low dissolved oxygen levels did so in 2000.

Comparison of Results for Each Indicator in 2000 to Previous Years – Full Vital Signs monitoring was conducted on 16 reservoirs (total of 37 sites) in 2000. Additional monitoring was conducted on several other reservoirs using selected Vital Signs Monitoring tools in 2000 to meet specific needs (Table 2). These additional results are provided in the specific sections of this report as a means for making them available, but Reservoir Ecological Health scores were not developed for them.

The summary below clearly shows the negative influences of meteorological conditions in 2000, especially for chlorophyll concentrations and somewhat for DO concentrations. Seasonal average chlorophyll concentrations were higher in 2000 than in previous years at 18 of the 30 sites monitored. Also, a greater amount of water with low DO concentrations occurred at 7 of the 30 sites in 2000. Results for the other three indicators were either similar in 2000 compared to past years or were not consistently higher or lower than rating found in previous years. These indicators are not expected to vary greatly due to seasonal influences, unless those influences are severe. Rather, they are more representative of long-term changes which is the reason for their selection for this monitoring program.

Comparison of Results for Each Indicator in 2000 Compared to Previous Years				
Indicator	"Worse" Condition	# No Change•	"Better" Condition	Total Sites
Chlorophyll	18	12	0	30
DO	6	22	2	30
Fish	4	31	2	37
Benthos	7	24	4	35
Sediment	0	29	1	30

- For Chlorophyll, the "No Change" column represents the number of sites in which the 2000 seasonal average chlorophyll concentration was +/-20% of the long-term seasonal average.
- For Dissolved Oxygen, the "No Change" column is represented by the number is sites in 2000 in which the portion of the water column with DO concentration <2.0 mg/l was +/- 5% of the long-term average.
- For Fish, the "No Change" column is represented by a 2000 index score which is +/- 9 points of the long-term average score.
- For Benthos, the "No Change" column is represented by a 2000 index score which is +/- 5 points of the long-term average score.
- For Sediment Quality, the "No Change" column is represented by a perusal of results for all years looking for notable increases or decreases in the number of pollutants above a predetermined concentration.

Phytoplankton productivity in TVA reservoirs (as measured by chlorophyll concentrations in this monitoring program) is usually limited by a combination of three factors – nutrients, light, and retention time. In tributary reservoirs retention time is rarely a limiting factor because they have such a large volume relative to their inflow rate, which creates long retention times (100 - 300 days or even longer in drought years; Table 5). Longer retention times allow suspended particles to settle, increasing water clarity. As a result, light availability, which often limits algal productivity in main stream reservoirs, is rarely a problem during the summer in tributary reservoirs. Consequently, nutrient availability usually is the limiting factor in tributary reservoirs.

Periodic intense rainfall evens, such as the Valley-wide storm which occurred in April and spotty thunderstorms which are characteristic of summer, tend to supply and replenish ample amounts of nutrients. This enhances algal productivity following such events. However, as runoff decreased during the dry summer/autumn period, algal productivity decreased in many reservoirs due to nutrient depletion, despite increased water clarity and retention time.

Three of the six reservoir sites which exhibited an increased amount of low DOs in 2000 were in tributary reservoirs and known to have DO problems regardless of meteorological conditions. The other three sites were forebays of run-of-the-river reservoirs – Melton Hill, Watts Bar, and Wislon – and experience DO problems only in low flow years.

In summary, ratings for three of the five ecological indicators (sediment quality, benthos, and fish) were generally the same as in past years. Ratings for chlorophyll and somewhat DO were generally poorer in 2000 compared to previous years. Given the hydrological conditions which occurred in 2000, these Data and ratings for each of these indicators are summarized in Sections 2 through 6 of this document.

Reservoir Ecological Health Scores for 2000 – Combining all the aquatic ecosystem indicator ratings to determine the overall ecological health for each of the 16 reservoirs sampled in 2000 shows the following:

- 1 of the 16 rated good (1 run-of-river reservoirs and 0 tributary reservoirs);
- 6 of the 16 rated fair (3 run-of-river reservoirs and 3 tributary reservoirs); and
- 9 of the 16 rated poor (2 run-of-river reservoir and 7 tributary reservoirs).

The ecological health ratings for all reservoirs sampled in 1999 and/or 2000 are presented by classification unit in Table 3 and Figure 6. Main stem reservoirs scored higher (as in previous years) than any other class of reservoirs, while none of the reservoirs in the Interior Plateau Ecoregion scored better than fair. Comparisons of reservoir ecological health ratings with previous years (Table 4) shows that 12 of the 16 reservoirs sampled in 2000 scored within seven points of their long term average, none scored higher, and four scored lower than their long term average. The primary basis of selecting +/- 7 points to indicate comparability among years was that it spans the full scoring range of the fair category (<59 = Poor / 59-72 = Fair / >72 = Good). Professional judgment was also a consideration in this selection with special attention to the expected variation in the overall score as well as for the five indicators which constitute that score. Long-term is defined as the period for each reservoir for which comparable methods/locations exist thereby providing a true apples-to-apples comparison. Generally, this period was 1994 - 2000.

A summary of Vital Signs Monitoring results for each reservoir in 2000 is provided in Appendix A. Differences between 2000 and previous years are discussed and explained to the extent possible. Appendix A also includes ecological health scores for all years for which Vital

Signs Monitoring data exist. Scores are provided as reported (calculated based on the methods in use at the time they were originally reported) and based on the latest (1999) scoring methods.

Important physical and operational characteristics of reservoirs and the dams that control them are summarized in Table 5.

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Table 1. Computional Method for Evaluation of Reservoir Health;
Fort Loudounl Reservoir -- 2000 (Run-of-the-River Reservoir)

Aquatic Health Indicators	Observations			Ratings		
	Forebay	Transition	Inflow	Forebay	Transition	Inflow
Chlorophyll-a				1.0 (poor)	1.0 (poor)	No Rating
Summer Average, ug/l	17.8	20.7	No Sample			
Maximum Concentration	34.0	29.0	No Sample			
Dissolved Oxygen				4.5 (good)	5.0 (good)	No Rating
Percent less than 2 mg/l :						
X-Sectional Area	0.5 (5)	0 (5)	No Sample			
Bottom X-Sectional Length	7.5 (4)	0 (5)	No Sample			
Sediment Quality				1.5 (fair)	1.5 (fair)	No Rating
Metals/Pesticides/PCBs	PCBs, Chlordane	PCBs, Chlordane	No Sample			
Benthic Community				1 (poor)	3 (fair)	1 (poor)
Total Score - Seven Metrics	9	23	11			
Fish Community				4 (good)	4 (good)	4 (good)
Total Score - Twelve Metrics	45	49	48			
	Sampling Location Sum			12.0 of 22.5	14.5 of 22.5	5.0 of 10
	Reservoir Sum			31.5 of 55 (57%)		
	Overall Reservoir Evaluation			"poor"		

Overall Reservoir Evaluation Key:

Less than 59 % -- poor (red)
59 % to 72 % -- fair (yellow)
Greater than 72 % -- good (green)

Table 2. Reservoir Vital Signs Monitoring Activities, 2000

Reservoir	River Mile	Sampling Schedule (Monthly or Annual): Water Chemistry	Sediment Chemistry	Benthos	Fish
Kentucky	TRM 23.0	M	A	A	A
	TRM 85.0	M	A	A	A
	TRM 200-206	-	-	A	A
	Big Sandy 7.4	M	A	A	A
Pickwick	TRM 207.3[S,B,F]	M	A	A	A
	TRM 230.0	M	A	A	A
	TRM 253-259	-	-	A	A
	Bear Creek 8.4	M	A	A	A
Wilson	TRM 260.8	M	A	A	A
	TRM 273-274	-	-	A	A
Wheeler	TRM 277.0	M	A	A	A
	TRM 295.9	M	A	A	A
	TRM 347-348	-	-	A	A
	Elk River 6.0	M	A	A	A
Guntersville	TRM 350.0	M	A	A	A*
	TRM 375.2	M	A	A	A*
	TRM 420-424[B,F]	-	-	A	A*
Nickajack	TRM 425.5	M	A	A	A
	TRM 469-470	-	-	A	A
Chickamauga	TRM 472.3	M	A	A	A
	TRM 490.5	M	A	A	A
	TRM 518-529	-	-	A	A
	Hiwassee 8.5	M	A	A	A
Watts Bar	TRM 532.5	M	A	A	A*
	TRM 560.8[S,B,F]	M	A	A	A*
	TRM 600-601	-	-	A	A*
	CRM 19-22	-	-	A	A*
Fort Loudoun	TRM 605.5	M	A	A	A
	TRM 624.6	M	A	A	A**
	TRM 652	-	-	A	A
Tellico	LTRM 1.0	M	A	A	A
	LTRM 15.0	M	A	A	A
Melton Hill	CRM 24.0	M	A	A	A*
	CRM 45.0	M	A	A	A*
	CRM 59-66	-	-	A	A
Norris	CRM 80.0	M	A	A	A
	CRM 125.0	M	A	A	A
	PRM 30.0	M	A	A	A
[illegible]as	FBRM 34.5	M	A	A	A
	FBRM 51.0	M	A	A	A

Reservoir	River Mile	Sampling Schedule (Monthly or Annual): Water Chemistry	Sediment Chemistry	Benthos	Fish
Cherokee	HRM 55.0	M	A	A	A
	HRM 76.0	M	A	A	A
Ft.Pat Henry	SFHR 8.7	M	A	A	A
Boone	SFHR19.0	M	A	A	A
	SFHR 27.0	M	A	A	A
	WRM 6.5	M	A	A	A
South Holston	SFHR 51.0	M	A	A	A*
	SFHR 62.5	M	A	A	A*
Watauga	WRM 37.4[B,F]	M	A	A	A*
	WRM 45.5	M	A	A	A*
Fontana	LTRM 62.0	M	A	A	A*
	LTRM 81.5	M	A	A	A*
	TkRM 3.0	M	A	A	A*
Apalachia	HiRM 67.0	M	A	A	A
Hiwassee	HiRM 77.5	M	A	A	A*
	HiRM 85.0[S,B,F]	M	A	A	A*
Chatuge	HiRM 122.0[S,B,F]	M	A	A	A*
	Shooting Cr 1.5	M	A	A	A*
Nottely	NRM 23.5	M	A	A	A
	NRM 31.0	M	A	A	A
Blue Ridge	ToRM 54.1	M	A	A	A
Ocoee No.1	ORM 12.5	M	A	A	A
Tims Ford	ERM 135.0[S,B,F]	M	A	A	A
	ERM 150.0	M	A	A	A
Bear Creek	BCM 75.0	M	A	A	A
L. Bear Creek	LBCM 12.5	M	A	A	A
Cedar Creek	CCM 25.2	M	A	A	A
Normandy	DRM 249.5	M	A	A	A
Beech	BRM 36.0	M	A	A	A

Footnotes:

*Fish Tissue Site - 5 CHC and 5 LMB
**Fish Tissue Site - 10 CHC
S,B,F = QA Samples -- S=Sediment; B = Benthos; F = Fish
(M)-Monthly, April - October (A)-Annually

Shaded areas -- not sampled in 2000
Lightly shaded areas would be added for drought monitoring

Table 3. Ecological Health Scores for Reservoirs Monitored in 1999 and 2000 (All Scoring Based on the Latest, 1999, Criteria)

Reservoir	1998 Score/Rating	1999 Score/Rating	2000 Score/Rating
Reservoir Class: Mainstream Reservoirs			
Kentucky	NS	72 - Fair	NS
Pickwick	74 - Good	NS	71 - Fair
Wilson	78 - Good	NS	52 - Poor
Wheeler	NS	60 - Fair	NS
Guntersville	82 - Good	NS	77 - Good
Nickajack	NS	85 - Good	NS
Chickamauga	NS	82 - Good	NS
Watts Bar	64 - Fair	NS	59 - Fair
Ft. Loudoun	62 - Fair	49 - Poor	57 - Poor
Tellico	NS	59 - Fair	NS
Melton Hill	69 - Fair	NS	68 - Fair
Reservoir Class: Ridge and Valley Ecoregion			
Norris	NS	70 - Fair	NS
Douglas	NS	56 - Poor	NS
Cherokee	50 - Poor	NS	47 - Poor
Ft. Pat. Henry	NS	56 - Poor	NS
Boone	NS	39 - Poor	NS
South Holston	52 - Poor	NS	52 - Poor
Watauga	58 - Fair	NS	66 - Fair
Reservoir Class: Blue Ridge Ecoregion			
Apalachia	61 - Fair	59 - Fair	68 - Fair
Hiwassee	67 - Fair	NS	69 - Fair
Chatuge	49 - Poor	49 - Poor	58 - Poor
Blue Ridge	NS	84 - Good	NS
Parksville	NS	58 - Poor	NS
Nottely	NS	48 - Poor	NS
Fontana	68 - Fair	NS	70 - Fair
Reservoir Class: Interior Plateau Ecoregion			
Tims Ford	49 - Poor	NS	49 - Poor
Normandy	63 - Fair	NS	55 - Poor
Bear	NS	52 - Poor	NS
Little Bear	NS	69 - Fair	NS
Cedar	NS	73 - Good	NS
Beech	53 - Poor	NS	42 - Poor

Table 4. Reservoir Ecological Health Scores for 2000 Compared to Historic Mean for 199X* - 1999

	Res. Eco. Health Rating, as reported										Res. Eco. Health on 1999 Criteria										
Watershed / Reservoir	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	1991**	1992**	1993**	1994	1995	1996	1997	1998	1999	*LT Mean**	2000
Kentucky Res. WS																					
Kentucky Reservoir	77	88	75	71	74	N/A	78	N/A	72	N/A	69	87	81	74	71	N/A	78	N/A	72	*74*	N/A
Beech Reservoir	N/A	N/A	65	56	46	51	N/A	53	N/A	42	N/A	N/A	69	54	50	51	N/A	53	N/A	*52*	42
Duck River WS																					
Normandy Reservoir	N/A	N/A	56	68	59	69	N/A	63	N/A	55	N/A	N/A	62	64	59	69	N/A	63	N/A	*64*	55
Pickwick/Wilson WS																					
Pickwick Reservoir	77	75	73	84	N/A	73	N/A	75	N/A	71	77	80	70	81	N/A	72	N/A	74	N/A	*76*	71
Wilson Reservoir	60	68	71	71	N/A	75	N/A	78	N/A	52	58	67	76	70	N/A	75	N/A	78	N/A	*74*	52
Bear Creek Resrvoir	N/A	N/A	60	56	46	47	42	N/A	52	N/A	N/A	N/A	64	60	51	47	42	N/A	52	*50*	N/A
Little Bear Creek Res.	N/A	N/A	64	64	69	64	64	N/A	69	N/A	N/A	N/A	68	64	64	64	64	N/A	69	*65*	N/A
Cedar Creek Res.	N/A	N/A	56	80	60	64	69	N/A	73	N/A	N/A	N/A	64	72	60	64	69	N/A	73	*68*	N/A
Wheeler/Elk WS																					
Wheeler Reservoir	89	80	72	75	69	N/A	76	N/A	60	N/A	70	76	72	74	68	N/A	75	N/A	60	*69*	N/A
Tims Ford Reservoir	N/A	60	58	58	56	53	N/A	49	N/A	49	N/A	63	60	58	56	53	N/A	49	N/A	*54*	49
Guntersville/Seq. WS																					
Guntersville Res.	66	83	78	83	N/A	86	N/A	84	N/A	77	84	85	79	81	N/A	86	N/A	82	N/A	*83*	77
Nickajack/Chickamauga																					
Nickajack Reservoir	89	83	88	90	92	N/A	88	N/A	85	N/A	87	81	87	91	89	N/A	88	N/A	85	*88*	N/A
Chickamauga Res.	90	73	83	87	81	N/A	88	N/A	82	N/A	83	88	86	85	78	N/A	86	N/A	82	*83*	N/A
Hiwassee River WS																					
Hiwassee Res.	82	69	58	68	N/A	62	N/A	69	N/A	69	72	71	69	62	N/A	62	N/A	67	N/A	*64*	69
Chatuge Reservoir	60	56	67	77	N/A	84	N/A	52	49	58	59	79	79	72	N/A	78	N/A	49	49	*62*	58
Nottely Reservoir	60	60	64	56	47	N/A	48	N/A	48	N/A	60	61	62	56	49	N/A	48	N/A	48	*50*	N/A
Blue Ridge Res.	87	73	72	86	84	N/A	82	N/A	84	N/A	87	83	91	80	84	N/A	82	N/A	84	*83*	N/A
Ocoee No. 1 Res.	47	53	52	60	71	N/A	71	N/A	58	N/A	74	74	67	67	67	N/A	67	N/A	58	*65*	N/A
Apalachia	N/A	N/A	N/A	N/A	N/A	N/A	73	66	59	68	N/A	N/A	N/A	N/A	N/A	N/A	69	61	59	*63*	68

* LT = Long-term Mean - The time period included in the Historic Mean varies by reservoir due to varing periods of consistent record -- monitoring was not initiated on all reservoirs at the same time and sample locations within certain reservoirs have been moved.

** 1991, 1992, and 1993 are scored on 1999 criteria for 4 of the 5 indicators. A change in processing of benthic macroinvertebrate samples beginning in 1994 prevents appropriate scoring of the earlier results on the latter criteria.

Table 4. cont. Reservoir Ecological Health Score for 2000 Compared to Historic Mean for 199X* - 1999

	Res. Eco Health Rating, as reported										Res. Eco. Health on 1999 Criteria										
Watershed / Reservoir	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	1991**	1992**	1993**	1994	1995	1996	1997	1998	1999	*LT Mean**	2000
Watts Bar/Ft. Loud./Mel. Hill																					
Watts Bar Reservoir	69	71	68	79	N/A	68	N/A	67	N/A	59	72	79	76	72	N/A	68	N/A	64	N/A	*68*	59
Fort Loudoun Reservoir	60	53	58	61	49	52	58	64	49	57	63	63	56	62	47	52	57	62	49	*55*	57
Melton Hill Reserovir	80	67	68	72	N/A	73	N/A	70	N/A	68	67	65	66	71	N/A	69	N/A	69	N/A	*70*	68
Clinch/Powell WS																					
Norris Reservoir	57	67	67	69	60	N/A	64	N/A	70	N/A	71	72	69	66	61	N/A	67	N/A	70	*66*	N/A
L' Tenn. River WS																					
Tellico Reservoir	48	48	63	71	53	N/A	62	N/A	59	N/A	61	57	63	72	53	N/A	62	N/A	59	*62*	N/A
Fontana Reservoir	N/A	N/A	64	67	72	62	N/A	69	N/A	70	N/A	N/A	71	77	72	62	N/A	68	N/A	*70*	70
French Broad River WS																					
Douglas Reservoir	42	56	58	64	45	N/A	54	N/A	56	N/A	60	54	60	62	45	N/A	54	N/A	56	*54*	N/A
Holston River WS																					
Cherokee Reservoir	50	53	64	53	51	49	N/A	50	N/A	47	57	57	66	51	54	49	N/A	50	N/A	*51*	47
Fort Pat. Henry Res.	N/A	N/A	72	60	51	59	56	N/A	56	N/A	N/A	N/A	86	60	51	55	56	N/A	56	*56*	N/A
Boone Reservior	51	64	59	59	49	N/A	55	N/A	39	N/A	53	63	58	56	49	N/A	55	N/A	39	*50*	N/A
South Holston Res.	60	57	65	66	N/A	55	N/A	54	N/A	52	63	59	66	66	N/A	55	N/A	52	N/A	*58*	52
Watauga Reservor	80	57	61	65	N/A	72	N/A	60	N/A	66	75	72	63	63	N/A	72	N/A	58	N/A	*64*	66

* LT = Long-Term Mean -The time period included in the Historic Mean varies by reservoir due to varing periods of consistent record -- monitoring was not initiated on all reservoirs at the same time and sample locations within certain reservoirs have been moved.

** 1991, 1992, and 1993 are scored on 1999 criteria for 4 of the 5 indicators. A change in processing of benthic macroinvertebrate samples beginning in 1994 prevents appropriate scoring of the earlier results on the latter criteria.

Table 5. Characteristics of Vital Signs Reservoirs

Reservoir Name	Drainage Area (sq. miles)	Reservoir Length[a] (miles)	Surface Area[a] (acres x K)	Depth at Dam[a] (ft)	Volume[a] (ac-ft x K)	Average Annual Drawdown[b] (ft)	Average Reservoir Flow - POR Thru 2000 (cfs)	Average Reservoir Flow CY 2000 (cfs)	Average Hydraulic Residence Time Jan-Dec 2000[a] (Days)	Average Hydraulic Residence Time April-Sept 2000[a] (Days)
	Run-of-the-River Reservoirs									
Kentucky	40,200	184.3	160.3	88	2,839	5	66,255	32,780	44	40
Pickwick	32,820	52.7	43.1	84	924	6	55,393	31,893	15	15
Wilson	30,750	15.5	15.5	108	634	3	52,035	30,837	10	11
Wheeler	29,590	74.1	67.1	66	1,050	6	50,169	31,031	17	18
Guntersville	24,450	75.7	67.9	65	1,018	2	41,390	25,904	20	20
Nickajack	21,870	46.3	10.7	60	241	0	36,400	20,549	6	6
Chickamauga	20,790	58.9	35.4	83	628	7	34,573	20,218	16	15
Watts Bar	17,300	72.0/24.0[c]	39	105	1,010	6	27,402	15,553	33	31
Fort Loudoun	9,550	50	14.6	94	363	6	18,765	12,077	15	14
Melton Hill	3,343	44	5.7	69	120	0	5,011	2,156	28	26
Tellico	2,627	33.2	16.5	80	415	6	6,082[d]	4,016[d]	52	45
	Tributary River Reservoirs									
Norris	2,912	73.0/53.0[c]	34.2	202	2,040	32	4,232	1,897	542	489
Douglas	4,541	43.1	30.4	127	1,408	48	6,736	4,228	168	154
Cherokee	3,428	54	30.3	163	1,481	28	4,541	2,308	324	307
Ft Patrick Henry	1,903	10.4	0.9	81	27	0	2,643	1,512	9	7
Boone	1,840	17.4/15.3[c]	4.3	129	189	25	2536	1,420	67	52
South Holston	703	23.7	7.6	239	658	33	976	539	615	431
Watauga	468	16.3	6.4	274	569	26	711	413	695	509
Fontana	1,571	29	10.6	460	1,420	64	3,920	2,572	278	235
Hiwassee	968	22.2	6.1	255	422	45	2051	991	215	243
Chatuge	189	13	7.1	124	234	10	457	211	559	617
Nottely	214	20.2	4.2	167	170	24	413	186	461	590
Parksville	595	7.5	1.9	115	85	7	1411	628	68	68
Blue Ridge	232	11	3.3	156	193	36	607	284	343	321
Tims Ford	529	34.2	10.6	143	530	12	970	695	384	415
Bear Creek	232	16	0.7	74	10	11[e]	400	259	19	18
Cedar Creek	179	9	4.2	79	94	14[e]	304	191	248	314
Little Bear Creek	61	7.1	1.6	82	45	12[e]	106	67	339	399
Normandy	195	17	3.2	83	110	11	341	252	220	214
Beech	16	5.3	0.9	32	11	1[e]				

Footnotes: a. Estimates based on normal maximun pool; b. Tennessee River System Operations and Planning Review, Final EIS, TVA/RDG/EQS--91/1, 1990;
c. Major arms of reservoir; d. Estimated flow based on releases from Chilhowee Dam and adjusted based on drainage area between Chilhowee and Tellico Dams;
e. Estimated based on difference between normal maximum summer pool and average minimum winter pool elevations.

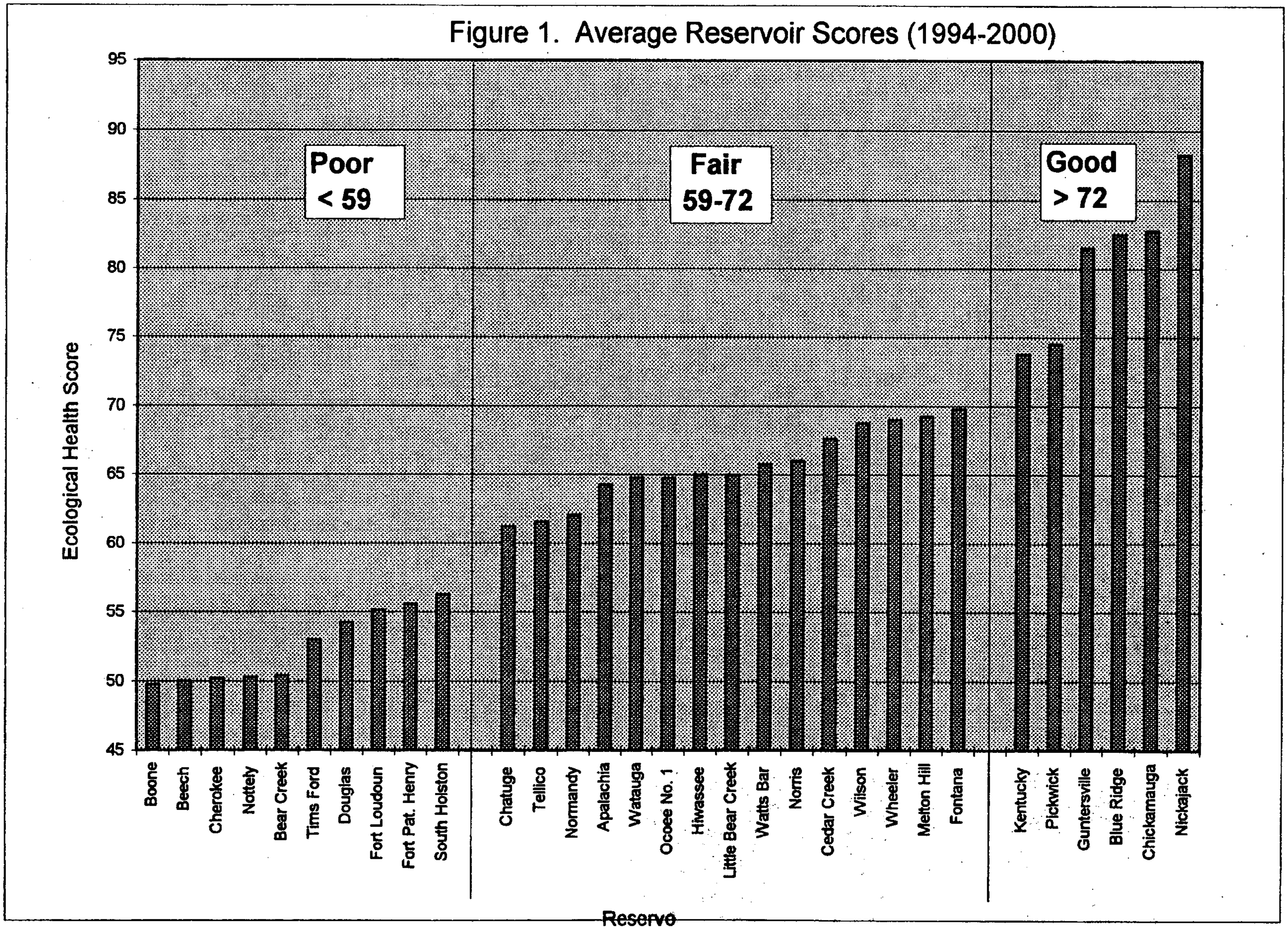
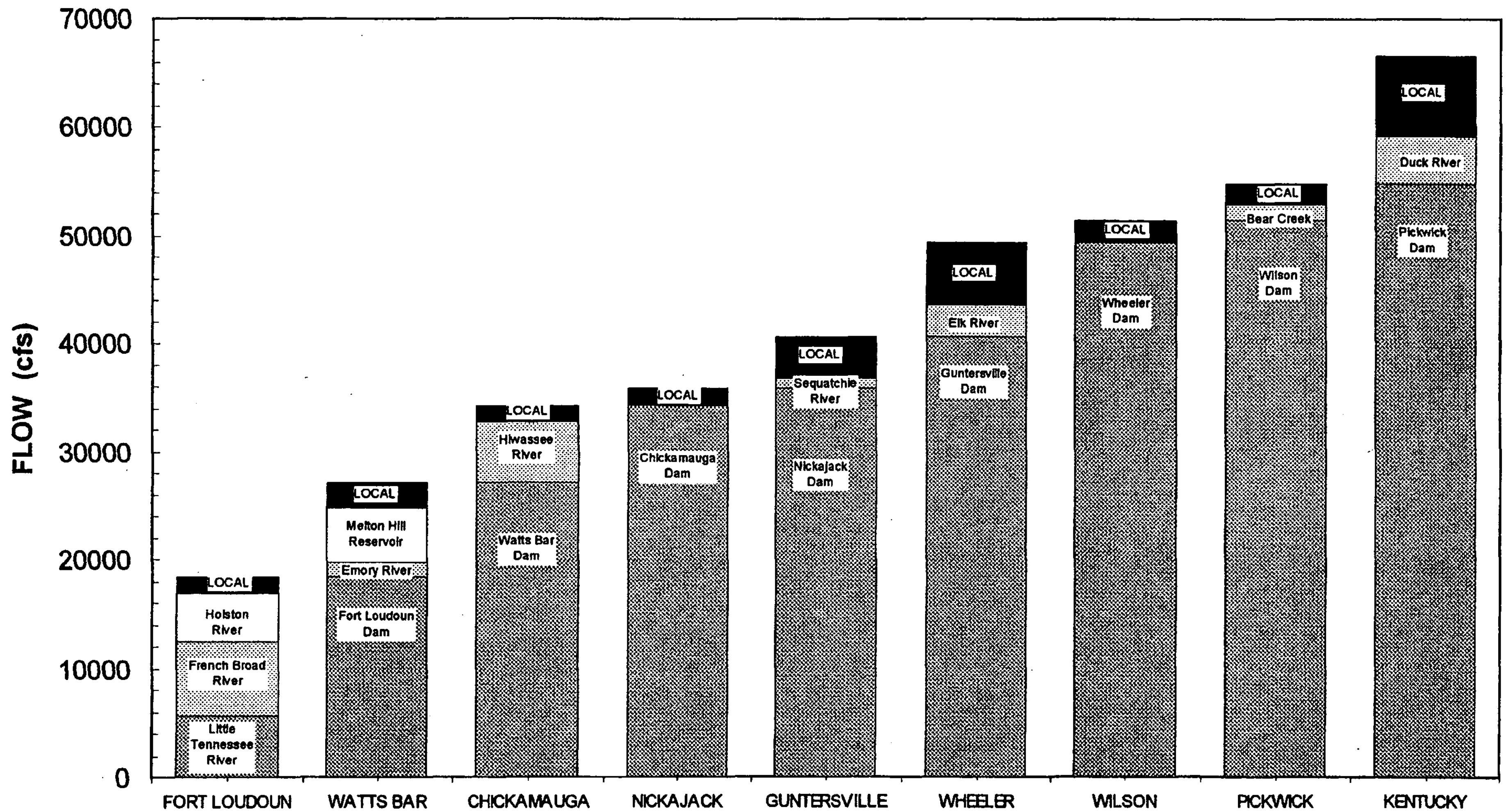


Figure 1. Average Reservoir Scores (1994-2000)
Ecological Health Score
95
90
85
80
75
70
65
60
55
50
45
Poor
< 59
Fair
59-72
Good
> 72
Boone
Beech
Cherokee
Nottely
Bear Creek
Tims Ford
Douglas
Fort Loudoun
Fort Pat. Henry
South Holston
Chatuge
Tellico
Normandy
Apalachia
Watauga
Ocoee No. 1
Hiwassee
Little Bear Creek
Watts Bar
Norris
Cedar Creek
Wilson
Wheeler
Melton Hill
Fontana
Kentucky
Pickwick
Guntersville
Blue Ridge
Chickamauga
Nickajack
Reservo

Figure 2. Average Annual Tennessee River Flows Showing Contributions of Major Tributaries and Local Inflows.



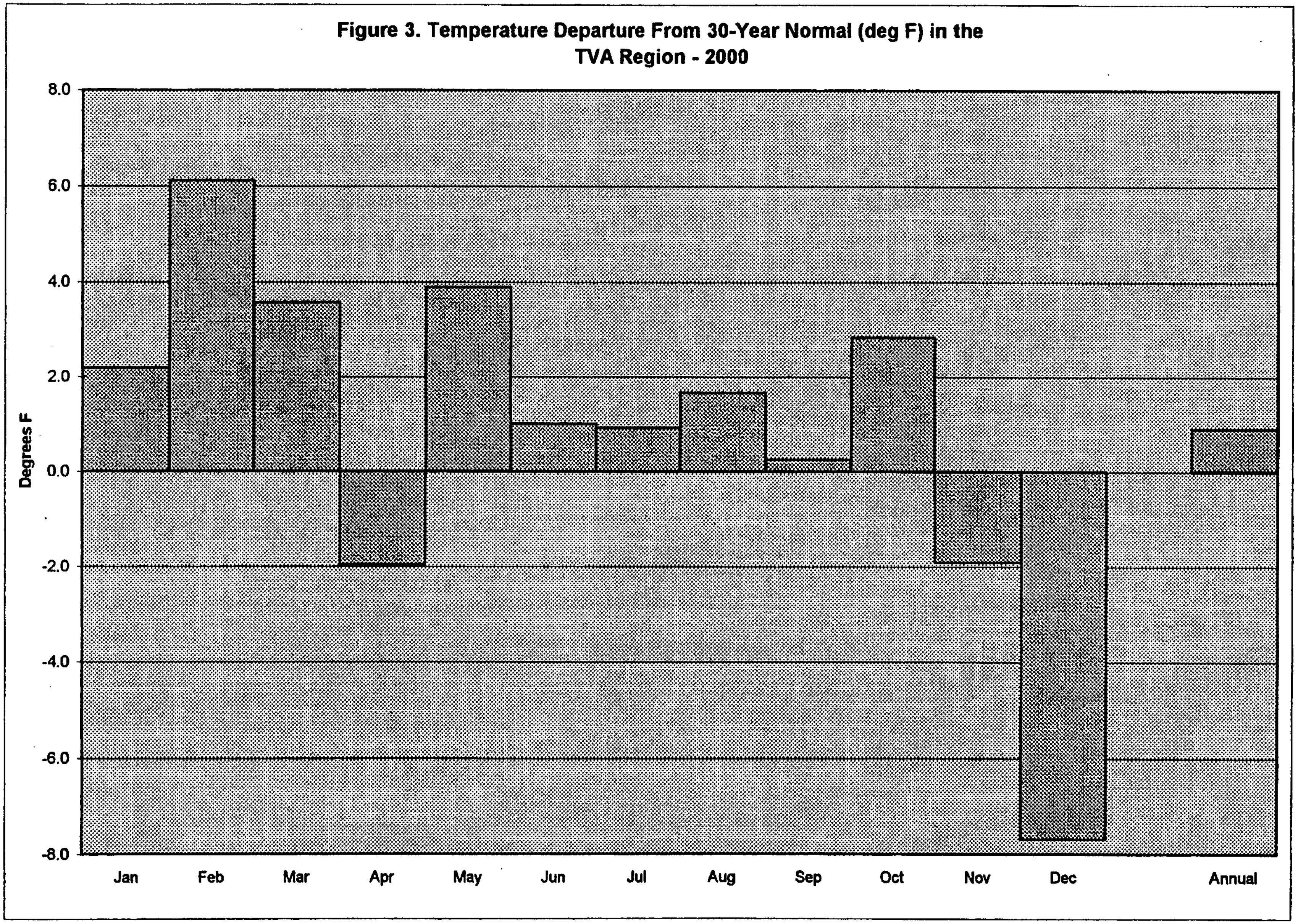


Figure 3. Temperature Departure From 30-Year Normal (deg F) in the TVA Region - 2000
Degrees F
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Annual

Table 4. PRECIPITATION DEPARTURES FROM LONG-TERM MEAN (1900-1999)
FOR THE TENNESSEE RIVER BASIN

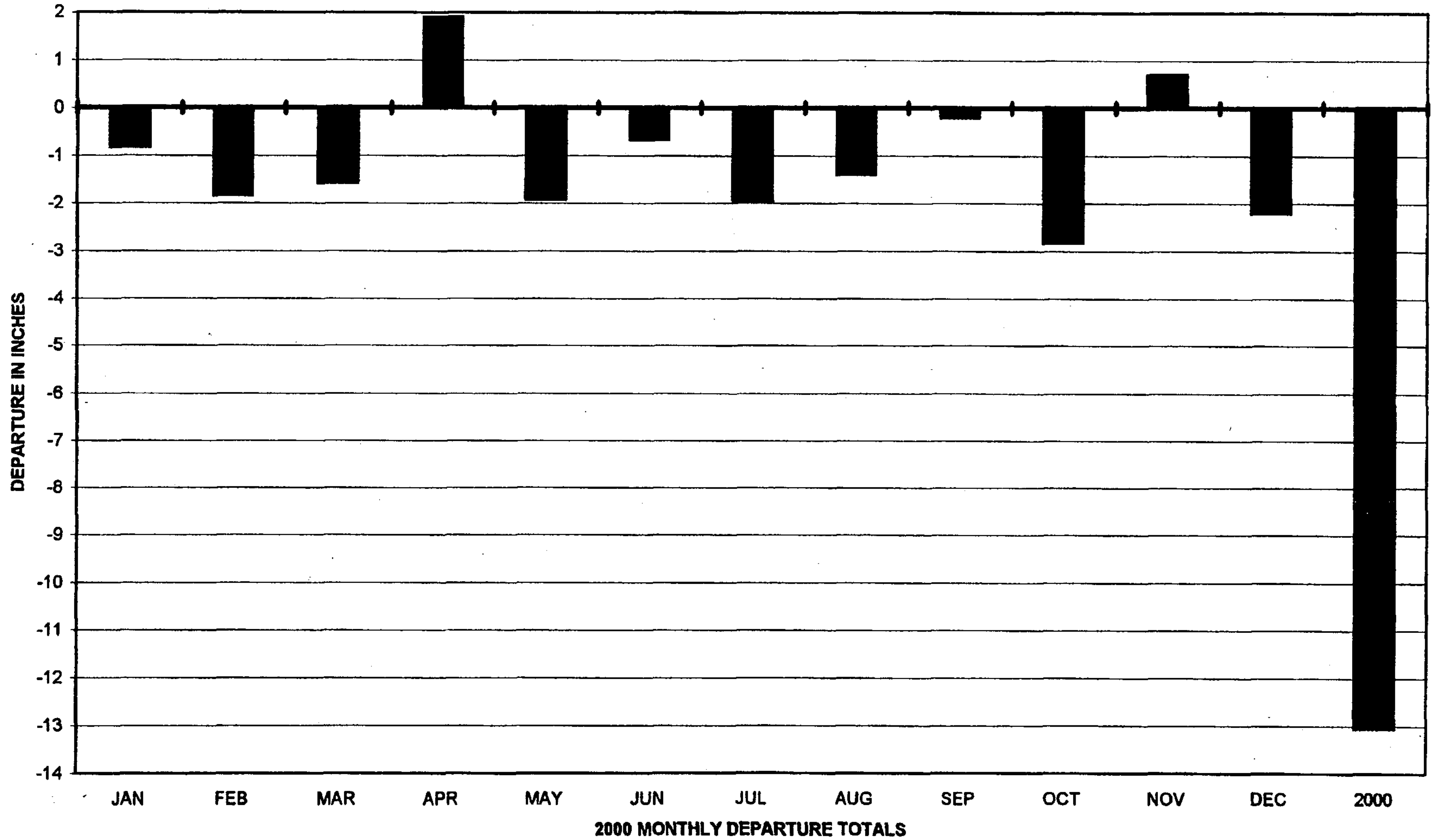


Figure 4a. PRECIPITATION FOR THE TENNESSEE RIVER BASIN - 2000

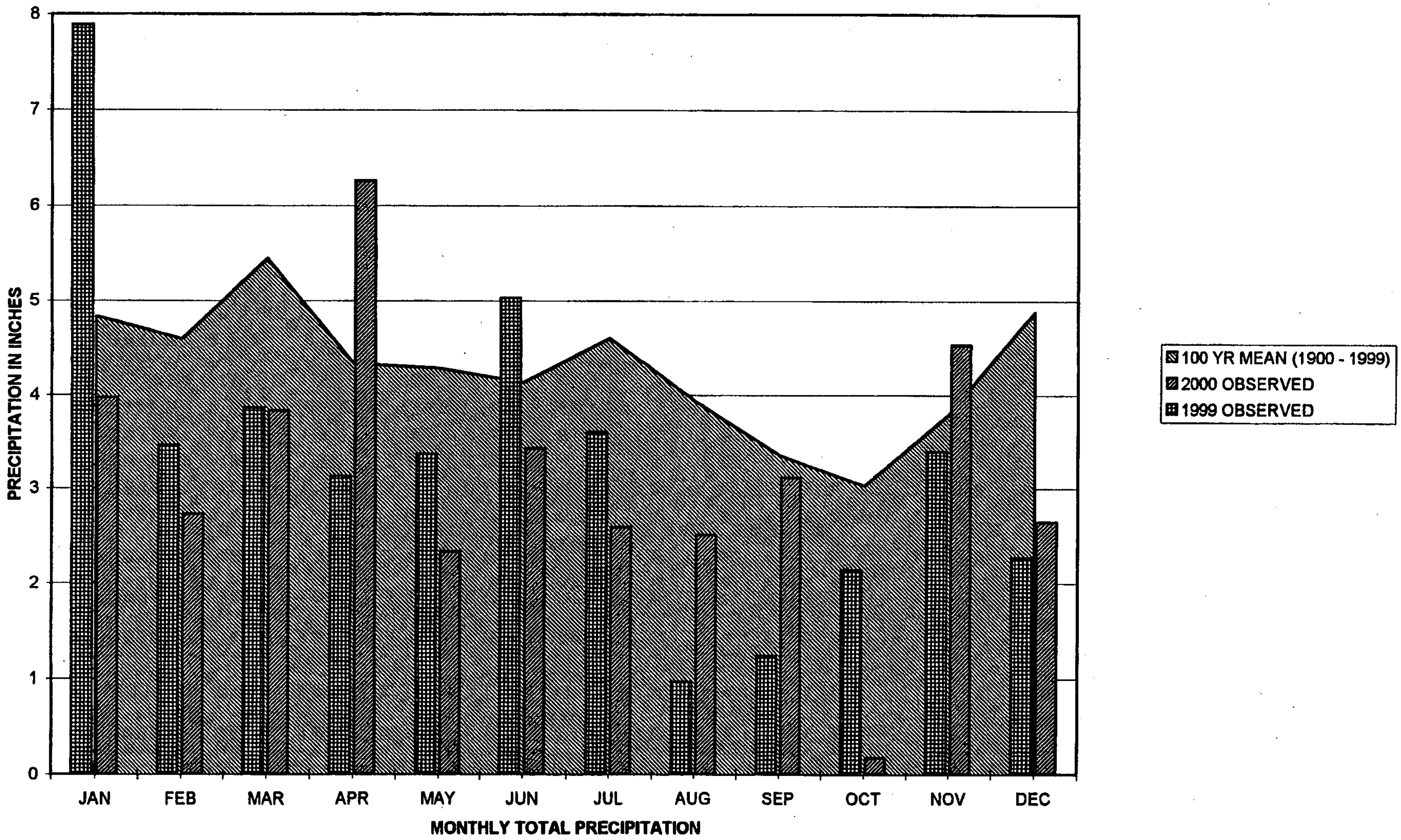


Figure 5. RUNOFF DEPARTURES FROM LONG-TERM MEAN (1900-1999) FOR THE TENNESSEE RIVER BASIN ABOVE KENTUCKY DAM

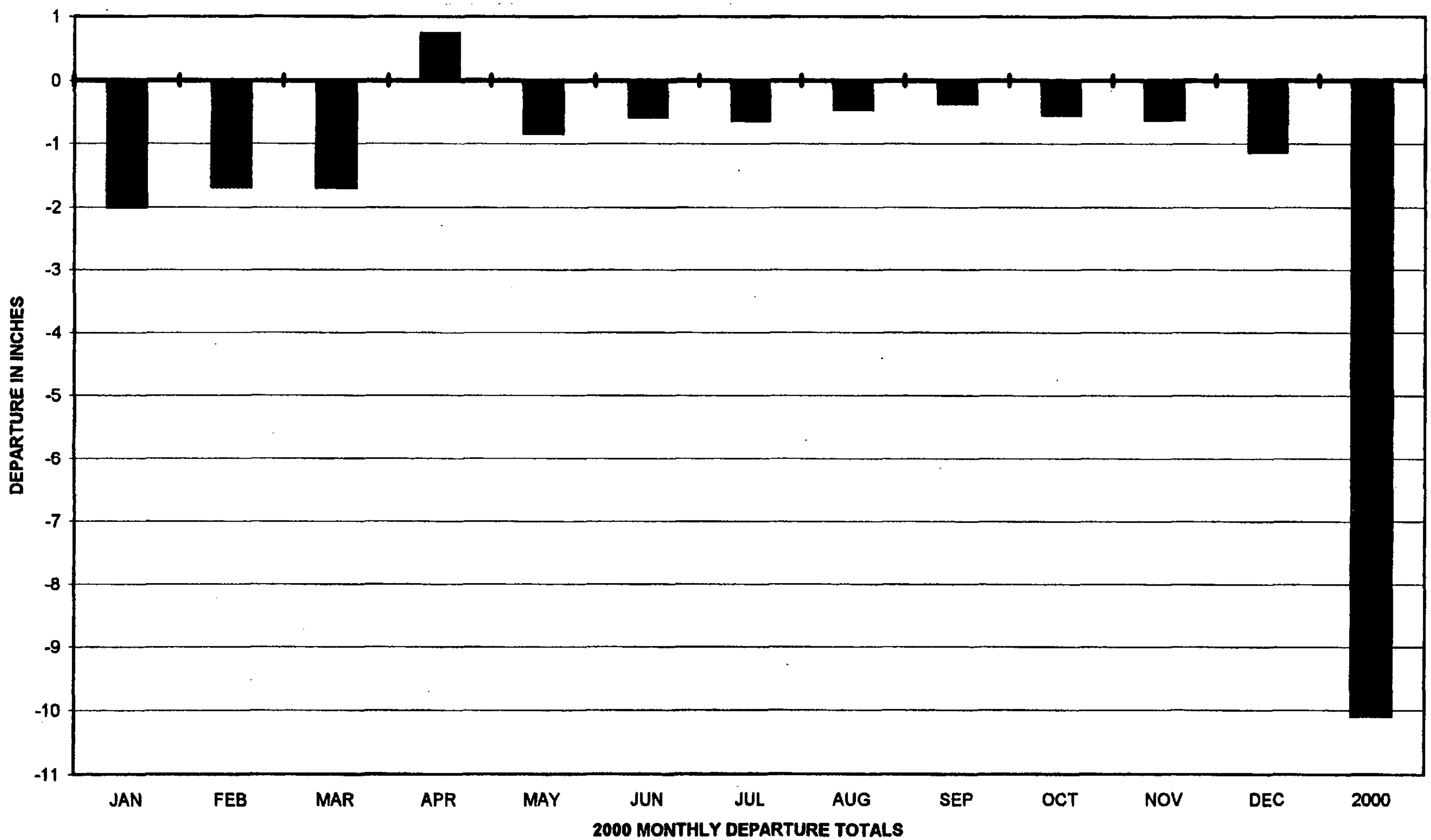


Table 5a. RUNOFF ABOVE KENTUCKY DAM - 2000

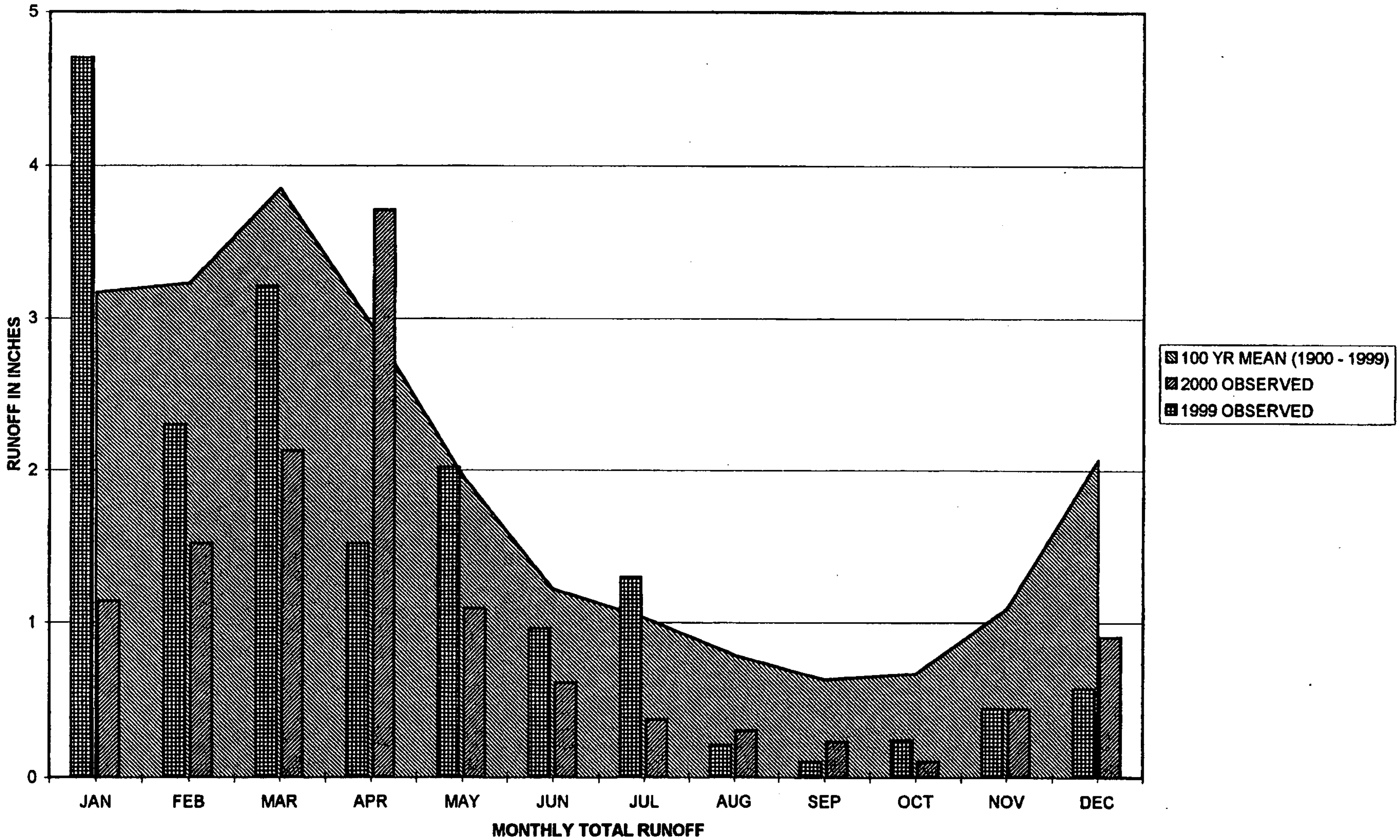
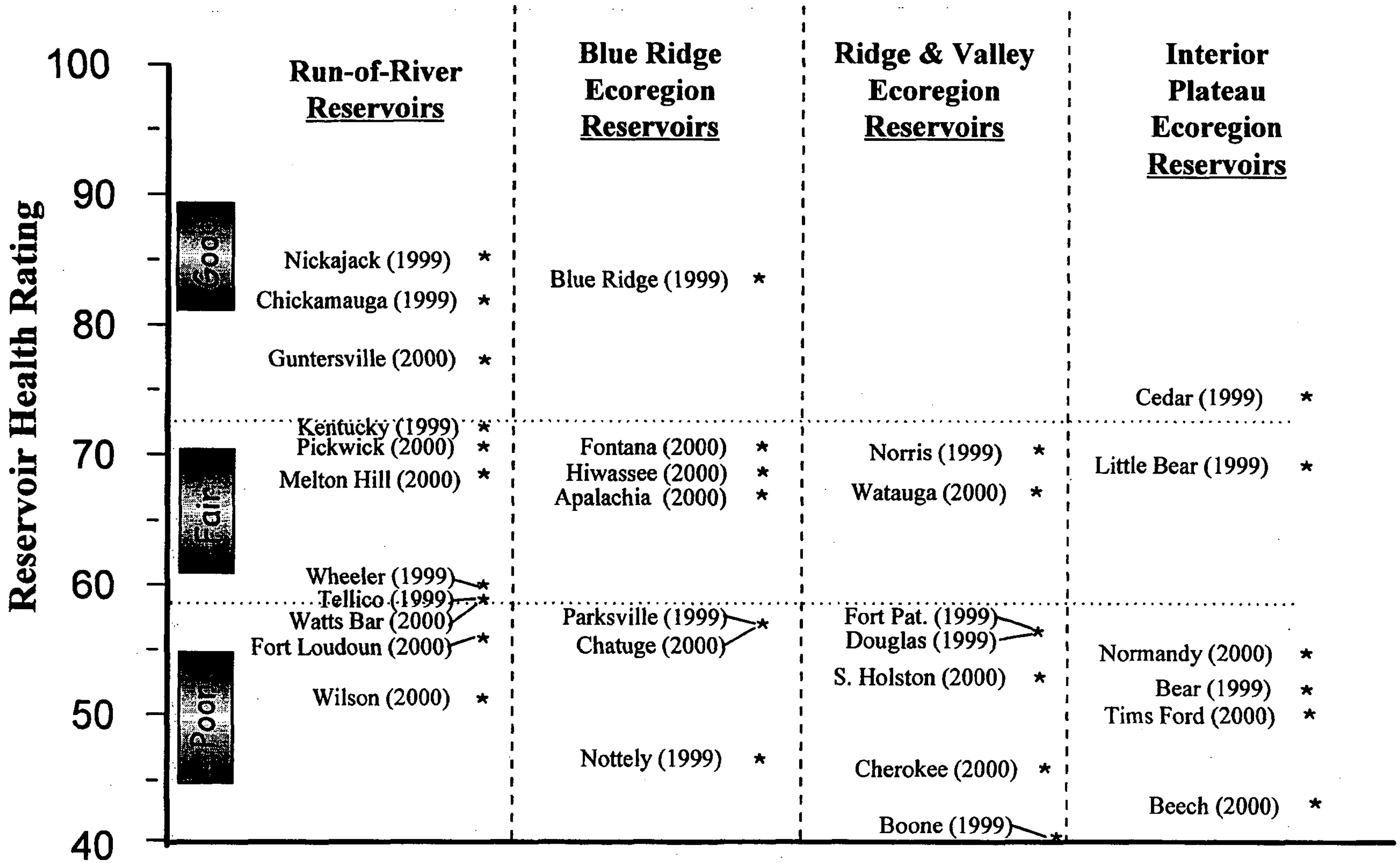


Figure 6. 1999/2000 Ecological Health Summary

(Reservoirs were sampled in the year in parenthesis.)



Section 2. Dissolved Oxygen (DO)

Philosophical Approach/Background

Oxygen is vital for life. In situations where funding is limited and only one indicator of reservoir health could be measured, DO would likely be the indicator of choice. Hutchinson (1975) states that probably more can be learned about a lake from a series of oxygen measurements than from any other kind of chemical data. The presence, absence, and levels of DO in a lake or reservoir both control and are controlled by many physical, chemical, and biological processes (e.g., photosynthesis, respiration, oxidation-reduction reactions, bacterial decomposition, temperature). DO measurements coupled with observations of water clarity (Secchi depth), temperature, nutrients, and some basic hydrologic and morphometric information provide meaningful insight into the ecological health of a reservoir.

Ideally, a reservoir has near-saturation concentrations of DO throughout the water column available to fish, insects, and zooplankton for respiration. This is usually the case during winter and spring, when most reservoirs are well mixed. However, in summer (characterized by more available sunlight, warmer water temperatures, and lower flows) both thermal stratification and increased biological activity may combine to produce a greater biochemical demand for oxygen than is available, particularly in the deeper portions of the reservoir. As a result, summer levels of DO often are below saturation in the metalimnion and hypolimnion of a reservoir or lake. This hypolimnetic and metalimnetic oxygen depletion is a common, but undesirable, occurrence in many reservoirs, especially storage impoundments. Not only do lower concentrations of DO in the water column affect the assimilative capacity of a reservoir, but if they are low enough and/or sustained long enough, they adversely affect the health and diversity of the fish and benthic communities. Sustained near-bottom anoxia not only promotes the biochemical release of phosphorus which affects trophic conditions, but also promotes the release of ammonia, sulfide, and dissolved metals into the interstitial pore and near-bottom waters. If this phenomenon persists long enough, many of these reduced chemicals can cause chronic or acute toxicity to benthos.

A dissolved oxygen concentration of 2 mg/L was selected as a level below which undesirable ecological conditions could result. Values below this level primarily cause adverse impacts on benthic macroinvertebrate organisms and loss of quality habitat for fish. Historic information for reservoirs in the Tennessee Valley has shown that the burrowing mayfly (Hexagenia sp.) disappears from the benthic community at DO concentrations of 2 mg/L and below (Masters and McDonough, 1993). Most fish species avoid areas with DO concentrations below 2.0 mg/L (loss of habitat); fish health, growth, and reproduction is reduced at these levels, and many highly desirable species such as sauger and walleye simply cannot survive at such low levels of DO.

A question fundamental to reservoir ecological health evaluation as well as reservoir classification issues is -- should reservoir ecological health evaluations be based on (1) ideal conditions, for example, low DO concentrations represent an unacceptable ecological condition; or (2) the best conditions expected for a reservoir given the environmental and operational characteristics of the dam/reservoir, for example, very low DO concentrations are acceptable in many tributary reservoirs because of withdrawal schemes, stratification, etc. The approach selected for this program is -- poor DO is unacceptable regardless of type of reservoir or dam operation. Hence, reservoirs were not separated into classes for DO evaluations/expectations because the expectation was the same for all reservoirs.

Data Collection Methods

DO data were collected monthly during the summer (April-October) of 2000, concurrently with chlorophyll, nutrients, and other physical/chemical samples. The 2000 sampling scheme included collection of physical/chemical water quality variables at 30 locations on 16 reservoirs for routine Vital Signs Monitoring. Physical/chemical water quality variables were sampled an additional 15 sites on 6 reservoirs in 2000 due to drought conditions (See Table 2 in Section 1 for specific locations sampled in each reservoir.) Water quality sampling, as described in Table 2, included in situ water column measurements of temperature, dissolved oxygen, pH, and conductivity; Secchi depth measurements; and photic zone (defined as twice the Secchi depth or 4-meters, whichever is greater) composite samples for laboratory analysis of chlorophyll-a, nutrient (total phosphorus, ammonia-nitrogen, nitrate+nitrite-nitrogen, and organic nitrogen), and total dissolved carbon. Water quality profiles and sampling were conducted over the original river channel at the reservoir's maximum depth at each location. Physical/chemical water quality sampling was not conducted at reservoir inflow locations because many of these locations are free flowing (or tailwater areas of upstream dams) and are more representative of riverine processes (and the upstream reservoir), rather than conditions in the reservoir being assessed.

Two specific QA/QC activities were incorporated into the reservoir physical/chemical water sampling. These were: (1) collection and analysis of triplicate sets of water samples once during the year at seven locations to assess sample collection and handling, laboratory analysis, and natural sample variability; and (2) preparation and analysis of ten sets of nutrient container blanks (when the nutrient samples were collected) to assess the degree of contamination associated with the nutrient sample bottles.

DO Rating Scheme

A conceptual model was developed for dissolved oxygen rating criteria. The rating criteria represent a multidimensional approach that includes dissolved oxygen levels both throughout the water column (WC_{DO}) and near the bottom (B_{DO}) of the reservoir. The DO rating at each sampling location (ranging from 1 "poor" to 5 "good") is based on monthly summer water column and bottom water DO measurements. (Summer is defined as a six-month period when maximum thermal stratification and maximum hypolimnetic anoxia is expected to occur: April through September for the run-of-the-river reservoirs and May through October for the tributary reservoirs.)

The final DO rating is the average of the water column DO (WC_{DO}) rating and the bottom DO rating (B_{DO}):

DO Rating = 0.5 (WC_{DO} rating + B_{DO} rating), where:

WC_{DO} (Water Column DO) Rating--a six-month average of the percent of the reservoir cross-sectional area (at the location where the sampling was conducted) that has a dissolved oxygen (DO) concentration less than 2.0 mg/L. (See Figure 1).

Average Cross-Sectional Area (DO less than 2 mg/L)	WC_{DO} Rating for Sampling Location*
<5%	5 (good);
≥5% but ≤10%	3 (fair);
>10%	1 (poor).

*Because most state DO water quality criteria for fish and aquatic life specify a minimum of 5.0 mg/L DO at the 1.5 meter (5 foot) depth, the WC_{DO} rating was lowered if the measured DO at the 1.5 meter depth at a sampling location was below 5.0 mg/L at any time. These adjustments were as follows.

Minimum DO at 1.5 meter depth	Sampling Location WC_{DO} Rating Change
<5.0 mg/L	Decreased one unit (e.g., 5 to 4);
<4.0 mg/L	Decreased two units (e.g., 5 to 3);
<3.0 mg/L	Decreased three units (e.g., 5 to 2);
etc.	etc.

B_{DO} (Bottom DO) Rating--a six month average of the percent of the reservoir cross-sectional bottom length (at the location where sampling was conducted) that has a DO concentration less than 2.0 mg/L, as follows:

Average Cross-Sectional Length* (DO less than 2 mg/L)	B_{DO} Rating for Sampling Location
0%	5 (good);
0 to 10%	4
10 to 20%	3 (fair);
20 to 30%	2
>30%	1 (poor).

*The average percent cross-sectional bottom length was computed based on the total cross-sectional bottom length at average minimum winter pool elevation. In addition, if anoxic bottom conditions (i.e., 0 mg/L) were observed at a location, the B_{DO} rating was lowered one unit, with a minimum rating of 1.

Results from 2000 Monitoring

Table 1 summarizes DO results for each location monitored in 2000. The summary of DO results includes information on water column and bottom DO measurements and the final DO rating. This table includes DO results and ratings for all sites monitored in 2000. Most sites were monitored as part of routine Vital

Signs Monitoring. Water quality measurements including DO were taken at several additional sites due to drought conditions. Reservoirs where this occurred are footnoted in Table 1.

Isopleths for dissolved oxygen and temperature are provided in Appendix B for each sample location during the 2000 sampling season. Isopleths for sites included in rouitne Vitals Signs Monitoring in 2000 are provided first followed by isopleths for the other sites.

References

Hutchinson, G. Evelyn, 1975. A Treatise on Limnology, Volume 1, Part 2 - Chemistry of Lakes, J. Wiley and Sons, New York.

Masters, A., and T.A. McDonough, April 1993. TVA Water Management, Chattanooga, Tennessee, Personal Communication.

Table 1

2000 Dissolved Oxygen Results -- Vital Signs Monitoring Data

(using average minimum winter pool elevations)

	Dissolved Oxygen						
	Water Column DO			Bottom DO			
Reservoir	Less than 5.0 mg/l ? (@ 1.5 meters)	Percent of X-Section <2.0 mg/l	Rating	Bottom DO 0 mg/l ?	Percent of B-L @ MP < 2.0 mg/l	Rating	**Final DO Rating**
RUN-OF-THE-RIVER RESERVOIRS							
Kentucky[1]							
Forebay(TRM 23.0)	No	2.7	5	No	4.0	4	**4.5**
T-Zone(TRM 85.0)	No	0.0	5	No	0.0	5	**5**
Inflow(TRM 200-206)	-	-	-	-	-	-	**(no rating)**
Embay(BSRM 7.4)	No	3.8	5	No	8.5	4	**4.5**
Pickwick							
Forebay(TRM 207.3)	No	3.8	5	No	8.7	4	**4.5**
T-Zone(TRM 230.0)	No	0.0	5	No	0.0	5	**5**
Inflow(TRM 253-259)	-	-	-	-	-	-	**(no rating)**
Embay(BCM 8.4)	No	3.5	5	No	12.6	3	**4**
Wilson							
Forebay(TRM 260.8)	No	10.5	1	Yes	42.7	1	**1**
Inflow(TRM 273-274)	-	-	-	-	-	-	**(no rating)**
Wheeler[1]							
Forebay(TRM 277.0)	No	5.0	3	No	16.4	3	**3**
T-Zone(TRM 295.9)	No	0.0	5	No	0.0	5	**5**
Inflow(TRM 347-348)	-	-	-	-	-	-	**(no rating)**
Embay(ERM 6.0)	No	14.0	1	No	42.4	1	**1**
Guntersville							
Forebay(TRM 350.0)	No	0.0	5	No	0.0	5	**5**
T-Zone(TRM 375.2)	No	0.0	5	No	0.0	5	**5**
Inflow(TRM 420-424)	-	-	-	-	-	-	**(no rating)**
Nickajack[1]							
Forebay(TRM 425.5)	No	0.0	5	No	0.0	5	**5**
Inflow(TRM 469-470)	-	-	-	-	-	-	**(no rating)**
Chickamauga[1]							
Forebay(TRM 472.3)	No	0.5	5	No	4.4	4	**4.5**
T-Zone(TRM 490.5)	No	2.5	5	No	8.6	4	**4.5**
Inflow(TRM 518-529)	-	-	-	-	-	-	**(no rating)**
Embay(HRM 8.5)	No	0.0	5	No	0.0	5	**5**

Table 1

2000 Dissolved Oxygen Results -- Vital Signs Monitoring Data

(using average minimum winter pool elevations)

Reservoir	Dissolved Oxygen: Water Column DO: Less than 5.0 mg/l ? (@ 1.5 meters)	Water Column DO: Percent of X-Section <2.0 mg/l	Rating	Bottom DO: Bottom DO 0 mg/l ?	Bottom DO: Percent of B-L @ MP < 2.0 mg/l	Rating	**Final DO Rating**
Watts Bar							
Forebay(TRM 531.0)	No	12.5	1	No	24.1	2	**1.5**
T-Zone(TRM 560.8)	No	2.0	5	No	9.7	4	**4.5**
Inflow(TRM 600-601)	-	-	-	-	-	-	**(no rating)**
Inflow(CRM 19-22)	-	-	-	-	-	-	**(no rating)**
Fort Loudoun							
Forebay(TRM 605.5)	No	0.5	5	No	7.5	4	**4.5**
T-Zone(TRM 624.6)	No	0.0	5	No	0.0	5	**5**
Tellico							
Forebay(LTRM 1.0)			5			5	**5**
T-Zone(LTRM 15.0)			5			5	**5**
Melton Hill							
Forebay(CRM 24.0)	No	9.2	3	No	19.4	3	**3**
T-Zone(CRM 45.0)	No	0.0	5	No	0.0	5	**5**
TRIBUTARY RESERVOIRS							
Norris							
Forebay(CRM 80.0)			5			5	**5**
Mid-Res(CRM 125.0)			5			5	**5**
Mid-Res(PRM 30.0)			5			5	**5**
Cherokee							
Forebay(HRM 55.0)	No	30.5	1	Yes	49.9	1	**1**
Mid-Res(HRM 77.0)	No	32.0	1	No	75.5	1	**1**
Douglas[1]							
Forebay(FBRM 34.5)	No	37.3	1	Yes	60.9	1	**1**
Mid-Res(FBRM 51.0)	No	31.2	1	Yes	271.8	1	**1**
Ft. Patrick Henry							
Forebay(SFHRM 8.7)			5			5	**5**
Boone[1]							
Forebay(SFHRM 19.0)	No	12.2	1	No	28.8	2	**1.5**
Mid-Res(SFHRM 27.0)	No	20.0	1	Yes	30.5	1	**1**
Mid-Res(WRM 6.5)	No	0.2	5	No	3.4	4	**4.5**

Table 1

2000 Dissolved Oxygen Results -- Vital Signs Monitoring Data

(using average minimum winter pool elevations)

	Dissolved Oxygen						
	Water Column DO			Bottom DO			
Reservoir	Less than 5.0 mg/l ? (@ 1.5 meters)	Percent of X-Section <2.0 mg/l	Rating	Bottom DO 0 mg/l ?	Percent of B-L @ MP < 2.0 mg/l	Rating	**Final DO Rating**
South Holston							
Forebay(SFHRM 51.0)	No	10.8	1	No	27.1	2	**1.5**
Mid-Res(SFHRM 62.5)	No	18.0	1	No	42.6	1	**1**
Watauga							
Forebay(WRM 37.4)	No	2.33	5	No	10.8	3	**4**
Mid-Res(WRM 45.5)	No	10.83	1	No	22.5	2	**1.5**
Fontana							
Forebay(LTRM 62.0)	No	0.3	5	No	28.3	2	**3.5**
Mid-Res(LTRM 81.5)	No	2.0	5	No	8.6	4	**4.5**
Mid-Res(TkRM 3.0)	No	7.2	3	No	15.9	3	**3**
Blue Ridge							
Forebay(ToRM 54.1)			5			5	**5**
Apalachia							
Forebay(HiRM 67.0)	No	4.3	5	No	27.8	2	**3.5**
Hiwassee							
Forebay(HiRM 77.5)	No	5.9	3	No	28.3	2	**2.5**
Mid-Res(HIRM 85.0)	No	0.0	5	No	0.0	5	**5**
Nottely							
Forebay(NRM 23.5)			5			5	**5**
Mid-Res(NRM 31.0)			5			5	**5**
Chatuge							
Forebay(HiRM 122.0)	No	8.2	3	No	18.8	3	**3**
Mid-Res(Shooting Cr 1.5)	No	9.3	3	No	26.0	2	**2.5**
Ocoee #1							
Forebay(ORM12.5)			5			5	**5**
Tims Ford							
Forebay(ERM 135.0)	No	49.8	1	Yes	78.7	1	**1**
Mid-Res(ERM 150.0)	No	46.7	1	Yes	84.5	1	**1**

Table 1

2000 Dissolved Oxygen Results -- Vital Signs Monitoring Data

(using average minimum winter pool elevations)

Reservoir	Dissolved Oxygen: Water Column DO: Less than 5.0 mg/l ? (@ 1.5 meters)	Water Column DO: Percent of X-Section <2.0 mg/l	Rating	Bottom DO: Bottom DO 0 mg/l ?	Bottom DO: Percent of B-L @ MP < 2.0 mg/l	Rating	**Final DO Rating**
Normandy							
Forebay(DRM 249.5)	Yes 4.4	24.2	1	Yes	44.7	1	1
Bear Creek							
Forebay(BCM 75.0)			5			5	5
Little Bear Creek							
Forebay(LBCM 12.5)			5			5	5
Cedar Creek[1]							
Forebay(25.2)	No	28.5	1	Yes	74.2	1	1
Beech							
Forebay(BRM 36.0)	No	29.0	1	Yes	46.9	1	1

Shaded monitoring locations were not sampled in 2000.

1=Water Quality Monitoring initiated due to drought conditions; full Vital Signs Monitoring not conducted

Table 2

RESERVOIR "VITAL SIGNS" WATER QUALITY MONITORING
WATER QUALITY MEASUREMENTS -- 2000

Samples/ Measurements	Depths(s)[a] (meters)	Container	Preservation/Handling
		FIELD - each survey	
Secchi disc	(record depth)	--	--
Temp, pH, DO, cond	0.3, 1.5, 4, etc.	in situ[b]	--
Chlorophyll[c]	S_c	1-L cubitainer	Immediately add 1 mL of $MgCO_3$, place on ice, filter within 3 hours
		LABORATORY - each survey	
Nutrients -- (total phosphorus, ammonia, nitrate + nitrite, and organic nitrogen)	S_c	250-mL	Add 1 mL of 1 + 4 H_2SO_4, place on ice
Total Organic Carbon	S_c	125-mL	Add 1 mL of 1 + 4 H_2SO_4,
Blanks[d] and Triplicates[e]		(same containers as above -- for nutrients)	
		AQUATIC BIOLOGICAL - each survey	
Algal Assemblage[f] solution	S_c	125-mL, dark bottle	Add 2-mL of Lugol's or M3
Zooplankton Tow[g]	Bottom to Surface tow	250-mL	Add approx. 20mL buffered formalin per 250 mL of sample
		SEDIMENT - July survey	
Sediment[h] (metals, PCBs, and pesticides)	Top 3cm composite	1 - 1 liter glass wide mouth bottle	Immediately place on ice

a. S_c - indicates a surface composite sample.

b. Hydrolab measurements of temperature, pH, DO, and conductivity will be made at the depths shown and at 2-meter intervals (4-meter intervals on tributary reservoirs) to the bottom of the reservoir. Measurements will be made at intermediate depths any time the temperature changes $\geq$2°C or the DO changes $\geq$1 mg/L from the previous measurement.

c. Recommended chlorophyll filters -- Whatman GF/C, 47 mm, 1.2 µm pore size, MFR No.1822-047.

d. Container blanks will be prepared according to the schedule given in Workpaln.

e. Triplicate samples - Three separate and distinct samples, each collected separately and individually, will be collected, once during the year, at the locations and according to the schedule given Workplan.

f. Algae samples will be placed in dark bottles and preservative with M3/Lugol's.

g. Zooplankton net should be retrieved from bottom to surface at a constant rate of 0.5 to 0.7 meters per second.

h. All sediment samples (and duplicates) will be collected in July.

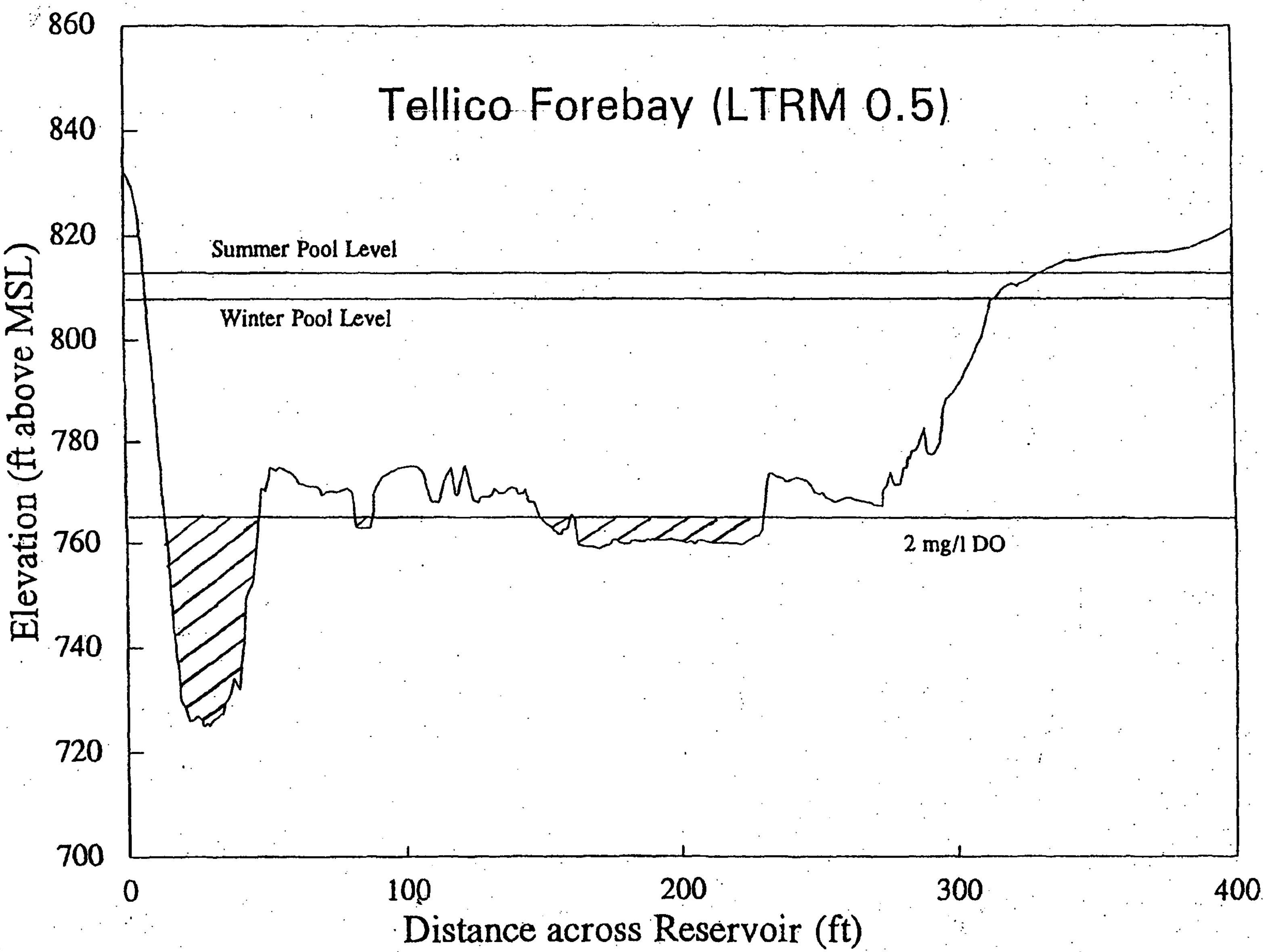


Figure 1. Cross-sectional Area of Tellico Reservoir Forebay Showing the Area with DO Less Than 2.0 mg/1.

Section 3. Chlorophyll and Nutrients

Philosophical Approach/Background

Algae are the base of the aquatic food chain; consequently, measuring algal biomass or primary productivity is important in evaluating ecological health. Without algae converting sunlight energy, carbon dioxide, and nutrients into oxygen and new plant material, a lake or reservoir could not support other aquatic life. Chlorophyll-a is a simple, long-standing, and well-accepted measurement for estimating algal biomass, algal productivity, and trophic condition of a lake or reservoir (Carlson, 1977).

Generally, lower chlorophyll concentrations in the oligotrophic range are thought of being indicative of good water quality conditions. Conversely, high chlorophyll concentrations are usually considered indicative of cultural eutrophication. However, care must be taken not to over generalize. For example, it would be inappropriate to expect all reservoirs in the Tennessee Valley to have low chlorophyll concentrations because some reservoirs are in watersheds which have nutrient rich, easily erodable soils. Most watersheds in the Tennessee Valley provide sufficient nutrients to expect chlorophyll concentrations in the mesotrophic range, even in absence of anthropogenic sources and cultural etrophication. However, two watersheds in the Tennessee Valley have soils (and consequently waters) with naturally low nutrient levels--the Little Tennessee and Hiwassee. The streams and rivers in these watersheds drain the Blue Ridge Ecoregion which is largely characterized by thin soils and is underlain mostly with hard crystalline and metasedimentary rocks.

Obviously, development of appropriate expectations is a critical step in evaluating implications of chlorophyll concentrations on the ecological health of a reservoir. The range of concentrations which are considered indicative of good, fair, and poor conditions must be tailored to reservoirs within each watershed based on knowledge of background or natural conditions. This leads to separating reservoirs into classes based upon these conditions.

The classification scheme used to develop expectations for chlorophyll in Tennessee Valley reservoirs was based on the "natural" nutrient level in a watershed.

Professional judgment was used to select concentrations considered indicative of good, fair, and poor conditions. Based on this approach, reservoirs were placed into one of two classes for chlorophyll expectations -- those expected to be oligotrophic because they are in watersheds with naturally low nutrient concentrations and those expected to be mesotrophic because the are in watersheds which naturally have greater nutrient availability. The reservoirs expected to be oligotrophic are those in the Blue Ridge Ecoregion. Included in this group are those in the Hiwassee River drainage--Hiwassee, Chatuge, Nottely, Blue Ridge, and Parksville reservoirs and those in the Little Tennessee River drainage--Tellico and Fontana. The remaining reservoirs, both mainstream reservoirs and tributary reservoirs, are expected to be mesotrophic.

The range of concentrations selected to represent good, fair, and poor conditions obviously will be much lower for reservoirs in nutrient-poor watersheds. For those reservoirs in watersheds with naturally low nutrient levels, the primary concern is early identification of cultural eutrophication. Appropriate actions can then be taken to control the nutrient loadings and prevent a shift to a higher trophic state. For reservoirs expected to be mesotrophic, the concern is that chlorophyll levels not become too great because of the associated undesirable conditions--occasional dense algal blooms, poor water clarity, low DOs, and the predominance of noxious bluegreen algae. In mesotrophic reservoirs where sufficient nutrients are available but chlorophyll concentrations remain low, there is likely something inhibiting this natural process, such as excessive turbidity, toxicity, etc. Consequently, the rating for chlorophyll-a may be lowered when such conditions are found.

Data Collection Methods

Water samples were collected monthly (April - September on run-of-river reservoirs and April-October on tributary reservoirs) from the photic zone (defined as twice the Secchi depth or 4-meters, whichever was greater) with a peristaltic pump. The water samples were collected from the entire photic zone, composited, and dispersed into bottles for laboratory analysis of chlorophyll, nutrients (total phosphorus, ammonia-nitrogen, nitrate+nitrite-nitrogen, and organic nitrogen), total organic carbon, and algal assemblage. In addition, in-situ water column profiles of temperature, dissolved oxygen, pH, conductivity; and Secchi depth measurements were made monthly. Zooplankton samples were also collected monthly with a 100 mm diameter net. Neither the zooplankton nor algal samples were processed as a routine part of this program. Rather, they were archived for later examination if the need arose.

The 2000 sampling scheme included collection of physical/chemical water quality variables at 30 locations on 16 reservoirs for routine Vital Signs Monitoring. Physical/chemical water quality variables were sampled an additional 15 sites on 6 reservoirs in 2000 due to drought. Additional details on collection methods are given in Data Collection Methods, Section 2 and Table 2-Section 2.

Chlorophyll Rating Scheme

Chlorophyll ratings at each sampling location were based on the average summer concentration of monthly, composite photic zone samples collected from April through October (or September), using the criteria shown in Figure 1.

Results from 2000 Monitoring

Table 1 summarizes chlorophyll results for each location monitored as part of routine Vital Signs Monitoring in 2000. This summary includes the average chlorophyll concentration for the monitoring season, the maximum observed chlorophyll concentration, and the Final Chlorophyll-a Rating. Table 2 is a summary of the physical/chemical and nutrient quality data for all locations monitored during the summer of 2000. Most sites were monitored as part of routine Vital Signs Monitoring. Water quality measurements including chlorophyll were taken at several additional sites due to drought conditions as shown in Table 2.

References

Carlson, R.E., 1977. "A Trophic State Index for Lakes." Limnology and Oceanography, 22:361-369.

Table 1
2000 Chlorophyll-a Results -- Vital Signs Reservoir Monitoring Data

Date	Location	River Mile	Lab Chlorophyll-a Results		Lab Chlorophyll-a Average		Rating
April 04	Apalachia-FB	HIWASSEE RIVER 67.0	5	5			
May 03	Apalachia-FB	HIWASSEE RIVER 67.0	8	8			
June 07	Apalachia-FB	HIWASSEE RIVER 67.0	6	6			
July 11	Apalachia-FB	HIWASSEE RIVER 67.0	5	5			
August 08	Apalachia-FB	HIWASSEE RIVER 67.0	5	5			
September 07	Apalachia-FB	HIWASSEE RIVER 67.0	7	7			
October 02	Apalachia-FB	HIWASSEE RIVER 67.0	5	5			
					5.86		2.7
April 05	Beech-FB	Beech River 36.0	41	*			
May 03	Beech-FB	Beech River 36.0	31	*			
June 15	Beech-FB	Beech River 36.0	15	15			
July 10	Beech-FB	Beech River 36.0	13	13			
August 07	Beech-FB	Beech River 36.0	13	13			
September 11	Beech-FB	Beech River 36.0	14	14			
October 02	Beech-FB	Beech River 36.0	4	ii			
					13.75	*	0.1
April 04	Chatuge-FB	HIWASSEE RIVER 122.0	5	5			
May 03	Chatuge-FB	HIWASSEE RIVER 122.0	5	5			
June 07	Chatuge-FB	HIWASSEE RIVER 122.0	3	3			
July 11	Chatuge-FB	HIWASSEE RIVER 122.0	2	2			
August 08	Chatuge-FB	HIWASSEE RIVER 122.0	3	3			
September 07	Chatuge-FB	HIWASSEE RIVER 122.0	2	2			
October 02	Chatuge-FB	HIWASSEE RIVER 122.0	3	3			
					3.29		4.8
April 04	Chatuge SC-FB	SHOOTING CREEK 1.5	4	4			
May 03	Chatuge SC-FB	SHOOTING CREEK 1.5	5	5			
June 07	Chatuge SC-FB	SHOOTING CREEK 1.5	4	4			
July 11	Chatuge SC-FB	SHOOTING CREEK 1.5	3	3			
August 08	Chatuge SC-FB	SHOOTING CREEK 1.5	3	3			
September 07	Chatuge SC-FB	SHOOTING CREEK 1.5	3	3			
October 02	Chatuge SC-FB	SHOOTING CREEK 1.5	3	3			
					3.57		4.5
April 12	Cherokee-FB	HIWASSEE RIVER 55.0	21	21			
May 08	Cherokee-FB	HIWASSEE RIVER 55.0	15	15			
June 12	Cherokee-FB	HIWASSEE RIVER 55.0	10	10			
July 18	Cherokee-FB	HIWASSEE RIVER 55.0	12	12			
August 14	Cherokee-FB	HIWASSEE RIVER 55.0	10	10			
September 11	Cherokee-FB	HIWASSEE RIVER 55.0	11	11			
October 12	Cherokee-FB	HIWASSEE RIVER 55.0	8	8			
					12.43		2.8
April 12	Cherokee-MR	HIWASSEE RIVER 76.0	12	12			
May 08	Cherokee-MR	HIWASSEE RIVER 76.0	39	*			
June 12	Cherokee-MR	HIWASSEE RIVER 76.0	13	13			
July 18	Cherokee-MR	HIWASSEE RIVER 76.0	17	17			
August 14	Cherokee-MR	HIWASSEE RIVER 76.0	19	19			
September 11	Cherokee-MR	HIWASSEE RIVER 76.0	20	20			
October 12	Cherokee-MR	HIWASSEE RIVER 76.0	8	8			
					14.83	*	1.0
April 03	Fontana-FB	LITTLE TENNESSEE RIVER 62.0	1	1			
May 02	Fontana-FB	LITTLE TENNESSEE RIVER 62.0	1	1			
June 06	Fontana-FB	LITTLE TENNESSEE RIVER 62.0	1	1			
July 10	Fontana-FB	LITTLE TENNESSEE RIVER 62.0	2	2			
August 07	Fontana-FB	LITTLE TENNESSEE RIVER 62.0	3	3			
September 06	Fontana-FB	LITTLE TENNESSEE RIVER 62.0	3	3			
October 03	Fontana-FB	LITTLE TENNESSEE RIVER 62.0	3	3			
					2.00		5.0
April 03	Fontana LT-MR	LITTLE TENNESSEE RIVER 81.5	10	10			
May 02	Fontana LT-MR	LITTLE TENNESSEE RIVER 81.5	3	3			
June 06	Fontana LT-MR	LITTLE TENNESSEE RIVER 81.5	5	Triplicate			
June 06	Fontana LT-MR	LITTLE TENNESSEE RIVER 81.5	6	6			
June 06	Fontana LT-MR	LITTLE TENNESSEE RIVER 81.5	6	Triplicate			
July 10	Fontana LT-MR	LITTLE TENNESSEE RIVER 81.5	7	7			
August 07	Fontana LT-MR	LITTLE TENNESSEE RIVER 81.5	3	ii			
September 06	Fontana LT-MR	LITTLE TENNESSEE RIVER 81.5	4	4			
October 03	Fontana LT-MR	LITTLE TENNESSEE RIVER 81.5	4	4			
					5.67		2.9

Table 1

2000 Chlorophyll-a Results -- Vital Signs Reservoir Monitoring Data

Date	Location	River Mile	Lab Chlorophyll-a				Rating
			Results		Average		
April 03	Fontana Tk-MR	TUCKASEEGEE RIVER 3.0	5	5			
May 02	Fontana Tk-MR	TUCKASEEGEE RIVER 3.0	3	3			
June 06	Fontana Tk-MR	TUCKASEEGEE RIVER 3.0	2	2			
July 10	Fontana Tk-MR	TUCKASEEGEE RIVER 3.0	8	8			
August 07	Fontana Tk-MR	TUCKASEEGEE RIVER 3.0	7	7			
September 06	Fontana Tk-MR	TUCKASEEGEE RIVER 3.0	8	8			
October 03	Fontana Tk-MR	TUCKASEEGEE RIVER 3.0	4	4			
					5.29		3.2
April 13	Fort Loudoun-FB	TENNESSEE RIVER 605.5	18	18			
May 10	Fort Loudoun-FB	TENNESSEE RIVER 605.5	12	12			
June 14	Fort Loudoun-FB	TENNESSEE RIVER 605.5	34	*			
July 18	Fort Loudoun-FB	TENNESSEE RIVER 605.5	17	17			
August 14	Fort Loudoun-FB	TENNESSEE RIVER 605.5	22	22			
September 11	Fort Loudoun-FB	TENNESSEE RIVER 605.5	20	20			
					17.80	*	0.0
April 13	Fort Loudoun-TZ	TENNESSEE RIVER 624.6	8	8			
May 10	Fort Loudoun-TZ	TENNESSEE RIVER 624.6	29	29			
June 14	Fort Loudoun-TZ	TENNESSEE RIVER 624.6	28	28			
July 18	Fort Loudoun-TZ	TENNESSEE RIVER 624.6	18	18			
August 14	Fort Loudoun-TZ	TENNESSEE RIVER 624.6	21	21			
September 11	Fort Loudoun-TZ	TENNESSEE RIVER 624.6	20	20			
					20.67		1.0
April 18	Guntersville-FB	TENNESSEE RIVER 350.0	14	14			
May 11	Guntersville-FB	TENNESSEE RIVER 350.0	10	10			
June 16	Guntersville-FB	TENNESSEE RIVER 350.0	12	12			
July 18	Guntersville-FB	TENNESSEE RIVER 350.0	6	6			
August 17	Guntersville-FB	TENNESSEE RIVER 350.0	14	14			
September 19	Guntersville-FB	TENNESSEE RIVER 350.0	9	9			
					10.83		3.6
April 17	Guntersville-TZ	TENNESSEE RIVER 375.2	2	2			
May 11	Guntersville-TZ	TENNESSEE RIVER 375.2	8	8			
June 16	Guntersville-TZ	TENNESSEE RIVER 375.2	4	4			
July 18	Guntersville-TZ	TENNESSEE RIVER 375.2	7	7			
August 17	Guntersville-TZ	TENNESSEE RIVER 375.2	4	4			
September 19	Guntersville-TZ	TENNESSEE RIVER 375.2	4	4			
					4.83		5.0
April 04	Hiwassee-FB	HIWASSEE RIVER 77.0	5	5			
May 03	Hiwassee-FB	HIWASSEE RIVER 77.0	5	5			
June 07	Hiwassee-FB	HIWASSEE RIVER 77.0	4	4			
July 11	Hiwassee-FB	HIWASSEE RIVER 77.0	3	3			
August 08	Hiwassee-FB	HIWASSEE RIVER 77.5	4	4			
September 07	Hiwassee-FB	HIWASSEE RIVER 77.5	5	5			
October 02	Hiwassee-FB	HIWASSEE RIVER 77.5	5	5			
					4.43		3.9
April 04	Hiwassee-MR	HIWASSEE RIVER 85.0	6	6			
May 03	Hiwassee-MR	HIWASSEE RIVER 85.0	5	5			
June 07	Hiwassee-MR	HIWASSEE RIVER 85.0	5	5			
July 11	Hiwassee-MR	HIWASSEE RIVER 85.0	6	6			
August 08	Hiwassee-MR	HIWASSEE RIVER 85.0	6	6			
September 07	Hiwassee-MR	HIWASSEE RIVER 85.0	8	8			
October 02	Hiwassee-MR	HIWASSEE RIVER 85.0	6	6			
					6.00		2.6
April 12	Melton Hill-FB	CLINCH RIVER 24.0	15	15			
May 08	Melton Hill-FB	CLINCH RIVER 24.0	17	17			
June 12	Melton Hill-FB	CLINCH RIVER 24.0	6	6			
July 20	Melton Hill-FB	CLINCH RIVER 24.0	12	12			
August 16	Melton Hill-FB	CLINCH RIVER 24.0	11	11			
September 13	Melton Hill-FB	CLINCH RIVER 24.0	15	15			
					12.67		2.7
April 12	Melton Hill-TZ	CLINCH RIVER 45.0	4	4			
April 12	Melton Hill-TZ	CLINCH RIVER 45.0	5	Triplicate			
April 12	Melton Hill-TZ	CLINCH RIVER 45.0	4	Triplicate			
May 08	Melton Hill-TZ	CLINCH RIVER 45.0	19	19			
June 12	Melton Hill-TZ	CLINCH RIVER 45.0	5	5			
July 20	Melton Hill-TZ	CLINCH RIVER 45.0	8	8			

Table 1
2000 Chlorophyll-a Results -- Vital Signs Reservoir Monitoring Data

Date	Location	River Mile	Lab Chlorophyll-a Results		Lab Chlorophyll-a Average		Rating
August 16	Melton Hill-TZ	CLINCH RIVER 45.0	2	2			
September 13	Melton Hill-TZ	CLINCH RIVER 45.0	6	6			
					7.33		5.0
April 19	Normandy-FB	DUCK RIVER 249.50	13	13			
May 09	Normandy-FB	DUCK RIVER 249.50	15	15			
June 19	Normandy-FB	DUCK RIVER 249.50	16	16			
July 19	Normandy-FB	DUCK RIVER 249.50	17	17			
August 16	Normandy-FB	DUCK RIVER 249.50	12	12			
September 20	Normandy-FB	DUCK RIVER 249.50	5	5			
October 03	Normandy-FB	DUCK RIVER 249.50	8	8			
					12.29		2.9
April 05	Pickwick-FB	TENNESSEE RIVER 207.3	3	3			
May 03	Pickwick-FB	TENNESSEE RIVER 207.3	20	20			
June 15	Pickwick-FB	TENNESSEE RIVER 207.3	19	19			
July 11	Pickwick-FB	TENNESSEE RIVER 207.3	15	15			
August 08	Pickwick-FB	TENNESSEE RIVER 207.3	13	13			
September 12	Pickwick-FB	TENNESSEE RIVER 207.3	4	4			
					12.33		2.8
April 05	Pickwick-TZ	TENNESSEE RIVER 230.0	3	3			
May 03	Pickwick-TZ	TENNESSEE RIVER 230.0	12	12			
June 15	Pickwick-TZ	TENNESSEE RIVER 230.0	29	29			
July 11	Pickwick-TZ	TENNESSEE RIVER 230.0	21	21			
August 08	Pickwick-TZ	TENNESSEE RIVER 230.0	8	8			
September 12	Pickwick-TZ	TENNESSEE RIVER 230.0	7	7			
					13.33		2.3
April 05	Pickwick-Emb	BEAR CREEK EMBAY 8.4	1	ii			
May 03	Pickwick-Emb	BEAR CREEK EMBAY 8.4	11	11			
June 15	Pickwick-Emb	BEAR CREEK EMBAY 8.4	35	*			
July 11	Pickwick-Emb	BEAR CREEK EMBAY 8.4	11	11			
August 08	Pickwick-Emb	BEAR CREEK EMBAY 8.4	19	19			
September 12	Pickwick-Emb	BEAR CREEK EMBAY 8.4	39	*			
					13.67	*	0.2
April 10	South Holston-FB	SOUTH FORK HOLSTON RIVER 51.0	9	9			
May 09	South Holston-FB	SOUTH FORK HOLSTON RIVER 51.0	11	11			
June 13	South Holston-FB	SOUTH FORK HOLSTON RIVER 51.0	4	4			
June 13	South Holston-FB	SOUTH FORK HOLSTON RIVER 51.0	4	Triplicate			
June 13	South Holston-FB	SOUTH FORK HOLSTON RIVER 51.0	4	Triplicate			
July 19	South Holston-FB	SOUTH FORK HOLSTON RIVER 51.0	Interference				
August 15	South Holston-FB	SOUTH FORK HOLSTON RIVER 51.0	4	4			
September 12	South Holston-FB	SOUTH FORK HOLSTON RIVER 51.0	5	5			
October 11	South Holston-FB	SOUTH FORK HOLSTON RIVER 51.0	3	3			
					6.00		5.0
April 10	South Holston-MR	SOUTH FORK HOLSTON RIVER 62.5	18	18			
May 09	South Holston-MR	SOUTH FORK HOLSTON RIVER 62.5	20	20			
June 13	South Holston-MR	SOUTH FORK HOLSTON RIVER 62.5	8	8			
July 19	South Holston-MR	SOUTH FORK HOLSTON RIVER 62.5	12	12			
August 15	South Holston-MR	SOUTH FORK HOLSTON RIVER 62.5	10	10			
September 12	South Holston-MR	SOUTH FORK HOLSTON RIVER 62.5	10	10			
October 11	South Holston-MR	SOUTH FORK HOLSTON RIVER 62.5	7	7			
					12.14		2.9
April 19	Tims Ford-FB	ELK RIVER 135.0	7	7			
May 09	Tims Ford-FB	ELK RIVER 135.0	9	9			
June 19	Tims Ford-FB	ELK RIVER 135.0	8	8			
July 19	Tims Ford-FB	ELK RIVER 135.0	10	10			
August 16	Tims Ford-FB	ELK RIVER 135.0	5	5			
September 20	Tims Ford-FB	ELK RIVER 135.0	5	5			
October 03	Tims Ford-FB	ELK RIVER 135.0	5	5			
					7.00		5.0

Table 1
2000 Chlorophyll-a Results – Vital Signs Reservoir Monitoring Data

Date	Location	River Mile	Lab Chlorophyll-a Results		Average		Rating
April 19	Tims Ford-MR	ELK RIVER 150.0	20	20			
May 09	Tims Ford-MR	ELK RIVER 150.0	23	23			
June 19	Tims Ford-MR	ELK RIVER 150.0	11	11			
June 19	Tims Ford-MR	ELK RIVER 150.0	10	Triplicate			
June 19	Tims Ford-MR	ELK RIVER 150.0	11	Triplicate			
July 19	Tims Ford-MR	ELK RIVER 150.0	6	6			
August 16	Tims Ford-MR	ELK RIVER 150.0	5	5			
September 20	Tims Ford-MR	ELK RIVER 150.0	11	11			
October 03	Tims Ford-MR	ELK RIVER 150.0	13	13			
					12.71		2.6
April 10	Watauga-FB	WATAUGA RIVER 37.4	2	2			
May 09	Watauga-FB	WATAUGA RIVER 37.4	7	7			
June 13	Watauga-FB	WATAUGA RIVER 37.4	5	5			
July 19	Watauga-FB	WATAUGA RIVER 37.4	4	4			
August 15	Watauga-FB	WATAUGA RIVER 37.4	5	5			
September 12	Watauga-FB	WATAUGA RIVER 37.4	4	4			
October 11	Watauga-FB	WATAUGA RIVER 37.4	4	4			
					4.43		5.0
April 10	Watauga-MR	WATAUGA RIVER 45.5	3	3			
May 09	Watauga-MR	WATAUGA RIVER 45.5	9	9			
June 13	Watauga-MR	WATAUGA RIVER 45.5	5	5			
July 19	Watauga-MR	WATAUGA RIVER 45.5	5	5			
August 15	Watauga-MR	WATAUGA RIVER 45.5	7	7			
September 12	Watauga-MR	WATAUGA RIVER 45.5	8	8			
October 11	Watauga-MR	WATAUGA RIVER 45.5	7	7			
					6.29		5.0
April 05	Watts Bar-FB	TENNESSEE RIVER 531.0	7	Triplicate			
April 05	Watts Bar-FB	TENNESSEE RIVER 531.0	8	8			
April 05	Watts Bar-FB	TENNESSEE RIVER 531.0	8	Triplicate			
May 04	Watts Bar-FB	TENNESSEE RIVER 531.0	14	14			
June 08	Watts Bar-FB	TENNESSEE RIVER 531.0	9	9			
July 12	Watts Bar-FB	TENNESSEE RIVER 531.0	18	18			
August 09	Watts Bar-FB	TENNESSEE RIVER 532.5	18	18			
September 05	Watts Bar-FB	TENNESSEE RIVER 532.5	16	16			
					13.83		2.1
April 05	Watts Bar-TZ	TENNESSEE RIVER 560.80	2	2			
May 04	Watts Bar-TZ	TENNESSEE RIVER 560.80	11	11			
June 08	Watts Bar-TZ	TENNESSEE RIVER 560.80	17	17			
July 12	Watts Bar-TZ	TENNESSEE RIVER 560.80	16	16			
August 09	Watts Bar-TZ	TENNESSEE RIVER 560.80	13	13			
September 05	Watts Bar-TZ	TENNESSEE RIVER 560.80	19	19			
					13.00		2.5
April 18	Wilson-FB	TENNESSEE RIVER 260.8	7	7			
April 18	Wilson-FB	TENNESSEE RIVER 260.8	6	Triplicate			
April 18	Wilson-FB	TENNESSEE RIVER 260.8	8	Triplicate			
May 04	Wilson-FB	TENNESSEE RIVER 260.8	14	14			
June 12	Wilson-FB	TENNESSEE RIVER 260.8	22	22			
July 07	Wilson-FB	TENNESSEE RIVER 260.8	33	*			
August 11	Wilson-FB	TENNESSEE RIVER 260.8	7	7			
September 11	Wilson-FB	TENNESSEE RIVER 260.8	5	5			
					11.00	*	2.5

* – Indicates one (or more) chlorophyll-a results equaled or exceeded 30 ug/L

ii – Indicates phaeophtin levels were high, therefore the chlorophyll value was rejected.

Shading indicates ratings for samples collected in nutrient limited watersheds

Table 2
2000 Vital Signs Reservoir Monitoring Summary

	Kentucky Forebay (TRM 23.0)[1]				Kentucky Transition (TRM 85.0)[1]				Kentucky Embay (Big Sandy 7.4)[1]			
	N	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	73	24.1	15.4	31.0	58	25.0	16.0	30.4	38	24.1	14.8	31.4
Dissolved Oxygen (mg/L)	73	6.5	0.3	9.7	58	6.8	5.0	9.2	38	6.4	0.5	9.5
pH (s.u.)	73	7.3	6.6	8.4	58	7.3	7.1	7.7	38	7.2	6.7	8.7
Conductivity (us/cm)	73	152	136	179	58	165	148	184	38	130	77	220
Organic N (mg/L)	6	0.35	0.20	0.50	6	0.31	0.17	0.37	6	0.50	0.27	0.68
Ammonia N (mg/L)	6	0.04	0.01	0.08	6	0.12	0.04	0.19	6	0.01	0.01	0.01
Nitrate+Nitrite N (mg/L)	6	0.24	0.01	0.60	6	0.21	0.05	0.48	6	0.05	0.01	0.17
Total Nitrogen (mg/L)	6	0.63	0.49	0.93	6	0.64	0.49	0.86	6	0.55	0.31	0.79
Total Phosphorus (mg/L)	6	0.063	0.034	0.090	6	0.065	0.042	0.100	6	0.041	0.017	0.060
TN / TP Ratio	6	10.5	8.2	16.5	6	10.2	7.0	14.3	6	14.0	10.0	18.2
Chlorophyll-a (ug/L)	6	13.8	3.0	27.0	6	7.7	3.0	15.0	6	24.7	13.0	39.0
TOC	6	3.2	2.9	3.6	6	3.2	2.8	3.7	6	4.2	3.9	4.5
Secchi Depth (m)	6	1.20	0.70	1.50	6	0.97	0.80	1.20	6	0.87	0.60	1.10

	Pickwick Forebay (TRM 207.3)				Pickwick Transition (TRM 230.0)				Pickwick Embayment (BCM 8.4)			
	N	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	94	24.9	15.6	31.1	62	24.7	15.8	30.6	41	24.3	14.1	31.6
Dissolved Oxygen (mg/L)	94	6.1	0.5	9.0	62	7.1	4.5	10.3	41	5.3	0.2	8.2
pH (s.u.)	94	7.4	6.7	8.7	62	7.6	7.0	8.5	41	7.3	6.8	8.2
Conductivity (us/cm)	94	156	133	281	62	161	144	183	41	131	55	169
Organic N (mg/L)	6	0.41	0.31	0.54	6	0.38	0.30	0.54	6	0.47	0.34	0.62
Ammonia N (mg/L)	6	0.03	0.01	0.07	6	0.03	0.01	0.06	6	0.01	0.01	0.03
Nitrate+Nitrite N (mg/L)	6	0.20	0.01	0.60	6	0.27	0.01	0.62	6	0.10	0.01	0.25
Total Nitrogen (mg/L)	6	0.62	0.43	0.93	6	0.68	0.41	0.98	6	0.57	0.42	0.71
Total Phosphorus (mg/L)	6	0.057	0.039	0.070	6	0.057	0.045	0.067	6	0.035	0.024	0.050
TN / TP Ratio	6	10.9	6.6	15.5	6	12.1	6.8	17.6	6	16.7	12.6	24.6
Chlorophyll-a (ug/L)	6	12.3	3.0	20.0	6	13.3	3.0	29.0	6	19.3	1.0	39.0
TOC	6	3.2	2.7	3.4	6	3.1	2.7	3.4	6	3.7	3.0	5.5
Secchi Depth (m)	6	1.40	0.80	1.90	6	1.20	0.70	1.40	6	0.85	0.30	1.10

	Wilson Forebay (TRM 260.8)			
	N	Mean	Min	Max
Temperature (deg C)	102	23.8	15.3	29.8
Dissolved Oxygen (mg/L)	102	5.6	0.1	11.1
pH (s.u.)	102	7.5	6.7	9.1
Conductivity (us/cm)	102	159	138	187
Organic N (mg/L)	6	0.40	0.29	0.60
Ammonia N (mg/L)	6	0.03	0.01	0.06
Nitrate+Nitrite N (mg/L)	6	0.17	0.01	0.52
Total Nitrogen (mg/L)	6	0.60	0.40	0.87
Total Phosphorus (mg/L)	6	0.056	0.043	0.070
TN / TP Ratio	6	10.6	7.0	14.9
Chlorophyll-a (ug/L)	6	14.7	5.0	33.0
TOC	6	3.2	2.6	3.7
Secchi Depth (m)	6	1.82	1.00	2.50

	Wheeler Forebay (TRM 277.0)[1]				Wheeler Transition (TRM 295.9)[1]				Wheeler Embayment (ERM 6.0)[1]			
	N	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	67	25.3	15.5	31.4	43	24.7	15.5	30.7	40	23.7	13.3	31.5
Dissolved Oxygen (mg/L)	67	6.6	0.3	13.2	43	7.2	5.3	10.7	40	5.7	0.2	13.2
pH (s.u.)	67	7.6	6.8	9.1	43	7.3	7.0	8.7	40	7.7	7.1	8.9
Conductivity (us/cm)	67	158	131	183	43	159	131	183	40	215	183	247
Organic N (mg/L)	6	0.35	0.21	0.48	6	0.31	0.16	0.47	6	0.45	0.11	0.70
Ammonia N (mg/L)	6	0.02	0.01	0.05	6	0.03	0.01	0.05	6	0.01	0.01	0.03
Nitrate+Nitrite N (mg/L)	6	0.15	0.01	0.50	6	0.19	0.05	0.37	6	0.27	0.01	0.93
Total Nitrogen (mg/L)	6	0.50	0.36	0.84	6	0.53	0.34	0.72	6	0.74	0.57	1.12
Total Phosphorus (mg/L)	6	0.061	0.050	0.080	6	0.068	0.060	0.080	6	0.185	0.150	0.230
TN / TP Ratio	6	8.3	6.0	12.0	6	7.8	5.7	10.3	6	4.1	2.7	5.9
Chlorophyll-a (ug/L)	6	13.3	6.0	26.0	6	10.5	2.0	21.0	6	19.8	2.0	32.0
TOC	6	3.2	2.6	3.5	6	3.0	2.6	3.7	6	3.0	1.7	3.8
Secchi Depth (m)	6	1.40	0.70	1.80	6	1.13	0.80	1.40	5	0.90	0.70	1.10

1=Water Quality Monitoring initiated due to drought conditions; full Vital Signs Monitoring not conducted.

(If a duplicate/triplicate sample is collected at a sampling location, only the first sample (D1 or T1) of the duplicate/triplicate is used to determine the mean, minimum, and maximum values.)

Table 2
2000 Vital Signs Reservoir Monitoring Summary

	Guntersville Forebay (TRM 350.0)				Guntersville Transition (TRM 375.2)			
	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	65	24.8	16.1	30.4	47	25.6	16.2	30.9
Dissolved Oxygen (mg/L)	65	6.8	3.4	9.5	47	6.8	5.7	9.2
pH (s.u.)	65	7.6	7.1	8.4	47	7.4	7.2	8.1
Conductivity (us/cm)	65	159	133	183	47	170	143	191
Organic N (mg/L)	6	0.32	0.26	0.35	6	0.24	0.17	0.35
Ammonia N (mg/L)	6	0.02	0.01	0.04	6	0.03	0.01	0.06
Nitrate+Nitrite N (mg/L)	6	0.11	0.01	0.39	6	0.21	0.14	0.36
Total Nitrogen (mg/L)	6	0.44	0.36	0.68	6	0.47	0.33	0.61
Total Phosphorus (mg/L)	6	0.035	0.014	0.050	6	0.035	0.018	0.043
TN / TP Ratio	6	14.7	9.3	32.1	6	14.4	9.8	19.6
Chlorophyll-a (ug/L)	6	10.8	6.0	14.0	6	4.8	2.0	8.0
TOC	6	2.9	2.7	2.9	6	2.7	2.5	3.1
Secchi Depth (m)	6	1.63	1.10	2.00	6	1.75	1.30	2.40

	Nickajack Forebay (TRM 425.5)[1]			
	N	Mean	Min	Max
Temperature (deg C)	64	24.2	15.2	30.5
Dissolved Oxygen (mg/L)	64	6.4	3.4	10.0
pH (s.u.)	64	7.2	7.0	8.0
Conductivity (us/cm)	64	170	144	192
Organic N (mg/L)	6	0.39	0.11	1.10
Ammonia N (mg/L)	6	0.04	0.01	0.09
Nitrate+Nitrite N (mg/L)	6	0.19	0.13	0.29
Total Nitrogen (mg/L)	6	0.62	0.31	1.35
Total Phosphorus (mg/L)	6	0.038	0.030	0.060
TN / TP Ratio	6	16.7	10.3	34.6
Chlorophyll-a (ug/L)	6	7.2	1.0	17.0
TOC	6	2.8	2.3	3.0
Secchi Depth (m)	6	1.61	0.75	2.50

	Chickamauga Forebay (TRM 472.3)[1]				Chickamauga Transition (TRM 490.5)[1]				Chickamauga Embay (HIRM 8.5)[1]			
	N	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	62	24.2	14.9	30.1	73	24.1	15.4	31	33	22.2	12.9	31.3
Dissolved Oxygen (mg/L)	62	6.5	1.6	10.6	73	6.5	0.3	9.7	33	6.4	2.7	10.4
pH (s.u.)	62	7.4	6.9	8.4	73	7.3	6.6	8.4	33	7.0	6.8	8.2
Conductivity (us/cm)	62	169	151	192	73	152	136.4	179	33	186	94	277
Organic N (mg/L)	6	0.26	0.15	0.40	6	0.35	0.2	0.5	6	0.33	0.22	0.53
Ammonia N (mg/L)	6	0.04	0.01	0.10	6	0.04	0.01	0.08	6	0.05	0.01	0.16
Nitrate+Nitrite N (mg/L)	6	0.14	0.05	0.29	6	0.24	0.01	0.6	6	0.16	0.08	0.28
Total Nitrogen (mg/L)	6	0.43	0.30	0.54	6	0.63	0.49	0.93	6	0.54	0.37	0.79
Total Phosphorus (mg/L)	6	0.026	0.017	0.030	6	0.063	0.034	0.09	6	0.077	0.030	0.190
TN / TP Ratio	6	17.3	10.0	26.0	6	10.5	8.222	16.471	6	9.2	3.4	15.8
Chlorophyll-a (ug/L)	6	10.3	2.0	18.0	6	13.8	3	27	6	11.5	2.0	21.0
TOC	6	2.6	2.3	2.9	6	3.2	2.9	3.6	6	3.7	2.7	4.4
Secchi Depth (m)	6	1.57	1.00	1.80	6	1.2	0.7	1.5	6	0.79	0.25	1.20

	Watts Bar Forebay (TRM 532.5)				Watts Bar Transition (TRM 560.8)			
	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	86	22.2	12.9	30.1	54	22.5	13.1	29.5
Dissolved Oxygen (mg/L)	86	5.7	0.2	11.0	54	7.0	1.1	9.9
pH (s.u.)	86	7.6	6.9	9.0	54	7.5	6.9	8.6
Conductivity (us/cm)	86	172	104	215	54	169	105	222
Organic N (mg/L)	6	0.27	0.18	0.38	6	0.31	0.21	0.48
Ammonia N (mg/L)	6	0.02	0.01	0.04	6	0.02	0.01	0.03
Nitrate+Nitrite N (mg/L)	6	0.08	0.01	0.22	6	0.13	0.01	0.23
Total Nitrogen (mg/L)	6	0.37	0.21	0.45	6	0.45	0.34	0.57
Total Phosphorus (mg/L)	6	0.020	0.011	0.030	6	0.036	0.014	0.080
TN / TP Ratio	6	19.9	7.0	29.9	6	15.6	7.1	24.3
Chlorophyll-a (ug/L)	6	13.7	7.0	18.0	6	13.0	2.0	19.0
TOC	6	2.7	2.3	3.0	6	2.7	2.5	3.1
Secchi Depth (m)	6	1.78	1.25	2.10	6	1.13	0.25	1.50

1=Water Quality Monitoring initiated due to drought conditions; full Vital Signs Monitoring not conducted.

(If a duplicate/triplicate sample is collected at a sampling location, only the first sample (D1 or T1) of the duplicate/triplicate is used to determine the mean, minimum, and maximum values.)

Table 2
2000 Vital Signs Reservoir Monitoring Summary

	Fort Loudoun Forebay (TRM 605.5)				Fort Loudoun Transition (TRM 624.6)			
	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	80	21.1	14.5	28.6	65	21.4	13.7	28.2
Dissolved Oxygen (mg/L)	80	6.2	1.6	12.3	65	7.9	4.3	13.4
pH (s.u.)	80	7.5	6.9	9.0	65	7.8	7.2	9.1
Conductivity (us/cm)	80	185	95	235	65	211	167	256
Organic N (mg/L)	6	0.39	0.23	0.60	6	0.45	0.27	0.61
Ammonia N (mg/L)	6	0.01	0.01	0.02	6	0.02	0.01	0.04
Nitrate+Nitrite N (mg/L)	6	0.13	0.02	0.47	6	0.20	0.01	0.64
Total Nitrogen (mg/L)	6	0.52	0.33	0.83	6	0.66	0.34	0.94
Total Phosphorus (mg/L)	6	0.033	0.018	0.060	6	0.049	0.040	0.062
TN / TP Ratio	6	16.8	9.5	22.1	6	13.5	8.5	18.8
Chlorophyll-a (ug/L)	6	20.5	12.0	34.0	6	20.7	8.0	29.0
TOC	6	3.1	2.8	3.3	6	2.8	2.2	3.4
Secchi Depth (m)	6	1.49	1.25	2.00	6	1.25	0.90	1.80

	Melton Hill Forebay (CRM 24.0)				Melton Hill Transition (CRM 45.0)			
	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	82	18.9	13.8	29.8	46	18.3	12.0	29.1
Dissolved Oxygen (mg/L)	82	7.1	0.4	16.6	46	8.5	5.8	12.1
pH (s.u.)	82	7.8	7.2	8.9	46	7.7	7.5	8.4
Conductivity (us/cm)	82	280	209	312	46	289	206	316
Organic N (mg/L)	6	0.62	0.07	2.30	6	0.24	0.06	0.42
Ammonia N (mg/L)	6	0.01	0.01	0.01	6	0.02	0.01	0.04
Nitrate+Nitrite N (mg/L)	6	0.10	0.01	0.25	6	0.30	0.07	0.54
Total Nitrogen (mg/L)	6	0.73	0.13	2.31	6	0.55	0.14	0.90
Total Phosphorus (mg/L)	6	0.020	0.018	0.023	6	0.020	0.010	0.040
TN / TP Ratio	6	38.4	5.7	128.3	6	36.1	6.4	72.0
Chlorophyll-a (ug/L)	6	12.7	6.0	17.0	6	7.3	2.0	19.0
TOC	6	2.8	2.5	3.1	6	2.2	1.9	2.4
Secchi Depth (m)	6	1.63	1.25	1.80	6	1.03	0.50	1.50

	Cherokee Forebay (HRM 55.0)				Cherokee Mid-Res (HRM 76.0)			
	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	123	18.0	7.6	28.9	104	20.0	10.5	29.9
Dissolved Oxygen (mg/L)	123	5.3	0.2	14.7	104	4.8	0.2	20.0
pH (s.u.)	123	7.8	7.2	8.9	104	7.7	7.1	9.2
Conductivity (us/cm)	123	307	256	364	104	303	239	388
Organic N (mg/L)	7	0.31	0.10	0.64	7	0.44	0.23	0.67
Ammonia N (mg/L)	7	0.01	0.01	0.03	7	0.03	0.01	0.10
Nitrate+Nitrite N (mg/L)	7	0.07	0.01	0.22	7	0.15	0.01	0.64
Total Nitrogen (mg/L)	7	0.45	0.22	0.67	7	0.61	0.33	0.90
Total Phosphorus (mg/L)	7	0.019	0.010	0.036	7	0.037	0.023	0.059
TN / TP Ratio	7	24.5	16.7	38.2	7	17.6	11.0	32.1
Chlorophyll-a (ug/L)	7	12.4	8.0	21.0	7	18.3	8.0	39.0
TOC	7	3.8	2.6	4.4	7	3.5	2.8	4.1
Secchi Depth (m)	7	1.76	1.30	2.25	7	1.37	1.10	1.75

	Douglas Forebay (FBRM 34.5)[1]				Douglas Mid-Res (FBRM 51.0)[1]			
	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	102	19.6	10.0	28.4	79	21.4	12.5	29.0
Dissolved Oxygen (mg/L)	102	4.6	0.2	12.1	79	5.0	0.2	12.2
pH (s.u.)	102	7.4	6.6	9.5	79	7.6	6.6	9.5
Conductivity (us/cm)	102	147	123	172	79	150	110	214
Organic N (mg/L)	7	0.32	0.09	0.57	7	0.38	0.20	0.67
Ammonia N (mg/L)	7	0.02	0.01	0.03	7	0.02	0.01	0.06
Nitrate+Nitrite N (mg/L)	7	0.11	0.01	0.36	7	0.10	0.01	0.33
Total Nitrogen (mg/L)	7	0.44	0.21	0.79	7	0.48	0.28	1.00
Total Phosphorus (mg/L)	7	0.015	0.007	0.030	7	0.028	0.010	0.060
TN / TP Ratio	7	30.2	21.0	51.4	7	20.7	8.0	41.0
Chlorophyll-a (ug/L)	7	9.9	4.0	16.0	7	16.3	10.0	31.0
TOC	7	3.0	2.4	3.5	7	3.2	2.4	4.0
Secchi Depth (m)	7	1.76	1.30	2.40	7	1.50	0.90	1.80

1=Water Quality Monitoring initiated due to drought conditions; full Vital Signs Monitoring not conducted.

(If a duplicate/triplicate sample is collected at a sampling location, only the first sample (D1 or T1) of the duplicate/triplicate is used to determine the mean, minimum, and maximum values.)

Table 2
2000 Vital Signs Reservoir Monitoring Summary

	Boone Forebay (SFHRM19.0)[1]				Boone Mid-Res (SFHRM 27.0)[1]				Boone Mid-Res (WRM 6.5)[1]			
	N	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	135	15.8	6.7	26.8	110	16.9	10.3	27.5	85	17.4	8.8	27.6
Dissolved Oxygen (mg/L)	135	5.7	0.3	16.6	110	6.3	0.2	13.8	85	7.8	0.4	11.5
pH (s.u.)	135	7.7	7.1	9.3	110	7.8	7.3	9.0	85	7.8	7.0	9.2
Conductivity (us/cm)	135	200	131	309	110	252	176	354	85	149	111	184
Organic N (mg/L)	7	0.45	0.11	0.74	7	0.47	0.14	0.77	7	0.42	0.20	0.65
Ammonia N (mg/L)	7	0.01	0.01	0.02	7	0.02	0.01	0.07	7	0.01	0.01	0.02
Nitrate+Nitrite N (mg/L)	7	0.14	0.01	0.53	7	0.14	0.01	0.62	7	0.18	0.01	0.56
Total Nitrogen (mg/L)	7	0.59	0.33	1.03	7	0.62	0.28	1.05	7	0.60	0.39	0.78
Total Phosphorus (mg/L)	7	0.019	0.006	0.028	7	0.027	0.016	0.040	7	0.025	0.017	0.034
TN / TP Ratio	7	36.5	16.5	63.3	7	22.4	17.5	28.9	7	25.4	16.0	39.0
Chlorophyll-a (ug/L)	7	15.0	5.0	25.0	7	19.4	9.0	28.0	7	19.3	8.0	45.0
TOC	7	4.0	2.2	6.4	7	4.3	3.1	6.2	7	3.4	2.1	4.9
Secchi Depth (m)	7	1.54	1.00	2.40	7	1.25	0.75	1.80	7	1.29	0.90	1.90

	South Holston Forebay (SFHRM 51.0)				South Holston Mid-Res (SFHRM 62.5)			
	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	184	12.4	5.1	27.5	120	16.3	6.2	27.8
Dissolved Oxygen (mg/L)	184	6.0	0.2	13.3	120	5.7	0.3	12.5
pH (s.u.)	184	7.6	7.0	9.1	120	7.8	6.9	9.2
Conductivity (us/cm)	184	202	174	270	120	202	167	263
Organic N (mg/L)	7	0.30	0.12	0.52	7	0.34	0.10	0.64
Ammonia N (mg/L)	7	0.01	0.01	0.01	7	0.01	0.01	0.01
Nitrate+Nitrite N (mg/L)	7	0.11	0.01	0.22	7	0.14	0.01	0.44
Total Nitrogen (mg/L)	7	0.41	0.31	0.53	7	0.48	0.26	0.78
Total Phosphorus (mg/L)	7	0.010	0.006	0.013	7	0.015	0.009	0.024
TN / TP Ratio	7	46.1	31.0	75.7	7	31.1	21.1	40.6
Chlorophyll-a (ug/L)	6	6.0	3.0	11.0	7	12.1	7.0	20.0
TOC	7	2.9	2.2	3.7	7	2.9	2.1	3.7
Secchi Depth (m)	7	3.49	1.75	5.80	7	2.16	1.50	3.30

	Watauga Forebay (WRM 37.4)				Watauga Mid-Res (WRM 45.5)			
	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	178	12.1	6.1	26.2	131	14.9	7.1	27.2
Dissolved Oxygen (mg/L)	178	7.3	0.7	11.2	131	6.2	0.4	11.5
pH (s.u.)	178	7.2	6.4	8.8	131	7.2	6.3	9.0
Conductivity (us/cm)	178	88	83	101	131	86	75	96
Organic N (mg/L)	7	0.21	0.06	0.36	7	0.24	0.09	0.41
Ammonia N (mg/L)	7	0.01	0.01	0.01	7	0.01	0.01	0.01
Nitrate+Nitrite N (mg/L)	7	0.14	0.03	0.28	7	0.14	0.01	0.38
Total Nitrogen (mg/L)	7	0.36	0.20	0.50	7	0.39	0.21	0.59
Total Phosphorus (mg/L)	7	0.007	0.003	0.011	7	0.010	0.006	0.018
TN / TP Ratio	7	60.6	22.0	136.7	7	42.2	21.0	71.3
Chlorophyll-a (ug/L)	7	4.4	2.0	7.0	7	6.3	3.0	9.0
TOC	7	2.3	1.8	2.6	7	2.4	1.7	2.8
Secchi Depth (m)	7	3.53	2.50	5.50	7	2.81	2.00	3.75

	Fontana Forebay (LTRM 62.0)				Fontana Mid-Res (LTRM 81.5)				Fontana Mid-Res (TkRM 3.0)			
	N	Mean	Min	Max	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	232	12.0	6.1	27.9	116	18.1	8.2	29.8	115	17.71	7.80	29.10
Dissolved Oxygen (mg/L)	232	8.3	1.2	10.4	116	6.8	0.4	10.7	115	7.07	0.40	10.70
pH (s.u.)	232	6.4	5.7	7.8	116	6.6	5.8	8.7	115	6.59	5.50	8.80
Conductivity (us/cm)	232	25	18	40	116	40	25	81	115	23.35	16.20	41.00
Organic N (mg/L)	7	0.07	0.02	0.10	7	0.106	0.02	0.18	7	0.09	0.04	0.18
Ammonia N (mg/L)	7	0.01	0.01	0.01	7	0.01	0.01	0.01	7	0.01	0.01	0.01
Nitrate+Nitrite N (mg/L)	7	0.08	0.01	0.14	7	0.024	0.01	0.06	7	0.05	0.01	0.12
Total Nitrogen (mg/L)	7	0.14	0.07	0.21	7	0.127	0.03	0.17	7	0.15	0.06	0.20
Total Phosphorus (mg/L)	7	0.002	0.002	0.004	7	0.007	0.005	0.01	7	0.01	0.00	0.01
TN / TP Ratio	7	61.1	35.0	105.0	7	19.168	4.286	34	7	21.79	6.00	45.00
Chlorophyll-a (ug/L)	7	2.0	1.0	3.0	6	5.5	3.0	10.0	7	5.29	2.00	8.00
TOC	7	1.4	1.1	1.7	7	1.571	1.4	1.9	7	1.56	1.20	1.90
Secchi Depth (m)	7	6.44	4.00	10.00	7	2.65	1.75	3.75	7	3.50	2.50	4.25

1=Water Quality Monitoring initiated due to drought conditions; full Vital Signs Monitoring not conducted.

(If a duplicate/triplicate sample is collected at a sampling location, only the first sample (D1 or T1) of the duplicate/triplicate is used to determine the mean, minimum, and maximum values.)

Table 2
2000 Vital Signs Reservoir Monitoring Summary

Apalachia Forebay (HiRM 67.0)

	N	Mean	Min	Max
Temperature (deg C)	96	16.0	7.0	28.6
Dissolved Oxygen (mg/L)	96	6.9	0.5	11.5
pH (s.u.)	96	6.4	5.8	7.8
Conductivity (us/cm)	96	26	24	43
Organic N (mg/L)	7	0.11	0.02	0.19
Ammonia N (mg/L)	7	0.01	0.01	0.01
Nitrate+Nitrite N (mg/L)	7	0.11	0.09	0.13
Total Nitrogen (mg/L)	7	0.22	0.13	0.31
Total Phosphorus (mg/L)	7	0.006	0.004	0.010
TN / TP Ratio	7	39.0	23.0	55.0
Chlorophyll-a (ug/L)	7	5.9	5.0	8.0
TOC	7	1.6	1.3	1.7
Secchi Depth (m)	7	3.50	3.10	3.90

	Hiwassee Forebay (HiRM 77.5)				Hiwassee Mid-Res (HiRM 85.0)			
	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	151	16.4	7.7	28.4	102	17.9	8.3	28.5
Dissolved Oxygen (mg/L)	151	6.7	0.4	10.6	102	7.8	3.0	11.4
pH (s.u.)	151	6.4	5.8	7.6	102	6.7	6.0	8.6
Conductivity (us/cm)	151	26	22	36	102	26	24	32
Organic N (mg/L)	7	0.09	0.02	0.18	7	0.08	0.02	0.14
Ammonia N (mg/L)	7	0.01	0.01	0.01	7	0.01	0.01	0.01
Nitrate+Nitrite N (mg/L)	7	0.09	0.02	0.15	7	0.07	0.02	0.12
Total Nitrogen (mg/L)	7	0.18	0.08	0.31	7	0.15	0.09	0.23
Total Phosphorus (mg/L)	7	0.006	0.003	0.010	7	0.006	0.002	0.010
TN / TP Ratio	7	33.1	14.0	51.7	7	30.6	11.0	60.0
Chlorophyll-a (ug/L)	7	4.4	3.0	5.0	7	6.0	5.0	8.0
TOC	7	1.5	1.1	1.7	7	1.6	1.1	1.9
Secchi Depth (m)	7	3.59	2.75	4.40	7	3.66	3.25	4.25

	Chatuge Forebay (HiRM 122.0)				Chatuge Forebay (SCM 1.5)			
	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	107	16.1	7.7	27.8	97	16.8	8.1	28.1
Dissolved Oxygen (mg/L)	107	5.8	0.4	9.9	97	6.3	0.4	9.8
pH (s.u.)	107	6.4	5.7	7.4	97	6.5	5.8	7.6
Conductivity (us/cm)	107	20	18	33	97	20	18	29
Organic N (mg/L)	7	0.08	0.02	0.17	7	0.09	0.02	0.17
Ammonia N (mg/L)	7	0.01	0.01	0.01	7	0.01	0.01	0.01
Nitrate+Nitrite N (mg/L)	7	0.02	0.01	0.05	7	0.02	0.01	0.05
Total Nitrogen (mg/L)	7	0.10	0.03	0.19	7	0.11	0.03	0.20
Total Phosphorus (mg/L)	7	0.005	0.002	0.008	7	0.005	0.002	0.008
TN / TP Ratio	7	23.5	5.0	50.0	7	23.9	3.8	40.0
Chlorophyll-a (ug/L)	7	3.3	2.0	5.0	7	3.6	3.0	5.0
TOC	7	1.5	1.4	1.6	7	1.6	1.2	1.9
Secchi Depth (m)	7	3.39	2.25	4.75	7	3.44	2.50	4.50

	Tims Ford Forebay (ERM 135.0)				Tims Ford Mid-Res (ERM 150.0)			
	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	143	16.5	8.0	30.2	114	19.0	11.3	30.6
Dissolved Oxygen (mg/L)	143	3.9	0.2	12.0	114	4.2	0.2	12.2
pH (s.u.)	143	7.6	6.9	9.0	114	7.5	6.9	9.3
Conductivity (us/cm)	143	174	133	248	114	186	133	282
Organic N (mg/L)	7	0.28	0.12	0.38	7	0.33	0.14	0.43
Ammonia N (mg/L)	7	0.02	0.01	0.05	7	0.01	0.01	0.01
Nitrate+Nitrite N (mg/L)	7	0.02	0.01	0.05	7	0.13	0.01	0.49
Total Nitrogen (mg/L)	7	0.31	0.14	0.39	7	0.46	0.16	0.86
Total Phosphorus (mg/L)	7	0.013	0.004	0.020	7	0.014	0.009	0.030
TN / TP Ratio	7	26.5	17.0	35.0	7	32.6	17.8	54.2
Chlorophyll-a (ug/L)	7	7.0	5.0	10.0	7	12.7	5.0	23.0
TOC	7	3.2	2.8	3.7	7	3.6	3.1	4.0
Secchi Depth (m)	7	2.60	2.00	3.50	7	2.03	1.30	2.50

1=Water Quality Monitoring initiated due to drought conditions; full Vital Signs Monitoring not conducted.

(If a duplicate/triplicate sample is collected at a sampling location, only the first sample (D1 or T1) of the duplicate/triplicate is used to determine the mean, minimum, and maximum values.)

Table 2
2000 Vital Signs Reservoir Monitoring Summary

Cedar Creek Forebay (CCM 25.2)[1]

	N	Mean	Min	Max
Temperature (deg C)	97	19.8	13.3	30.2
Dissolved Oxygen (mg/L)	97	3.9	0.2	8.7
pH (s.u.)	97	7.8	7.2	8.7
Conductivity (us/cm)	97	225	191	262
Organic N (mg/L)	7	0.37	0.12	1.20
Ammonia N (mg/L)	7	0.01	0.01	0.03
Nitrate+Nitrite N (mg/L)	7	0.14	0.01	0.45
Total Nitrogen (mg/L)	7	0.51	0.14	1.32
Total Phosphorus (mg/L)	7	0.010	0.003	0.019
TN / TP Ratio	7	70.4	18.0	256.7
Chlorophyll-a (ug/L)	7	4.3	2.0	11.0
TOC	7	3.2	2.9	3.5
Secchi Depth (m)	7	1.99	1.40	2.50

Upper Bear Cr. Forebay (BCM 115.4)[1]

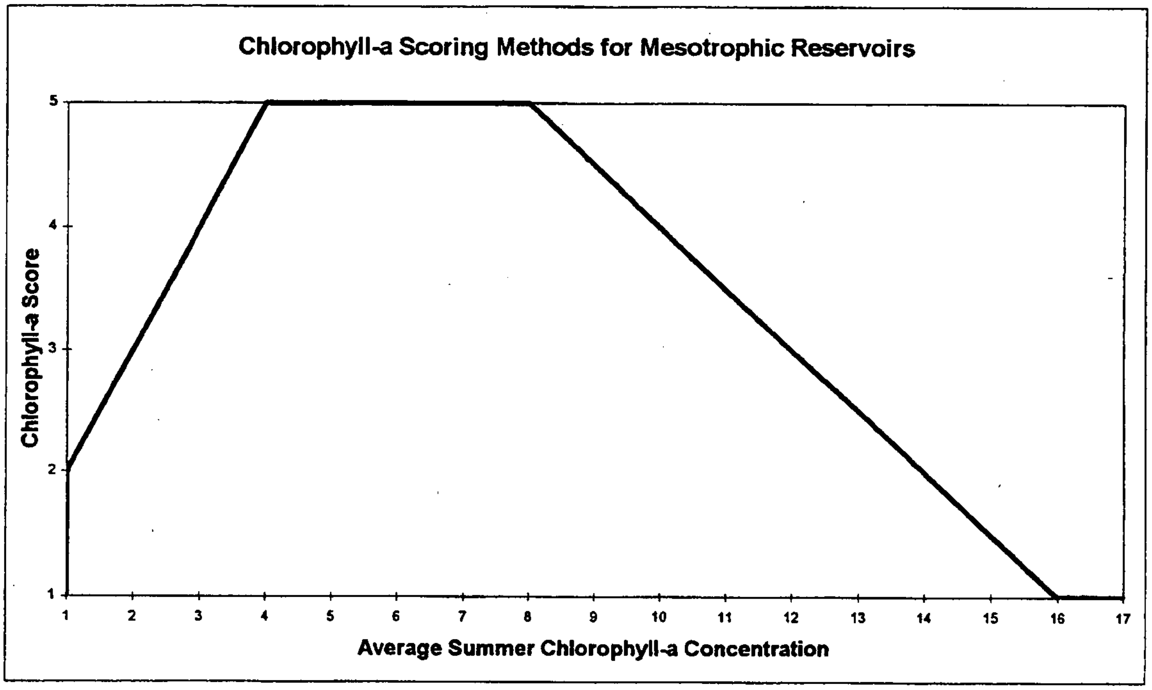
	N	Mean	Min	Max
Temperature (deg C)	91	21.7	9.8	30.4
Dissolved Oxygen (mg/L)	91	3.7	0.1	8.6
pH (s.u.)	91	6.5	6.0	8.8
Conductivity (us/cm)	91	60	44	127
Organic N (mg/L)	7	0.35	0.08	0.48
Ammonia N (mg/L)	7	0.09	0.01	0.22
Nitrate+Nitrite N (mg/L)	7	0.24	0.01	0.54
Total Nitrogen (mg/L)	7	0.67	0.37	1.02
Total Phosphorus (mg/L)	7	0.018	0.009	0.026
TN / TP Ratio	7	36.7	23.0	48.5
Chlorophyll-a (ug/L)	7	11.7	6.0	22.0
TOC	7	3.6	3.1	3.9
Secchi Depth (m)	7	1.36	0.90	1.70

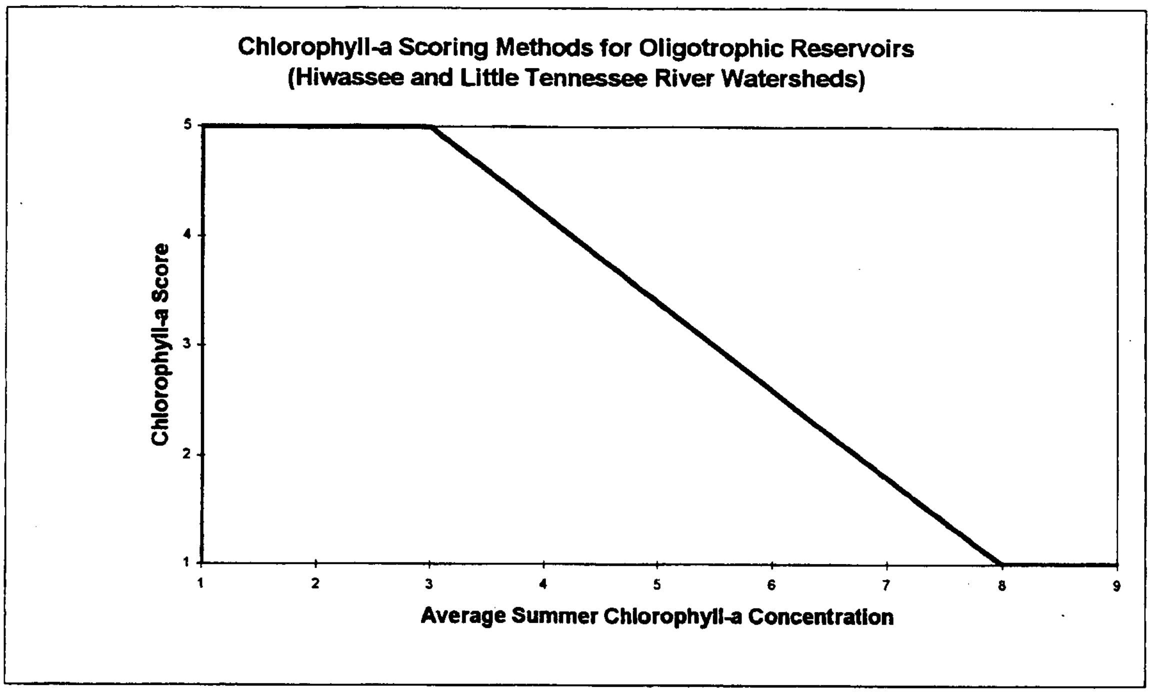
	Normandy Forebay (DRM 249.5)				Beech Forebay (BRM 36.0)			
	N	Mean	Min	Max	N	Mean	Min	Max
Temperature (deg C)	83	20.8	13.4	29.3	41	23.9	15.8	31.4
Dissolved Oxygen (mg/L)	83	4.9	0.1	10.2	41	5.3	0.2	9.4
pH (s.u.)	83	7.1	6.5	8.8	41	6.7	6.0	7.6
Conductivity (us/cm)	83	110	91	298	41	40	2	110
Organic N (mg/L)	7	0.30	0.12	0.43	7	0.40	0.26	0.51
Ammonia N (mg/L)	7	0.02	0.01	0.04	7	0.05	0.01	0.16
Nitrate+Nitrite N (mg/L)	7	0.12	0.04	0.29	7	0.02	0.01	0.04
Total Nitrogen (mg/L)	7	0.43	0.26	0.65	7	0.47	0.40	0.54
Total Phosphorus (mg/L)	7	0.027	0.017	0.040	7	0.020	0.009	0.033
TN / TP Ratio	7	17.1	9.7	27.6	7	28.6	12.7	54.0
Chlorophyll-a (ug/L)	7	12.3	5.0	17.0	6	21.2	13.0	41.0
TOC	7	3.6	2.9	4.2	7	3.8	3.4	4.1
Secchi Depth (m)	7	1	1.20	1.80	7	1.21	0.80	1.80

1=Water Quality Monitoring initiated due to drought conditions; full Vital Signs Monitoring not conducted.

(If a duplicate/triplicate sample is collected at a sampling location, only the first sample (D1 or T1) of the duplicate/triplicate is used to determine the mean, minimum, and maximum values.)

Figure 1. Chlorophyll-a Scoring Methods for Reservoirs





Chlorophyll-a Rating – The chlorophyll-a rating at each sampling location is based on the average summer concentration (of monthly photic zone composite samples). If triplicate samples are collected at a sampling location, only the median value of the triplicate is used in the calculation of the summer average and the maximum. If a monthly chlorophyll-a sample has a concentration that exceeds 30 ug/l, the value is not included in the calculation of the summer average, however, the final chlorophyll-a rating is decreased one unit, (i.e. 5 to 4, or 4 to 3, etc.) for each sample that exceeds 30 ug/l.

* If nutrients are present (e.g. total phosphorus greater than about 0.01 mg/L and nitrate+nitrite-nitrogen greater than about 0.05 mg/L) but chlorophyll-a concentrations are generally low (e.g. < 3ug/L), other limiting or inhibiting factors (e.g., high streamflows, turbidity, toxicity, etc.) must be considered. When these conditions exist, the chlorophyll-a rating is decreased one unit.

Section 4.0. Sediment Quality

Philosophical Approach/Background

Sediments at the bottoms of reservoirs serve as a repository for a variety of materials, especially chemicals which a have a low solubility in water. If contaminated, bottom sediments can have adverse impacts on bottom fauna and can often be long-term sources of toxic substances to the aquatic environment. They may impact wildlife and humans through the consumption of contaminated food or water or through direct contact. These impacts may occur even though the water above the sediments meets water quality criteria. Thus, examination of reservoir sediments is useful to determine if toxic chemicals are present and if chemical composition is changing through time.

There are several sediment assessment methods, but there is no single method that measures all contaminated sediment impacts at all times and to all biological organisms (EPA, 1992). Prior to 1995, TVA's approach used two sediment assessment methods--one biological (toxicity tests), the other chemical (direct chemical analysis of sediments)--to evaluate sediment quality. In 1995 and subsequent years only sediment chemical analysis of heavy metals, pesticides, and PCBs has been used. The primary reason for excluding toxicity tests in 1995 was budget reductions. Another important reason was that toxicity testing protocols had changed often during the four years they had been part of this monitoring program. Test media had changed from sediment elutriate to sediment pore water. Test procedures/organisms had changed from Microtox®, to Microtox® plus Rototox®, and later to Rototox® plus 24-hour acute test using Ceriodaphnia. Protocols were to change again in 1995 to the newly approved EPA methods using whole sediments and amphipods and midge larvae.

As discussed in Section 1 of this report, an initial question concerning evaluation of sediment monitoring results and implications of sediment quality on overall reservoir ecological health is essentially a classification issue -- should evaluations of sediment results be based on: (1) ideal conditions; for example, sediments should not have high concentrations of metals compared to background, should have no or at most very low concentrations of pesticides, and should not pose a toxic threat to biota; or (2) the best conditions expected for a reservoir given the environmental and operational characteristics of the dam/reservoir; for example, high concentrations of reduced metals are acceptable in tributary reservoirs due to anoxic conditions resulting from long retention times and thermal stratification. The approach taken for these studies accepts only ideal conditions. That is, metal concentrations should not be elevated and pesticides should not be present. In this situation, there is no need for classification because the same conditions are desired for all reservoirs.

Sediment Collection Methods

Sediment samples were collected during the summer of 2000 from 30 locations, i.e., the forebays and transition zones (or mid-reservoir) of 6 run-of-river reservoirs and10 tributary reservoirs as shown in Table 2 of Section 1. In addition, 5 of the 30 locations were randomly selected for replicate QA/QC sampling. Replicate samples were collected, handled, and processed independently from the other sample at each respective site. Results from these three sets of replicates were used to assess field methods consistency, variations in laboratory physical/chemical analyses, and spatial homogeneity of the sediment. Eckman dredge samplers were used to collect approximately the top three centimeters of sediment. Each sediment sample was a composite of at least three subsamples independently collected at each sampling location from the original stream channel. At each sampling site, the subsamples were composited, thoroughly mixed to uniform color and consistency. Samples were placed on ice immediately after collection and compositing, and were shipped or carried to the laboratory where they were analyzed for 13 metals and 26 selected organics (organochlorine pesticides and PCBs), as shown in Tables 1 and 1a.

Sediment Rating Scheme

As described above, sediment quality evaluations were based on both results of toxicity tests (S_{TOX}) and chemical analysis (S_{CHM}) prior to 1995. The Sediment Quality Rating scheme used during this period was the result of average rating of the sample's toxicity and its sediment chemistry:

$$\textbf{Sediment Quality Rating} = \mathbf{0.5\ (S_{TOX}\ rating + S_{CHM}\ rating).}$$

Since both the sediment toxicity rating and the sediment chemistry rating could range from 1 (poor quality) to 5 (excellent quality), this resulted in an final, Sediment Quality Rating ranging from 1 (poor quality) to 5 (excellent quality) for a given reservoir location. To arrive at an overall ecological health score for a reservoir location, this Sediment Quality Rating was then combined with ratings for the other four indicators (DO, chlorophyll, benthos, and fish). Together, all five indicators carried equal weight and each indicator could range from 1 to 5. This methodology is described in more detail in Section 1.

With the elimination of sediment toxicity testing beginning in 1995, it seemed inappropriate that the Sediment Quality Rating (based only on the results of chemical analyses) should carry equal weight with the other four ecological indicators. It was decided that the Sediment Quality Rating would be revised and carry only half the weight as the other four indicators of reservoir ecological health, and equal one half the sediment chemistry rating. Consequently, the revised Sediment Quality Rating ranges from 1 (poor quality) to 2.5 (excellent quality).

Sediment Quality Rating = 0.5 (S_{CHM} rating).

When this monitoring began in 1990 there were no sediment guidelines for this region of the country to use as the basis for evaluating sediment chemistry results. However, guidelines for metals had been suggested by EPA Region V for the Great Lakes (EPA, 1977). A comparison of sediment chemistry results from this monitoring program to those guidelines found that, except in known polluted areas (and except for zinc as described below), results from Tennessee Valley reservoirs rarely exceeded the values suggested by EPA, Region V. Thus, these guidelines for cadmium, chromium, copper, lead, mercury, and nickel were accepted as the standard for comparison of sediment chemistry (metals) concentrations resulting from this monitoring program (Table 1).

The initial comparison of metals concentrations from Tennessee Valley reservoirs to guidelines suggested by EPA, Region V found numerous areas where zinc concentrations exceeded the suggested guideline of 200 ug/kg. This indicated that the EPA, Region V suggested guideline of 200 ug/kg for zinc may not be an appropriate measure of "back-ground" conditions for the Tennessee Valley. Because the suggested guideline of 200 ug/kg did not allow for discrimination among sites, a detailed review of all available zinc results for the Tennessee Valley was conducted (based on a STORET retrieval at that time). As a result of that review, a concentration of 300 ug/kg was selected because it effectively separated areas with known or suspected sources from those considered to be representative of "background" conditions.

Arsenic was added to the list of metal analytes for this monitoring program beginning in 1994. A comparison of arsenic concentrations in sediments from Tennessee Valley reservoirs to the EPA, Region V suggested guideline for arsenic (8.0 ug/kg) resulted in the same problem described above for zinc – this concentration did not effectively discriminate among sites. After thorough consideration of all sediment results from this region, a concentration of 15 ug/kg was accepted as the "back-ground" value for purposes of evaluating Vital Signs results.

The approach to evaluating results from laboratory analysis of sediment samples for organochlorine pesticides and PCBs was different from that for heavy metals. Metals are a natural component of soil and sediment so there is a "back-ground" concentration which must be considered acceptable. This is not the case for the organochlorine pesticides and PCBs because these are man-made chemicals. Therefore, the approach taken for evaluating these results was that presence of any of these chemicals was indication of an undesirable condition and thus caused the sediment quality rating to be lowered. This approach means that the laboratory detection limit is the "guideline" for these chemicals (Table 1 and 1a).

Each sampling location's sediment chemistry is rated as follows:

Sediment Chemistry S_{CHM} Rating	Sediment Chemistry*
5 (good)	No analytes exceed guidelines;
3 (fair)	One or two analytes exceed guidelines;
1 (poor)	Three or more exceed guidelines.

*Analytes (i.e., heavy metals, pesticides, and PCBs) and guidelines are listed in Tables 1 and 1a.

Results from 2000 Monitoring

Table 2 provides sediment chemistry rating, Final Sediment Quality Rating, and comments for each location examined in 2000. Table 3 presents the actual sediment chemistry data which resulted in the sediment chemistry rating for each location.

It should be noted that an improved digestion procedure (Hotblock) was used beginning in 1999. Digestion techniques used during the years have changed from Glass (1990-1994) to

Teflon (1995-1999) to Hotblock (1999). The Hotblock procedure provides better digestion and extraction for all metals but has particular implications for arsenic because it provides better conversion of all arsenic states to As^{-6}. As a result, arsenic concentrations increased at many sites compared to previous years, but few exceeded the guideline of 15 ug/kg.

References

Environmental Protection Agency, 1992. Sediment Classification Methods Compendium. EPA 823-R-92-006, USEPA, Washington, D.C.

Environmental Protection Agency, 1977. "Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments." USEPA, Region V, Chicago.

Table 1

Physical/Chemical Measurements of Sediment, Reservoir Vital Signs Monitoring, 2000

Description, units	Detection Limits (dry weight)	Sediment Quality Guidelines[a]
Metals		
Aluminum, mg/kg	5 mg/kg	--
Arsenic, mg/kg	0.5 mg/kg	15 mg/kg
Cadmium, mg/kg	0.5 mg/kg	6 mg/kg[b]
Calcium, mg/kg	10 mg/kg	--
Chromium, mg/kg	5 mg/kg	75 mg/kg[b]
Copper, mg/kg	1 mg/kg	50 mg/kg[b]
Iron, mg/kg	1 mg/kg	--
Lead, mg/kg	5 mg/kg	60 mg/kg[b]
Magnesium, mg/kg	1 mg/kg	--
Manganese, mg/kg	0.5 mg/kg	--
Mercury, mg/kg	0.1 mg/kg	1 mg/kg[b]
Nickel, mg/kg	5 mg/kg	50 mg/kg[b]
Zinc, mg/kg	1 mg/kg	300 mg/kg
Organochlorine Pesticides and PCB's		
Aldrin, µg/kg	10 µg/kg	10 µg/kg
α-Benzene Hexachloride (BHC), µg/kg	10 µg/kg	10 µg/kg
β-Benzene Hexachloride (BHC), µg/kg	10 µg/kg	10 µg/kg
γ-Benzene Hexachloride (Lindane), µg/kg	10 µg/kg	10 µg/kg
δ-Benzene Hexachloride (BHC), µg/kg	10 µg/kg	10 µg/kg
Chlordane, µg/kg	10 µg/kg	10 µg/kg
Dieldrin, µg/kg	10 µg/kg	10 µg/kg
ρ,ρ DDT, µg/kg	10 µg/kg	10 µg/kg
ρ,ρ DDD, µg/kg	10 µg/kg	10 µg/kg
ρ,ρ DDE, µg/kg	10 µg/kg	10 µg/kg
α-Endosulfan, µg/kg	10 µg/kg	10 µg/kg
β-Endosulfan, µg/kg	10 µg/kg	10 µg/kg
Endosulfan Sulfate, µg/kg	10 µg/kg	10 µg/kg
Endrin, µg/kg	10 µg/kg	10 µg/kg
Endrin Aldehyde, µg/kg	10 µg/kg	10 µg/kg
Heptachlor, µg/kg	10 µg/kg	10 µg/kg
Heptachlor Epoxide, µg/kg	10 µg/kg	10 µg/kg
Methoxychlor, µg/kg	10 µg/kg	10 µg/kg
PCB-1221, µg/kg	25 µg/kg	25 µg/kg
PCB-1232, µg/kg	25 µg/kg	25 µg/kg
PCB-1242, µg/kg	25 µg/kg	25 µg/kg
PCB-1248, µg/kg	25 µg/kg	25 µg/kg
PCB-1254, µg/kg	25 µg/kg	25 µg/kg
PCB-1260, µg/kg	25 µg/kg	25 µg/kg
PCB-1016, µg/kg	25 µg/kg	25 µg/kg
PCB's, Total, µg/kg	25 µg/kg	25 µg/kg
Toxaphene, µg/kg	500 µg/kg	500 µg/kg

[a] Unless otherwise noted, guidelines are suggested TVA Sediment Quality Guidelines.
[b] EPA Region V Guidelines for polluted freshwater sediment (EPA, 1977).

Table 1a

Analytical Methodology for Vital Signs Sediments, 2000

Parameter	Reference	Method Description	Minimum Detectable Concentration
Pesticides/PCBs:	EPA, SW 846: Methods 3550A & 8080A	CH_2CL_2, Kuderna-Danish/Mercury (KD/Hg), Gas Chromatograph/Electron Capture (GC/EC)	
Pesticides			10 ug/Kg
Toxaphene			500 ug/Kg
PCB's			25 ug/Kg
Metals:	EPA, SW 846: Methods 3050A & 6010A	HNO_3, Inductively Coupled Argon Plasma (ICAP)	
Iron			1 mg/Kg
Manganese			0.5 mg/Kg
Calcium			10 mg/Kg
Magnesium			1 mg/Kg
Copper			1 mg/Kg
Zinc			1 mg/Kg
Aluminum			5 mg/Kg
Nickel			5 mg/Kg
Cadmium			0.5 mg/Kg
Chromium			5 mg/Kg
Lead			5 mg/Kg
Arsenic:	EPA, SW 846: Method 7060A	HNO_3, Atomic Absorption Spectrophotometry (AAS), Heated Graphite Atomizer (HGA)	0.5 mg/Kg
Mercury:	EPA, SW 846: Method 7471A	$HNO_3/KMNO_4$, Cold Vapor (CV)--AAS	0.10 mg/Kg
Residue: (Solids)	EPA, SW 846: Method 3550A	Gravimetry	
Total			0.1 %
Volatile			0.1 %

Reference:

Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW 846, United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC 20460, Third Edition, Updates I, II, and IIA, September 1994.

Table 2

2000 Sediment Ratings – Vital Signs Reservoir Monitoring

Chemistry
5 - no analytes
3 - 1 or 2 analytes
1 - 3 or more analytes

Toxicity	
5 - no toxicity	No Toxicity Testing in 2000
3 - some toxicity	
1 - significant toxicity	

Final Sediment Quality Rating = 0.5 (SED-CHM)

Reservoir	Mile	Collection Date Comment	yyyymmdd	# Pest.	# Metals	SED-CHM RATING		SED-TOX RATING	FINAL SEDIMENT QUALITY RATING	COMMENTS (ppb, dry weight)
Pickwick	TRM 207.3	Dup-1	07/11/2000			5			2.5	
		Dup-2	07/11/2000			5			2.5	
		Precision	07/11/2000			5			2.5	
Pickwick	TRM 230.0		07/11/2000			5			2.5	
Pickwick	Bear Creek 8.4		07/11/2000			5			2.5	
		Precision	07/11/2000			5			2.5	
Wilson	TRM 260.8		07/10/2000			5			2.5	
Guntersville	TRM 350.0		07/18/2000	1		3			1.5	PCB-1254=27
Guntersville	TRM 375.2		07/18/2000			5			2.5	
		Precision	07/18/2000			5			2.5	
Watts Bar	TRM 532.5		07/12/2000	2		3			1.5	PCB-1254=29, DDT=13
Watts Bar	TRM 560.8	Dup-1	07/12/2000	2		3			1.5	PCB-1254=28,Chlordane=11
		Dup-2	07/12/2000	2		3	(3)		1.5	PCB-1254=29,Chlordane=10
Fort Loudoun	TRM 605.5		07/18/2000	2		3			1.5	PCB-1254=30,Chlordane=12
Fort Loudoun	TRM 624.6		07/18/2000	2		3	(3)		1.5	PCB-1254=30,Chlordane=10
Melton Hill	CRM 24.0		07/20/2000			5			2.5	
Melton Hill	CRM 45.0		07/20/2000			5			2.5	
Cherokee	HRM 55.0		07/18/2000	1		3	(4)		2.0	Chlordane=20 not confirmed
Cherokee	HRM 76.0		07/18/2000	1	1	3	(3)		1.5	Cu=59, Chlordane=21 not confirmed
South Holston	SFHRM 51.0		07/19/2000			5			2.5	
South Holston	SFHRM 62.5		07/19/2000	1		3			1.5	Chlordane=13
Watauga	WRM 37.4		07/19/2000			5			2.5	
Watauga	WRM 45.5		07/19/2000	1		3			1.5	Chlordane=14

Table 2

2000 Sediment Ratings -- Vital Signs Reservoir Monitoring

Chemistry
5 - no analytes
3 - 1 or 2 analytes
1 - 3 or more analytes

Toxicity
5 - no toxicity
3 - some toxicity
1 - significant toxicity

No Toxicity Testing In 2000

Final Sediment Quality Rating = 0.5 (SED-CHM)

Reservoir	Mile	Comment	Collection Date yyyymmdd	# Pest.	# Metals	SED-CHM RATING		SED-TOX RATING	FINAL SEDIMENT QUALITY RATING	COMMENTS (ppb, dry weight)
Fontana	LTRM 62.0		07/10/2000			5			2.5	
Fontana	LTRM 81.5		07/10/2000			5			2.5	
Fontana	TkRM 3.0		07/10/2000	2		3	(4)		2.0	Chlordane=10, DDT=11
Apalachia	HiRM 67.0		07/11/2000		1	3	(4)		2.0	Cu=50
Hiwassee	HiRM 77.5		07/11/2000			5			2.5	
Hiwassee	HiRM 85.0	Dup-1	07/11/2000			5			2.5	
		Dup-2	07/11/2000			5			2.5	
Chatuge	HiRM 122.0	Dup-1	07/11/2000		1	3			1.5	Cu=60
		Dup-2	07/11/2000		1	3			1.5	Cu=55
Chatuge	Shooting Cr 1.5		07/11/2000		3	1	(2)		1.0	Cr=75,Cu=65,Ni=50
Tims Ford	ERM 135.0	Dup-1	07/24/2000		1	3	(4)		2.0	Ni=50
		Dup-2	07/24/2000			5			2.5	
Tims Ford	ERM 150.0		07/24/2000			5			2.5	
Normandy	DRM 249.5		07/24/2000			5			2.5	
Beech	BRM 36.0		07/10/2000		1	3			1.5	Arsenic=18

Shaded (Duplicate/Precision) samples were not used to determine the Sediment Quality Ratings

Table 3
2000 Vital Signs Reservoir Monitoring Sediment Data

				Metals (mg/kg, dry weight)												
Reservoir	Mile	Comment	Sample Date yymmdd	Aluminum	ARSENIC	CADMIUM	CALCIUM	CHROMIUM	COPPER	IRON	LEAD	MAGNESIUM	MANGANESE	MERCURY	NICKEL	ZINC

Pickwick	TRM 207.3	Dup-1	07/11/2000	32000	8.8	<0.5	4500	32	30	38000	30	2700	3700	0.46	29	130
Pickwick	TRM 207.3	Dup-2	07/11/2000	31000	8.6	<0.5	3900	32	30	39000	29	2600	4000	0.49	29	130
Pickwick	TRM 230.0		07/11/2000	24000	7.8	<0.5	3000	27	29	29000	26	2100	3100	0.65	23	120
Pickwick	BCM 8.4		07/11/2000	29000	10	<0.5	2600	26	15	36000	23	1800	2200	<0.1	22	79
Wilson	TRM 260.8		07/10/2000	34000	9.6	<0.5	3300	35	34	42000	36	2800	3000	0.14	32	160
Wilson	TRM 260.8	Precision	09/25/2000	41000	10	<0.5	3340	40	32	43300	33	3410	3080	0.15	36	179
Guntersville	TRM 350.0		07/18/2000	32000	9.2	<0.5	4300	34	46	55000	44	3100	4300	0.28	34	250
Guntersville	TRM 375.2		07/18/2000	16000	6.6	<0.5	3000	22	24	24000	24	2300	2500	0.22	22	160
Watts Bar	TRM 532.5		07/12/2000	42000	12	<0.5	2500	38	41	46000	41	4400	5100	0.4	35	200
Watts Bar	TRM 560.8	Dup-1	07/12/2000	37000	11	<0.5	2700	36	45	43000	43	4500	4700	0.63	35	220
Watts Bar	TRM 560.8	Dup-2	07/12/2000	36000	10	<0.5	2600	35	44	42000	39	4400	4500	0.68	35	210
Fort Loudoun	TRM 605.5		07/18/2000	35000	8.6	0.9	7600	26	33	55000	31	5100	2400	0.13	21	280
Fort Loudoun	TRM 624.6		07/18/2000	27000	13	<0.5	8300	22	22	37000	23	4600	3300	0.11	32	83
Melton Hill	CRM 24.0		07/20/2000	19000	11	<0.5	7900	21	38	28000	33	4100	4100	<0.1	24	110
Melton Hill	CRM 45.0		07/20/2000	14000	14	<0.5	6100	19	35	24000	31	3500	3700	<0.1	21	98
Cherokee	HRM 55.0		07/18/2000	33000	11	<0.5	9500	32	44	43000	39	2600	990	0.16	26	110
Cherokee	HRM 76.0		07/18/2000	32000	14	<0.5	11000	32	59	42000	39	3300	1100	0.41	26	160
South Holston	SFHRM 51.0		07/19/2000	28000	12	<0.5	3400	29	28	50000	29	3700	4800	<0.1	24	110
South Holston	SFHRM 62.5		07/19/2000	29000	12	<0.5	1400	29	38	40000	29	4100	750	0.13	31	110
Watauga	WRM 37.4		07/19/2000	37000	8.6	<0.5	2300	31	36	55000	32	5500	5900	0.14	32	150
Watauga	WRM 45.5		07/19/2000	42000	10	<0.5	5000	34	39	64000	38	4000	2000	0.14	28	190
Fontana	LTRM 62.0		07/10/2000	76000	3.2	<0.5	730	41	49	68000	35	6200	3000	0.12	35	160
Fontana*	LTRM 62.0		08/07/2000*	62000	5	<0.5	700	41	47	64000	30	3700	1100	0.11	29	150
Fontana	LTRM 62.0	Precision	09/25/2000	68000	7	<0.5	611	36	39	64000	29	6900	2200	0.11	31	142
Fontana	LTRM 81.5		07/10/2000	63000	<0.5	<0.5	1000	37	43	48000	25	7500	740	<0.1	30	140
Fontana	TkRM 3.0		07/10/2000	52000	0.6	<0.5	2000	44	41	49000	26	10000	640	<0.1	38	170
Hiwassee	HiRM 77.5		07/11/2000	84000	5.4	<0.5	690	41	44	75000	35	5200	1100	0.11	34	150
Hiwassee	HiRM 85.0	Dup-1	07/11/2000	73000	3	<0.5	1200	41	46	61000	33	5700	820	0.11	34	150
Hiwassee	HiRM 85.0	Dup-2	07/11/2000	71000	5.1	<0.5	1100	40	44	60000	32	5600	820	0.1	34	150

Table 3
2000 Vital Signs Reservoir Monitoring Sediment Data

Metals (mg/kg, dry weight)

Reservoir	Mile	Comment	Sample Date yymmdd	Aluminum	ARSENIC	CADMIUM	CALCIUM	CHROMIUM	COPPER	IRON	LEAD	MAGNESIUM	MANGANESE	MERCURY	NICKEL	ZINC
Chatuge	HIRM 122.0	Dup-1	07/11/2000	74000	1	<0.5	540	60	60	62000	24	3800	560	<0.1	39	100
Chatuge	HIRM 122.0	Dup-2	07/11/2000	76000	1.7	<0.5	540	57	55	55000	22	3800	470	<0.1	34	90
Chatuge	SCM 1.5		07/11/2000	76000	2.2	<0.5	540	75	65	65000	30	2700	610	0.11	50	93
Tims Ford	ERM 135.0	Dup-1	07/24/2000	27000	10	<0.5	6000	34	30	40000	22	3500	2600	<0.1	50	120
Tims Ford	ERM 135.0	Dup-2	07/24/2000	26000	10	<0.5	6300	35	23	42000	26	2300	3000	<0.1	37	110
Tims Ford	ERM 150.0		07/24/2000	35000	12	<0.5	2500	19	22	38000	20	1700	3200	0.11	31	73
Beech	BRM 36.0		07/10/2000	37000	18	<0.5	1500	28	23	52000	31	2300	1100	<0.1	23	94
Normandy	DRM 249.5		07/24/2000	25000	12	<0.5	610	37	43	33000	23	5300	2400	<0.1	30	150
Apalachia	HIRM 67.0		07/11/2000	90000	6.8	<0.5	680	44	50	82000	44	5400	1400	0.12	36	170
Apalachia*	HIRM 67.0		08/08/2000*	77000	3.4	<0.5	680	40	46	83000	30	3700	1100	0.13	30	140
Results for Metals Diestion Blank (AA11053)				<5	< 0.5	<0.5	<10	<5	<1	<1	<5	<1	<0.5	<0.10	<5	<1
Results for Sediment Reference Material (AA11054)																
			Reported Values	5350	131	96.1	2020	150	96.5	10100	97.1	1450	206	2.71	112	83.4
			Percent Recovery	119%	127%	108%	102%	113%	114%	133%	112%	123%	110%	95%	102%	116%
			Certified Values	4496	103	89	1980	133	85	7594	87	1179	187	3	110	72
			Approx. 95% C.I.													
VS-MS (Metal Spike)			Reported Values	86200	44.6	7.2	3640	59.5	57.3	61300	79.6	3880	3080	1.26	84	226
			Percent Recovery	93%	86%	100%	75%	100%	103%	90%	93%	119%	100%	111%	96%	94%

* An extra sediment sample was collected at the Fontana and Apalachia forebays one month after the routine collection date as an added QA/QC check in 2000. Samples were analyzed for metals only.

Table 3
2000 Vital Signs Reservoir Monitoring Sediment Data

Organochlorine Pesticides and PCBs (ug/kg, dry weight)

Reservoir	Mile	Comment	Sample Date yymmdd	ALDRIN	Benzene Hexachloride (BHC) ALPHA	BETA	DELTA	GAMMA	CHLORDANE	DIELDRIN	DDT's p,p DDD	p,p DDE	p,p DDT	Endosulfan ALPHA	BETA	SULFATE	ENDRIN
Pickwick	TRM 207.3	Dup-1	07/11/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Pickwick	TRM 207.3	Dup-2	07/11/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Pickwick	TRM 230.0		07/11/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Pickwick	BCM 8.4		07/11/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Wilson	TRM 260.8		07/10/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Guntersville	TRM 350.0		07/18/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Guntersville	TRM 375.2		07/18/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Watts Bar	TRM 532.5		07/12/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	13	<10.	<10.	<10.	<10.
Watts Bar	TRM 560.8	Dup-1	07/12/2000	<10.	<10.	<10.	<10.	<10.	11	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Watts Bar	TRM 560.8	Dup-2	07/12/2000	<10.	<10.	<10.	<10.	<10.	10	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Fort Loudoun	TRM 605.5		07/18/2000	<10.	<10.	<10.	<10.	<10.	12	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Fort Loudoun	TRM 624.6		07/18/2000	<10.	<10.	<10.	<10.	<10.	10	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Melton Hill	CRM 24.0		07/20/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Melton Hill	CRM 45.0		07/20/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Cherokee	HRM 55.0		07/18/2000	<10.	<10.	<10.	<10.	<10.	20NC	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Cherokee	HRM 76.0		07/18/2000	<10.	<10.	<10.	<10.	<10.	21NC	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
South Holston	SFHRM 51.0		07/19/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
South Holston	SFHRM 62.5		07/19/2000	<10.	<10.	<10.	<10.	<10.	13	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Watauga	WRM 37.4		07/19/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Watauga	WRM 45.5		07/19/2000	<10.	<10.	<10.	<10.	<10.	14	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Fontana	LTRM 62.0		07/10/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Fontana	LTRM 81.5		07/10/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Fontana	TkRM 3.0		07/10/2000	<10.	<10.	<10.	<10.	<10.	10	<10.	<10.	<10.	11	<10.	<10.	<10.	<10.
Hiwassee	HiRM 77.5		07/11/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Hiwassee	HiRM 85.0	Dup-1	07/11/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Hiwassee	HiRM 85.0	Dup-2	07/11/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Chatuge	HiRM 122.0	Dup-1	07/11/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Chatuge	HiRM 122.0	Dup-2	07/11/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Chatuge	SCM 1.5		07/11/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.

Table 3

2000 Vital Signs Reservoir Monitoring Sediment Data

Organochlorine Pesticides and PCBs (ug/kg, dry weight)

Reservoir	Mile	Comment	Sample Date yymmdd	ALDRIN	Benzene Hexachloride (BHC) ALPHA	BHC BETA	BHC DELTA	BHC GAMMA	CHLORDANE	DIELDRIN	DDT's p,p DDD	DDT's p,p DDE	DDT's p,p DDT	Endosulfan ALPHA	Endosulfan BETA	Endosulfan SULFATE	ENDRIN
Tims Ford	ERM 135.0	Dup-1	07/24/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Tims Ford	ERM 135.0	Dup-2	07/24/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Tims Ford	ERM 150.0		07/24/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Beech	BRM 36.0		07/10/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Normandy	DRM 249.5		07/24/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
Apalachia	HiRM 67.0		07/11/2000	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.

Results from Organic Extraction Blank (AA11045)				<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.	<10.
VS-MS (ORG PEST SPK)			Reported Values	248	275	292	326	315	--	629	552	523	1549	557	439	1264	431
			Percent Recovery	149%	165%	175%	195%	189%	--	189%	55%	157%	154%	167%	131%	126%	129%
VS-MS (ORG CHLOR SPIKE)			Reported Values	--	--	--	--	--	303	--	--	--	--	--	--	--	--
			Percent Recovery	--	--	--	--	--	114%	--	--	--	--	--	--	--	--

Section 5. Benthic Macroinvertebrates

Philosophical Approach/Background

Benthic macroinvertebrates are usually included in aquatic monitoring programs because they are important to the aquatic foodweb and because they have limited capability of movement thereby preventing them from avoiding undesirable conditions. The assemblage of macroinvertebrates in a reservoir is expected to be vastly different from that in a free-flowing river. Also, substantial differences are expected along a longitudinal gradient with organisms adapted to a more riverine environment expected at the upper end or inflow of a reservoir and organisms adapted to a lacustrine environment expected in the pool near the dam. Other factors to consider in evaluating the benthos in reservoirs include reservoir operational characteristics (e.g., depth of withdrawal for discharge, water depth, depth of drawdown for flood control, retention time, stratification, bottom anoxia, substrate type and stability) and physical/chemical features owing to geological characteristics of different ecoregions.

One of the most important factors to consider is that reservoirs are artificial systems. This is a significant issue because it influences the approach to be taken in interpretation of the data once collected. Because reservoirs are man-made systems, it is not possible to follow the well accepted Index of Biotic Integrity (IBI) approach of using reference sites to set the yard stick or expectations (termed reference conditions) of what a "good" benthic macroinvertebrate assemblage would be in a reservoir unaffected by human impacts. Other approaches must be used to develop the criteria by which the results will be compared to determine if they represent good, fair, or poor conditions. These include: historical or preimpoundment conditions, predictive models, best observed conditions, or professional judgment. As stated above, preimpoundment conditions are inappropriate due to significant habitat alterations. The state of the science of benthic macroinvertebrate assemblages in reservoirs is insufficient for predictive models to be effective. This leaves the latter two as the most viable alternatives for establishing appropriate reference conditions or expectations for these organisms in reservoirs. TVA's experience has found use of best observed conditions adjusted using professional judgment is the best approach. Use of best observed conditions requires an extensive database to determine expectations, and use of professional judgment requires substantial experience with the group of reservoirs under consideration. To use this concept, results in the data base which approach desired conditions for a given characteristic (metric) are considered representative of best observed condition. Monitoring results falling within that range would be considered "good". Details of this approach to developing scoring ranges are provided later in this section.

Another important consideration in evaluating benthic macroinvertebrate results is that care must be taken to compare only those reservoirs for which comparison is appropriate. That is, only reservoirs for which similar communities would be expected should be compared--those in the same ecoregion with comparable physical characteristics. Hence, separation of reservoirs into appropriate classes is a critical step.

TVA's monitoring program includes 31 reservoirs. For classification purposes these have been divided into two major groups : run-of-the-river reservoirs (those with short retention times and winter drawdown of only a few feet) and tributary reservoirs (those with long retention times and substantial winter drawdowns). The tributary reservoirs have been further divided into three groups by ecoregion and reservoir physical characteristics.

	Tributary Reservoirs		
Run-of-River	Blue Ridge	Ridge & Valley	Interior Plateau
Kentucky	Apalachia*	Cherokee	Normandy
Pickwick	Hiwassee	Ft. Patrick Henry*	Bear Creek
Wilson	Chatuge	Boone	Little Bear Creek
Wheeler	Nottely	South Holston	Cedar Creek
Guntersville	Parksville*	Douglas	Beech*
Nickajack	Blue Ridge	Norris	
Chickamauga	Fontana	Tims Ford**	
Watts Bar	Watauga		
Fort Loudoun			
Tellico***			
Melton Hill			

* These reservoirs are included in their respective classes because they are physically located within the specified ecoregion; however, results were excluded from developing scoring ranges: Apalachia and Ft. Patrick Henry because of their nominal drawdown and short retention times are uncharacteristic of other reservoirs their in class; Beech because its physical attributes (primarily its shallow nature and bowel shape) are quite different from the other reservoirs in that class; and Parksville because of known pollution (very high metal concentrations), which would be expected to cause a degraded benthic macroinvertebrate community.

** Tims Ford is in the Interior Plateau ecoregion but due to operational and morphological characteristics was considered more similar to and classified with Ridge and Valley reservoirs. Results from Tims Ford were excluded from developing reference conditions for either class.

*** Tellico is essentially in a class by itself - it has a nominal drawdown like the other run-of-river reservoirs to allow for navigation yet it typically stratifies in summer like a tributary reservoir due to its physical characteristics, in particular its relatively long retention time. For these reasons, results for Tellico were excluded from developing scoring criteria for all reservoir classes and was scored against run-of-river reservoir scoring criteria.

Once reservoirs have been appropriately classified, scoring criteria (i.e., those values for each characteristic or metric which will be considered good, fair, or poor) must be developed. When using best observed conditions, a data base must exist and decisions made as to how best separate data for each metric into the three scoring ranges. TVA's approach is, for each metric, to first omit outliers, then trisect the range of the remaining values (including zero if appropriate for a particular metric). Cutoff points between the ranges are examined closely and adjusted as needed based on professional judgment. These three ranges represent good, fair, and poor conditions and form the reference conditions or expectations for each metric. More details of TVA's approach to developing scoring ranges are provided under the Benthic macroinvertebrate Invertebrate Rating Scheme below.

Sample Collection Methods

Benthic macroinvertebrate samples were collected in the late fall/early winter (November-December) at 35 locations on 16 TVA reservoirs in 2000 (Table 1, Section 1). This was the sixth year for sample collection to occur during the late fall/early winter time frame. Previous to 1995, sample collection had occurred during late winter/early spring (February-March). The problem with using late winter/early spring benthic macroinvertebrate information is that the results are an indication of the conditions which existed during the summer and autumn of the previous year. This had the undesirable effect of causing results for benthic macroinvertebrates to be out of synch with the rest of the monitoring data for a particular year because Vital Signs monitoring results are summarized and reported on a calendar year cycle. Benthos sampling was initially conducted in late winter/early spring because the required reporting date of mid-January did not allow sample processing time in the laboratory. Also, there was concern that insect instars would be so small that they could pass through the collection screen and/or be difficult to identify. Thorough evaluation of the 1993—1994 results showed late fall/early winter collection and use of field identification to the Family and Order levels would negate most of the problems resulting from late winter/early spring sampling and would improve the contribution of this important assemblage to the overall reservoir evaluation. The basis for these changes is documented in Section 4, Appendix A of Dycus, 1995. Evaluation of data resulting from use of these methods is discussed in each subsequent annual reports as shown in the Literature Cited section.

At each sample location, a line-of-sight transect was established across the width of the reservoir, and one Ponar grab sample collected at 10 equally-spaced locations along this transect. When rocky substrates were encountered, a Peterson dredge was used. Care was taken to collect samples only from the permanently wetted bottom portion of the reservoir (i.e., below the elevation of the minimum winter pool level). Samples were washed, counted, and identified in the field to either Family or Order level as appropriate (i.e., the lowest practical in the field). Samples were then transferred to a labeled collection jar, and fixed with 10 percent buffered formalin solution.

The Quality Control (QC) element of the benthic macroinvertebrate evaluation includes two components. One examines how the final benthic score is affected by the change from laboratory processing to field processing. The other examines the reproducibility of benthic macroinvertebrate sampling results. To fulfill the first component, samples from seven sites (about 20% of the sampling locations) were processed in the field (described above) and later sent to the benthic laboratory for processing as in previous years (sorted and quantified at the lowest practical taxon). Benthic scores were developed for both sets of sample results and compared.

To examine the reproducibility of the collection and analysis procedure, the same seven sites selected above were sampled a second time. This was achieved by collecting the first set of 10 samples, leaving the sampling location, and then returning as near as possible to the original transect site (usually on the same day) and repeating the collection of a second (replicate) set of 10 samples. In this effort, both sets of samples were field processed and benthic scores developed for each set of samples and compared. All classes of reservoirs and types of locations (i.e., forebay, transition zone, embayment, and inflow) were included in the QC effort.

<u>Benthic Macroinvertebrate Rating Scheme</u>

Selection of specific metrics and their associated reference conditions (expectations) are obviously important steps in developing a rating scheme for an indicator. Basically, this means selecting the characteristics (metrics) of an indicator, in this case benthic macroinvertebrates, which will form the basis of the evaluation and further deciding the scoring range for each metric which will be used to identify good, fair, and poor conditions. Generally, a numeric value is then assigned to each metric depending on where it falls in the scoring range with good = 5, fair = 3, and poor = 1. The metrics are then summed to provide an overall evaluation or rating for the indicator.

The number of metrics used by this monitoring program to evaluate benthic macroinvertebrate results varied between six and eight the first few years with seven being used the last four years. Through 1997 the same metrics were used for all classes of reservoirs sampled, although scoring ranges differed by reservoir class and type of sample location. Beginning in 1998 and continued into 1999 and 2000, certain metrics differed between the run-of-river reservoirs and tributary reservoirs, although seven metrics were used in both cases. The need for this change was identified by the QC component of this program and discussed in Dycus and Meinert, 1998. The problem was that scores for repeat sets of samples from tributary reservoirs were occasionally quite different from one another. The primary contributing factor appeared to be presence/absence of one or two EPT organisms in one sample set yet not in the repeat set. EPT organisms are relatively rare in tributary reservoirs due to physical constraints. As a result, scoring criteria were comparably low for the EPT metric as well as the Long-lived metric (EPT organisms are the primary contributor to this metric in tributary reservoirs). If it happened that just one or two mayflies, for example, were found in a sample set, the rating for the EPT metric could shift from poor (1 point) to good (5 points). If it happened that the mayfly was greater than 10 mm in length, it would also count as a Long-lived taxon and result in a shift from 1 to 5 points for that metric. Absence of mayflies in the repeat set could cause up to 10 point difference in the Benthic Macroinvertebrate Score between the sample sets. This was considered unacceptable.

This situation arose because metrics to evaluate the benthic community was first developed for use on results from the run-of-river reservoirs where EPT organisms, especially mayflies, are common. The same metrics were later applied to results from the tributary reservoirs with the assumption that simply adjusting the scoring range would be sufficient to account for differences between the two groups of reservoirs. The QC program demonstrated this assumption was not valid and some type of change was needed.

One of the potential solutions described in Dycus and Meinert (1998) was to determine if other metrics might be more appropriate for tributary reservoirs. Experience has shown that the benthic macroinvertebrate fauna in tributary reservoirs is dominated by chironomids and oligochates with other taxa present on a case by case basis. Therefore, the metrics chosen for use must accept the fact that the benthos present in tributary reservoirs are ecologically poor by any other comparison. After careful evaluation it was determined that five of the seven metrics which had been used previously still had validity for use on tributary reservoir benthos data. However, the EPT Taxa and Long-Lived Taxa metrics were not appropriate. Two new metrics were chosen as replacements. One was Non-Chironomid & Oligochaete Taxa and the other was Chironomid Density. The first accepts the fact that presence (survival) of any taxon in addition to chironomid and oligochaete taxa is indicative of improved conditions compared to their absence. The second accepts that increasing density of chironomids indicates conditions are better than conditions where chironomids cannot survive at all.

The metrics used to evaluate 1998, 1999, and 2000 benthic macroinvertebrate results are identified in the table below and then described in more detail in the following paragraphs.

Metric	Run-of-River Reservoirs	Tributary Reservoirs*
Taxa Richness	X	X
EPT Taxa	X	
Long - Lived Taxa	X	
Non-Chironomid & Oligochaete Density	X	X
Percent Oligochaetes	X	X
Dominance	X	X
Zero Samples	X	X
Non-Chironomid & Oligochaete Taxa		X
Chironomid Density		X

*Rather than eliminating use of EPT organisms in tributary reservoirs, it was decided to allow "bonus points" (up to 2) if any EPT organism was found at the site, as long as the resulting benthic score did not exceed 35, the maximum possible benthic score as discussed later.

- **Taxa richness** (Used on both Run-of-River and Tributary Reservoirs)—This metric is calculated by averaging the total number of taxa present in each sample at a site. Taxa generally means Family or Order level because samples are processed in the field. For chironomids, taxa refers to obviously different organisms (i.e., separated by body size, head capsule size and shape, color, etc.). An increase in taxa richness indicates better conditions than low taxa richness.

- **EPT** (Used on Run-of-River Reservoirs only)—This metric is calculated by averaging the number of Ephemeroptera, Plecoptera, and Trichoptera taxa present in each sample at a site. Higher diversity of these taxa indicates good water quality and other habitat conditions in streams. A similar use is incorporated here despite expected lower numbers of these organisms in reservoirs than in streams.
- **Long-lived organisms** (Used on Run-of-River Reservoirs only)—This is a presence/absence metric which is evaluated based on the proportion of samples with at least one long-lived organism (Corbicula, Hexagenia, mussels, and snails) present. The presence of long-lived taxa is indicative of conditions which allow long-term survival.
- **Percentage as Oligochaetes** (Used on both Run-of-River and Tributary Reservoirs)—This metric is calculated by averaging the percentage of oligochaetes in each sample at a site. Oligochaetes are considered tolerant organisms so a higher proportion indicates poor water quality.
- **Percentage as dominant taxa** (Used on both Run-of-River and Tributary Reservoirs)—This metric is calculated by selecting the two most abundant taxa in a sample, summing the number of individuals in those two taxa, dividing that sum by the total number of animals in the sample, and converting to a percentage for that sample. The percentage was then average for the 10 samples at each site. Often, the most abundant taxa differed among the 10 samples at a site. This allows more discretion to identify imbalances at a site than developing an average for a single dominant taxon for all samples a site. This metric is used as an evenness indicator. Dominance of one or two taxa indicates poor conditions.
- **Density excluding Chironomids and Oligochaetes** (Used on both Run-of-River and Tributary Reservoirs)—This metric is calculated by first summing the number of organisms excluding chironomids and oligochaetes present in each sample and then averaging these densities for the 10 samples at a site. This metric examines the

community excluding taxa which often dominate under adverse conditions. A higher abundance of non-chironomids and oligochaetes indicates good water quality conditions.

- **Zero-samples (Proportion of samples with no organisms present)** (Used on both Run-of-River and Tributary Reservoirs)—This metric is the proportion of samples at a site which have no organisms present. "Zero-samples" indicate living conditions unsuitable to support aquatic life (i.e. toxicity, unsuitable substrate, etc.). Any site having one empty sample was assigned a score of three, and any site with two or more empty samples received a score of one. Sites with no empty samples were assigned a score of five.
- **Non-Chironomid & Oligochaete Taxa** (Used on Tributary Reservoirs only)—This metric is calculated by summing the total number of taxa, excluding chironomid and oligochaete taxa, present in each sample at a site. It is similar to the Taxa Richness metric above, but it is not considered redundant with that metric. The Taxa Richness metric on tributary reservoirs will be mostly chironomid and oligochaete taxa, whereas this new metric highlights presence (survival) of any additional taxa and recognizes their presence is indicative of improved conditions compared to their absence.
- **Chironomid Density** (Used on Tributary Reservoirs only)— This metric is calculated by averaging the density of chironomids in each sample at a site. It accepts that, for tributary reservoirs, increasing density of chironomids indicates conditions are better than conditions where chironomids cannot survive at all.

Scoring Criteria for each of the metrics were developed using the six years of Vital Signs monitoring which provide results from samples processed in the field (1994 - 1999). No further changes in scoring criteria are expected to occur in the future. Scoring ranges were developed as follows:

- Individual criteria were developed for each type of sampling location (forebay, transition zone/mid-reservoir, and inflow) for each of the four classes of reservoirs.

- Results from the 10 samples along a transect for each year were combined (averaged for most metrics) and outliers deleted.

- Results were then trisected with the third of the range representing desirable conditions assigned a value of 5 (good), the middle one-third assigned a 3 (fair), and the third representing undesirable conditions assigned a 1 (poor). Prior to 1998, trisection for all metrics was performed on the actual observed range of values. Beginning in 1998 the approach changed for all metrics except for the Percentage as Dominance Taxa metric. The approach for this metric was the same as in the past – trisection was conducted on actual observed values. For example, if the average Dominance at a particular type location in a particular reservoir class ranged from 50 to 95 percent, the range (45) was trisected (15) and the resulting scoring ranges would be 50 - 65 percent = good, 66 - 80 percent = fair, and 81 - 95 percent = poor. A slightly different approach was used for the other metrics beginning in 1998. For these metrics, the trisection included the entire possible (theoretical) range from the highest observed value to zero. In the above example there may have been an observed range in the number of taxa for all locations from 3 to 9. For the new approach 9 would have been trisected rather than 6 providing scoring ranges of ≤3 = poor, 4 - 6 = fair, and ≥7 = good. Values down to and including zero were included in the trisection even if they were not observed because zero represents an actual condition which could occur and would represent the worse-case condition.

  Following publication of the report summarizing 1998 results we realized we had incorrectly implemented the change described above. We found we had trisected the observed range rather than the maximum theoretical range as desired. We then incorrectly applied the trisected values or "cut-offs' to the maximum theoretical range. Using the observed example, where the number of taxa ranged from 3 to 9, we incorrectly trisected the observed range (6) which provided "cut-offs" of 2 units each. We then incorrectly applied those cut-offs to the maximum theoretical range (0 - 9) which resulted in scoring ranges of ≤2 = poor, 3 - 5 = fair, and ≥6 = good. This error made the benthic community scores presented in the 1998 report for field processed samples appear higher than they should have been. Prior to analyzing results for 1999, new scoring ranges were correctly developed and data for all years for which the field processed method has existed (1994 - 1999) were "rescored". These new scores are presented in the report summarizing 1999 results (Dycus and Baker, 2000) and below in the Results section of this report.

- Professional judgment and observations on the entire data base were used to adjust the cutoffs for the range of each metric, as appropriate.

Scoring criteria which resulted from these efforts are detailed by reservoir class for each metric in Table 1. Two versions of Table 1 (a and b) are provided. Table 1a provides scoring criteria for results for field processed samples. These criteria were developed based on samples collected 1994 through 1999. Table 1b provides scoring criteria for results from laboratory processed samples collected for QC purposes in 2000. These criteria were developed based on laboratory processing of samples collected 1994 through 1999.

As described above, sample results at each site were scored using the appropriate scoring ranges for each metric and assigned a value of either 5 (good), 3 (fair), or 1 (poor). Numerical ratings for the seven metrics were then summed. This resulted in a minimum score of 7 if all metrics at a site were poor, and a maximum score of 35 if all metrics were good.

One use of the benthic macroinvertebrate score is to help establish the overall ecological health score for a reservoir (see Section 1). The benthic macroinvertebrate community is one of five indicators which are summed to arrive at an overall Ecological Health Index for a reservoir.

To arrive at an evaluation of the condition of the benthic macroinvertebrate community at a sample location, scores were evaluated as follows:

Benthic Community Score	7-12	13-18	19-23	24-29	30-35
Community Condition	Very Poor	Poor	Fair	Good	Excellent
Contribution to Reservoir Ecological Health Score	1	2	3	4	5

Benthic community results along with results from the other four indicators and overall ecological health scores for each reservoir are used to keep the public informed on the conditions of Tennessee Valley reservoirs. In documents intended for the public, results for each of the five environmental indicators at each sample site are presented using one of three colors -- green (good), yellow (fair), or red (poor). This necessitates dividing scores for each indicator into three ranges. The benthic macroinvertebrate scores are categorized as follows:

Benthic Community Score	7-16	17-26	27-35
Color	Poor (Red)	Fair (Yellow)	Good (Green)

Results from 2000 Monitoring

Results and Benthic Community Scores

Results from 2000 benthos sampling are summarized for each sample location, separated by reservoir class and reservoir zone, in Table 2. This table includes final benthic scores, ratings for each of the seven metrics, and the data for each metric which drove the rating. Results for 1994, 1995, 1996, 1997, 1998, 1999, and 2000 were scored on the criteria described above and included in Table 2. All results in Table 2 are from field-processed samples. Results for lab-processed (QC) samples for 2000 are in Table 3. Appendix C provides mean density for each taxon at each location in 2000; first for field-processed samples, followed by lab-processed samples.

Table 4 provides benthic community scores for 1994 through 2000 at all monitoring locations. Scores shown are for field processed samples based on the latest (1999) scoring criteria. This table provides an "apples to apples" comparison through time. The 2000 scores for most locations (24 of 35) were similar to past scores (+/- 5 points of the long-term average benthic index score, see Section 1 for more detailed description of comparisons among years).

Evaluation of QC Results

As described earlier, QC efforts for benthic macroinvertebrates include two components. One is aimed at evaluating implications of developing scores for the benthic community based on field processed samples begun in 1995, rather than on lab processed samples as in previous years. (Note: In 1994 all samples were processed in both the field and lab but reported only for the lab. Beginning in 1995 the protocol changed to all field processing with only a subset of samples sent to the lab for verification.) Results (scores and metric ratings) from lab processed samples for this QC component in 2000 are in Table 3. They are not reported in Table 2 because different scoring criteria are used for lab processed samples, as discussed above.

The other QC component deals with how well the benthic scores can be repeated and is accomplished by collecting a second set of samples (also processed in the field) at selected locations. Results of this component for 1994, 1995, 1996, 1997, 1998, 1999, and 2000 are provided in Table 2 and identified with a "Q".

Determination of acceptable differences for QC results is an important issue and must consider study design and planned use of results. Given that the primary use of these results is to help evaluate the overall condition of a reservoir, the acceptable difference was defined in terms of impact on the Reservoir Ecological Health Score. The Reservoir Ecological Health Score is developed by summing the points (ratings) for the five indicators (chlorophyll, DO, sediment quality, benthos, and fish assemblage) and expressing as a percentage of the maximum points possible (see Section 1). The benthic macroinvertebrate community contributes from 1 to 5 points for each sample site to the overall Reservoir Ecological Health Score. A benthic community score between 7-12 contributes 1 point; 13-18 2 points; 19-23 3 points; 24-29 4 points; and 30-35 5 points. For reservoirs with only one sample location, a shift of 1 point changes the Reservoir Ecological Health Score 4.4 percent, a shift of 2 points results in an 8.8 percent change, etc. The former was deemed acceptable but the latter unacceptable. Therefore, for both components of the benthos QC effort, the difference in contribution between the original sample and the QC sample should be no more than 1 point.

When this reasoning is applied to the benthic score itself, replicate scores for QC sample sets should be no more than 6 points apart. Differences greater than this could cause a 2 point shift in the benthic community contribution to Ecological Health Score.

QC Results: Comparison of scores – field processed samples vs lab processed samples in 2000

Run-of-the-River Reservoirs	Benthic Community Scores		
	Field Score	Lab Score	Difference
Pickwick Forebay	27 (Good)	27 (Good)	0
Watts Bar Transition Zone	21 (Fair)	19 (Fair)	+2
Guntersville Inflow	25 (Good)	31 (Excellent)	-6
Tributary Reservoirs			
	Field Score	Lab Score	Difference
Blue Ridge Ecoregion			
Chatuge Forebay	15 (Poor)	27 (Good)	-12
Hiwassee Mid-reservoir	15 (Poor)	19 (Fair)	-4
Watuaga Forebay	9 (Very Poor)	11 (Very Poor)	-2
Ridge and Valley Ecoregion			
Tims Ford Forebay	7 (Very Poor)	7 (Very Poor)	0

Interior Plateau Ecoregion
None sampled in 2000 (although Tims Ford is physically within the Interior Plateau, it is scored as though it is located within the Ridge and Valley Ecoregion because the major part of its watershed is within that ecoregion.

Note: Field processed samples are scored on expectations appropriate for that level of taxonomic discernment as shown in Table 1a; whereas lab processed samples are scored on a different set of expectations appropriate for that level of discernment as shown in Table 1b.

Differences in all but one sample set were less than the desired maximum of 6. Summary statistics comparing scores for field processed and lab processed samples include a maximum difference 12 (1 set), a minimum difference of 0 (2 sets), a mean difference of 3.1, and 95 percent confidence interval of ± 4.4 (-1.3 to 7.5). The maximum difference (12) and mean difference (-3.1) are the greatest found to date in this monitoring program. Likewise, this data set is the first in which the upper bounds of the 95% CL exceeded the maximum desired difference of 6.

These results indicate potential problems with field-processed samples in 2000. However, when individual paired sample sets are examined, it is clear that the sample set with a maximum difference of 12 is clearly not representative of the other six paired sets. In fact, if this one set were excluded and the summary statistics recalculated, the results would indicate that scores based on field processing of samples provide an acceptable representation of scores based on lab-processing samples of the samples. That is, the maximum difference would be 6, the mean difference would be 1.7, and the 95% CL would be $\pm$3.1 (-1.4 to 4.8). Exclusion of any data without sound reason is irresponsible. In this case, their is sound reason to exclude the sample set with a difference of 12 from determining acceptability of 2000 scores (although they should not be excluded when examining opportunities for improvement in overall methodology). As it turns out, the questionable sample set was collected early in the sampling season by a newly assembled crew, and the sample set came from a tributary reservoir in an area with mostly sand substrate. Sampling sites with mostly sand substrates have proven a challenge for the most seasoned crews because of the difficulty of picking animals (mostly chironomids) from out of the large mass of sand under field conditions. The new field crew was still in the training stage when this site was sampled. Continued training and added experience in the field allowed this crew to improve ability and provide sound results as indicated by subsequent QC scores. Differences between the score derived from this crew's field processed sample results versus lab processing of those same samples were -2, -4 and +2 for the other three QC sample sets, thus indicating acceptability of scores derived from field processed samples.

One concern in previous years has been a bias in benthic index scores between field and lab processed samples. For the 1994 - 1996 results there was a bias toward higher scores from the samples when processed in the lab. As a result, adjustments in scoring criteria were made in prior to scoring 1997 results. These adjustments had the desired effect of eliminating the bias observed in 1994 - 1996, but may have gone too far and caused a possible bias in the other direction – scores for both 1997 and 1998 tended to be higher based on the field derived results than the lab derived results. Results for paired scores for 1999 were encouraging. (See the annual summary report for each of those years for detailed explanation of suspected problems and adjustments made to correct those problems - references cited above.) Results from 2000 QC samples indicated a possible negative bias for field processed samples. This will be considered and emphasis will be placed on sample picking and differentiation of taxa with the naked eye in training efforts for 2001 sampling.

QC Results: Scores for original samples compared to scores for repeat sampling in 2000

Run-of-the-River Reservoirs	Benthic Community Scores		
	Field Score Original	Field Score Repeat	Difference
Pickwick Forebay	27 (Good)	19 (Good)	8
Watts Bar Transition Zone	21 (Fair)	17 (Poor)	4
Guntersville Inflow	25 (Good)	29 (Good)	4

Tributary Reservoirs

	Field Score Original	Field Score Repeat	Difference
Blue Ridge Ecoregion			
Chatuge Forebay	15 (Poor)	17 (Poor)	2
Hiwassee Mid-reservoir	15 (Poor)	15 (Poor)	0
Watuaga Forebay	9 (Very Poor)	9 (Very Poor)	0
Ridge and Valley Ecoregion			
Tims Ford Forebay	7 (Very Poor)	11 (Very Poor)	4

Interior Plateau Ecoregion

None sampled in 2000 (although Tims Ford is physically within the Interior Plateau, it is scored as though it is located within the Ridge and Valley Ecoregion because the major part of its watershed is within that ecoregion.

Note: + and - signs are not provided for these differences because there is no basis for bias – neither would be expected to be higher or lower than the other; therefore, the absolute rather than the relative difference should be considered.

Scores from all paired sample sets compared favorably. Replicate sample sets from all six of the seven sites had scores that differed by 6 points or less. Replicate sample sets from two sites had identical scores. Only one of replicate sample sets had scores which differed by more than 6 points (8 points). The mean difference (3.1) for all QC sites in 2000 and associated 95 percent confidence limits ($\pm$ 2.7) provide a range (0.4 - 5.8) which does not include 6.

Results from this component continue to demonstrate that methodology being used provide reproducible scores. Summary statistics samples are provided below for all years when field processing of occurred.

Year	Maximum Observed Difference	Mean	95% CL	Lower Limit	Upper Limit
1994	12	2.3	± 2.0	0.3	4.3
1995	8	4.0	± 2.2	1.8	6.2
1996	12	4.5	± 3.7	0.8	8.2
1997	8	2.9	± 2.6	0.3	5.5
1998	6	2.3	± 1.9	0.4	4.2
1999	6	1.4	± 2.1	-0.7	3.5
2000	8	3.1	± 2.7	0.4	5.8

Reference

Dycus, D.L., 1995. "Aquatic Ecological Health Determinations for TVA Reservoirs--1994. An Informal Summary of 1994 Vital Signs Monitoring Results and Ecological Health Determination Methods." April 1995.

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Table 1a. Scoring Criteria for Benthic Macroinvertebrate Community; Field Processed Samples, Reservoir Vital Signs Monitoring - 2000

Run-of-the-River Reservoirs

Benthic Community Metrics	Forebay			Transition Zone			Inflow		
	1	3	5	1	3	5	1	3	5
Taxa Richness	≤2.4	2.5-4.7	≥4.8	≤2.1	2.2-4.3	≥4.4	≤2.8	2.9-5.7	≥5.8
EPT	≤0.4	0.5-0.7	≥0.8	≤0.3	0.4-0.7	≥0.8	≤0.3	0.4-0.7	≥0.8
Long-lived	≤0.3	0.4-0.7	≥0.8	≤0.3	0.4-0.7	≥0.8	≤0.3	0.4-0.7	≥0.8
Non Chiron &Oligo Density	≤118	119-235	≥236	≤291	292-580	≥581	≤568	569-1152	≥1153
Percent Oligochaetes	≥29.7	14.9-29.6	≤14.8	≥28.0	14.0-27.9	≤13.9	≥40.0	20.1-39.9	≤20.0
Dominance	≥90.7	81.4-90.6	≤81.3	≥87.8	78.8-87.7	≤78.7	≥85.0	78.8-84.9	≤78.7
Zero Samples	≥0.2	0.1	0	≥0.2	0.1	0	≥0.2	0.1	0

Blue Ridge Tributary Reservoirs*

Benthic Community Metrics	Forebay						Mid-Reservoir		
	1	3	5				1	3	5
Taxa Richness	≤1.3	1.4-2.7	≥2.8	-	-	-	≤1.1	1.2-2.3	≥2.4
Sum of Non Chiron & Oligo Taxa	≤4	5-8	≥9	-	-	-	≤1	2-4	≥5
Non Chiron and Oligo Density	≤66	67-131	≥132	-	-	-	≤3.0	3.1-6.1	≥6.2
Chironomid Density	≤96	97-191	≥192	-	-	-	≤185	186-369	≥370
Percent Oligochaetes	≥57.9	29.0-57.8	≤28.9	-	-	-	≥64.2	32.2-64.1	≤32.1
Dominance	≥95.0	89.8-94.9	≤89.7	-	-	-	≥98.7	97.3-98.6	≤97.2
Zero Samples	≥0.3	0.1-0.2	0	-	-	-	≥0.3	0.1-0.2	0

Table 1a. Cont', Scoring Criteria for Benthic Macroinvertebrate Community; Field Processed Samples, Reservoir Vital Signs Monitoring - 2000

Interior Plateau Tributary Reservoirs*

Benthic Community Metrics	Forebay						Mid-Reservoir		
	1	3	5				1	3	5
Taxa Richness	≤1.3	1.4-2.6	≥2.7	-	-	-	-	-	-
Sum of Non Chiron & Oligo Taxa	≤1	2-3	≥4	-	-	-	-	-	-
Non Chiron and Oligo Density	≤11.0	11.1-21.0	≥21.1	-	-	-	-	-	-
Chironomid Density	≤205	206-408	≥409	-	-	-	-	-	-
Percent Oligochaetes	≥61	31-60	≤30	-	-	-	-	-	-
Dominance	≥97.7	95.4-97.6	≤95.3	-	-	-	-	-	-
Zero Samples	≥0.3	0.1-0.2	0	-	-	-	-	-	-

Ridge and Valley Tributary Reservoirs*

Benthic Community Metrics	Forebay						Mid-Reservoir		
	1	3	5				1	3	5
Taxa Richness	≤0.8	0.9-1.7	≥1.8	-	-	-	≤1.5	1.6-3.1	≥3.2
Sum of Non Chiron & Oligo Taxa	≤1	2	≥3	-	-	-	≤2	3-6	≥7
Non Chiron and Oligo Density	≤34	35-68	≥69	-	-	-	≤10.0	10.1-20.0	≥20.1
Chironomid Density	≤100	101-199	≥200	-	-	-	≤321	322-642	≥643
Percent Oligochaetes	≥64.5	33.3-64.4	≤33.2	-	-	-	≥56.0	28.1-55.9	≤28.0
Dominance	≥99.0	97.8-98.9	≤97.7	-	-	-	≥97.0	94.0-96.9	≤93.9
Zero Samples	≥0.3	0.1-0.2	0	-	-	-	≥0.3	0.1-0.2	0

*Two points were added to total score if any EPT were present as long as the adjusted score did not exceed 35.

Table 1b. Scoring Criteria for Benthic Macroinvertebrate Community; Lab Processed Samples, Reservoir Vital Signs Monitoring - 2000

Run-of-the-River Reservoirs

Benthic Community Metrics	Forebay			Transition Zone			Inflow		
	1	3	5	1	3	5	1	3	5
Taxa Richness	<2.8	2.8-5.5	>5.5	<3.3	3.3-6.6	>6.6	<4.2	4.2-8.3	>8.3
EPT	<0.6	0.6-0.9	>0.9	<0.6	0.6-1.4	>1.4	<0.9	0.9-1.9	>1.9
Long-lived	<0.6	0.6-0.8	>0.8	<0.6	0.6-0.9	>0.9	<0.6	0.6-0.8	>0.8
Percent Oligochaetes	>41.9	41.9-21.0	<21.0	>21.9	21.9-11.0	<11.0	>23.9	23.9-12.0	<12.0
Dominance	>90.3	90.3-81.7	<81.7	>87.9	87.9-77.8	<77.8	>86.2	86.2-73.1	<73.1
Non Chiron & Oligo Density	<125.0	125.0-249.9	>249.9	<305.0	305.0-609.9	>609.9	<400.0	400.0-799.9	>799.9
Zero Samples	>0	-	0	>0	-	0	>0	-	0

Blue Ridge Tributary Reservoirs*

Benthic Community Metrics	Forebay						Mid-Reservoir		
	1	3	5	1	3	5	1	3	5
Taxa Richness	<1.8	1.8-3.5	>3.5	-	-	-	<1.8	1.8-3.5	>3.5
Sum of Non Chiron & Oligo Taxa	<5	5 - 9	>9				<5	6 - 10	>10
Non Chiron & Oligo Density	<25.0	25.0-49.9	>49.9	-	-	-	<15.0	15.0-29.9	>29.9
Chironomid Density	<91.1	91.1-182.9	>182.9				<167.1	167.1-334	≥334
Percent Oligochaetes	>47.9	47.9-24.0	<24.0	-	-	-	>53.9	53.9-27.0	<27.0
Dominance	>96.0	96.0-92.2	<92.2	-	-	-	>95.5	95.5-92.4	<92.4
Zero Samples	>0	-	0	-	-	-	>0	-	0

Table 1b. Cont', Scoring Criteria for Benthic Macroinvertebrate Community; Lab Processed Samples, Reservoir Vital Signs Monitoring - 2000

Interior Plateau Tributary Reservoirs*

Benthic Community Metrics	Forebay						Mid-Reservoir		
	1	3	5	1	3	5	1	3	5
Taxa Richness	<1.7	1.7-3.4	>3.4	-	-	-	-	-	-
Sum of Non Chiron & Oligo Taxa	<6	6 - 10	>10						
Non Chiron & Oligo Density	<25.0	25.0-49.9	>49.9	-	-	-	-	-	-
Chironomid Density	<56.1	56.1-112.0	>112.0						
Percent Oligochaetes	>61.9	61.9-31.0	<31.0	-	-	-	-	-	-
Dominance	>95.3	95.3-91.4	<91.4	-	-	-	-	-	-
Zero Samples	≥0	-	0	-	-	-	-	-	-

Ridge and Valley Tributary Reservoirs*

Benthic Community Metrics	Forebay						Mid-Reservoir		
	1	3	5	1	3	5	1	3	5
Taxa Richness	<1.2	1.2-2.4	>2.4	-	-	-	<2.0	2.0-3.9	>3.9
Sum of Non Chiron & Oligo Taxa	<4	4 - 6	>6				<5	6-10	>10
Non Chiron & Oligo Density	<40.0	40.0-79.9	>79.9	-	-	-	<21.0	21.0-41.9	>41.9
Chironomid Density	<82.1	82.1-163.9	>163.9				<218.1	218.1-435.9	>435.9
Percent Oligochaetes	>61.9	61.9-31.0	<31.0	-	-	-	>41.9	41.9-21.0	<21.0
Dominance	>98.3	98.3-97.0	<97.0	-	-	-	>98.1	98.1-96.6	<96.6
Zero Samples	>0	-	0	-	-	-	>0	-	0

*Two points were added to total score if any EPT were present as long as the adjusted score did not exceed 35.

Table 2. Results and Ratings for individual Metrics and Final Benthic Scores. Separated by Reservoir Class and Type of Sample Location.

Run-of-River Reservoirs -- Forebay Sites

Reservoir	Q	Mile	Year	Score	TAXA		LLIVED		EPT		% OLIGO		DOMN		TOTNONC		ZEROS	
Chickamauga	Q	472.3	94	31	5.9	5	1	5	0.5	3	26.3	3	78.6	5	298.3	5	0	5
Chickamauga		472.3	94	31	5.3	5	1	5	1	5	13.8	5	82.3	3	151.7	3	0	5
Chickamauga		472.3	95	27	4.3	3	0.9	5	0.4	1	14.9	5	85.3	3	310.0	5	0	5
Chickamauga		472.3	97	29	5.5	5	0.9	5	0.3	1	6.1	5	81.7	3	353.3	5	0	5
Chickamauga		472.3	99	25	5.1	5	0.9	5	0.3	1	15.5	3	84	3	141.7	3	0	5
Chickamauga	SQN	472.3	2000	27	4.8	5	0.8	5	0.2	1	17.0	3	87	3	305.0	5	0	5
Chickamauga	SQN	482	2000	23	3.7	3	0.9	5	0.3	1	27.9	3	87.6	3	230.0	3	0	5
Fort Loudoun		605.5	94	13	3	3	0.1	1	0.1	1	34.6	1	99.3	1	7.6	1	0	5
Fort Loudoun		605.5	95	13	3.2	3	0.1	1	0.1	1	43.1	1	96.5	1	11.7	1	0	5
Fort Loudoun		605.5	96	11	2.9	3	0.1	1	0.1	1	38.0	1	99.5	1	3.3	1	0.1	3
Fort Loudoun	Q	605.5	97	15	2.7	3	0.3	1	0.3	1	20.6	3	99	1	41.7	1	0	5
Fort Loudoun		605.5	97	15	3.2	3	0.4	3	0.4	1	38.0	1	99.3	1	30.0	1	0	5
Fort Loudoun		605.5	98	13	3.5	3	0.1	1	0.1	1	32.6	1	98.6	1	5.0	1	0	5
Fort Loudoun		605.5	99	9	2.4	1	0.1	1	0	1	36.3	1	100	1	3.3	1	0.1	3
Fort Loudoun		605.5	2000	9	2.3	1	0	1	0	1	49.2	1	100	1	5.0	1	0.1	3
Guntersville		350	94	27	4.9	5	1	5	0.6	3	20.0	3	86.6	3	143.3	3	0	5
Guntersville		350	96	35	6	5	1	5	0.8	5	12.8	5	72.6	5	246.7	5	0	5
Guntersville	Q	350	98	35	7	5	1	5	1	5	5.0	5	74.4	5	283.3	5	0	5
Guntersville		350	98	35	7.1	5	1	5	1.1	5	4.1	5	71.9	5	328.3	5	0	5
Guntersville		350	2000	23	4.6	3	0.9	5	0	1	7.7	5	90.4	3	81.7	1	0	5
Kentucky		7.4	94	19	6.2	5	0.2	1	0	1	5.9	5	94.1	1	60.0	1	0	5
Kentucky		7.4	95	19	4.9	5	0.1	1	0	1	8.7	5	93.5	1	78.3	1	0	5
Kentucky		7.4	97	23	5.6	5	0.5	3	0.1	1	2.4	5	93.7	1	128.3	3	0	5
Kentucky		7.4	99	21	6.3	5	0.3	1	0.3	1	10.6	5	89.6	3	86.7	1	0	5
Kentucky		23	94	27	6	5	0.9	5	0.2	1	25.6	3	81	5	173.3	3	0	5
Kentucky		23	95	23	4.4	3	0.7	3	0.2	1	17.4	3	85.4	3	523.3	5	0	5
Kentucky		23	97	27	6	5	0.7	3	0	1	7.2	5	86.3	3	328.3	5	0	5
Kentucky		23	99	21	5	5	0.6	3	0	1	15.1	3	85.7	3	106.7	1	0	5
Melton Hill		24	94	17	3.5	3	0.4	3	0.5	3	15.0	3	94	1	18.3	1	0.1	3
Melton Hill	Q	24	96	19	2.5	3	0.3	1	0.5	3	11.0	5	94	1	28.3	1	0	5
Melton Hill		24	96	11	2.4	1	0.3	1	0.4	1	18.1	3	98.3	1	18.3	1	0.1	3
Melton Hill		24	98	17	2.9	3	0.6	3	0.6	3	4.1	5	96.9	1	30.0	1	0.2	1
Melton Hill		24	2000	13	2.8	3	0.1	1	0.1	1	24.5	3	98.4	1	6.7	1	0.1	3
Nickajack	Q	425.5	94	31	4.8	5	0.9	5	1.1	5	11.3	5	82.4	3	151.7	3	0	5
Nickajack		425.5	94	31	4.8	5	0.8	5	1.5	5	4.5	5	82.8	3	138.3	3	0	5
Nickajack	Q	425.5	95	25	3.9	3	0.9	5	0.6	3	14.9	3	82.8	3	196.7	3	0	5
Nickajack		425.5	95	29	4.2	3	0.9	5	0.8	5	16.3	3	76.3	5	171.7	3	0	5
Nickajack		425.5	97	33	5.9	5	1	5	1	5	6.3	5	81.9	3	331.7	5	0	5
Nickajack		425.5	99	35	5.5	5	0.9	5	0.9	5	4.7	5	78.7	5	518.3	5	0	5
Pickwick		8.4	94	17	5	5	0	1	0	1	20.5	3	99.6	1	3.3	1	0	5
Pickwick		8.4	96	15	4.3	3	0.1	1	0	1	20.8	3	96.5	1	13.3	1	0	5
Pickwick		8.4	98	17	3.9	3	0	1	0	1	5.2	5	100	1	1.7	1	0	5
Pickwick		8.4	2000	15	3.4	3	0.2	1	0.1	1	19.4	3	98.7	1	8.3	1	0	5
Pickwick		207.3	94	29	4.9	5	0.5	3	0.5	3	12.2	5	78.8	5	213.3	3	0	5
Pickwick		207.3	96	29	5	5	0.6	3	0.9	5	14.5	5	84.4	3	228.3	3	0	5

Table 2. Results and Ratings for individual Metrics and Final Benthic Scores. Separated by Reservoir Class and Type of Sample Location.

Run-of-River Reservoirs -- Forebay Sites

Reservoir	Q	Mile	Year	Score	TAXA		LLIVED		EPT		% OLIGO		DOMN		TOTNONC		ZEROS	
Pickwick		207.3	98	29	4.4	3	1	5	0.7	3	5.4	5	90.2	3	271.7	5	0	5
Pickwick	Q	207.3	2000	19	3.4	3	0.6	3	0.4	1	9.4	5	92.7	1	75.0	1	0	5
Pickwick		207.3	2000	27	4.1	3	0.9	5	0.6	3	9.2	5	89.1	3	176.7	3	0	5
Tellico		1	94	7	0.8	1	0	1	0	1	55.6	1	100	1	0.0	1	0.4	1
Tellico		1	95	7	0.9	1	0	1	0	1	61.9	1	100	1	1.7	1	0.3	1
Tellico		1	97	9	1.8	1	0.1	1	0.1	1	28.5	3	98.1	1	11.7	1	0.2	1
Tellico		1	99	7	0.9	1	0.1	1	0	1	48.9	1	100	1	1.7	1	0.4	1
Watts Bar		531	94	13	3.8	3	0.2	1	0.3	1	24.0	3	92	1	20.0	1	0.1	3
Watts Bar	Q	531	96	13	3.1	3	0.2	1	0.4	1	44.4	1	94.8	1	10.0	1	0	5
Watts Bar		531	96	11	3	3	0.1	1	0.1	1	32.7	1	95.2	1	10.0	1	0.1	3
Watts Bar	Q	531	98	15	4.3	3	0.3	1	0.3	1	24.0	3	94.7	1	38.3	1	0	5
Watts Bar		531	98	13	4.1	3	0.2	1	0.2	1	33.1	1	94.8	1	40.0	1	0	5
Watts Bar		532.5	2000	15	2.8	3	0	1	0	1	26.5	3	98.6	1	11.7	1	0	5
Wheeler		277	94	19	4.8	5	0.4	3	0	1	19.1	3	93.1	1	41.7	1	0	5
Wheeler		277	95	15	3	3	0.2	1	0	1	15.7	3	95.9	1	21.7	1	0	5
Wheeler		277	97	23	4.8	5	0.6	3	0	1	10.0	5	88.7	3	80.0	1	0	5
Wheeler		277	99	17	3.9	3	0.6	3	0.2	1	19.3	3	92.1	1	70.0	1	0	5
Wheeler	Q	277	99	19	4.2	3	0.5	3	0	1	22.9	3	89.4	3	105.0	1	0	5
Wilson		260.8	94	17	4.6	3	0	1	0	1	9.1	5	94.1	1	78.3	1	0	5
Wilson		260.8	96	15	3.8	3	0	1	0	1	40.4	1	90.1	3	21.7	1	0	[illegible]
Wilson		260.8	98	15	4	3	0.2	1	0.1	1	27.1	3	91.9	1	45.0	1	0	5
Wilson		260.8	2000	15	3.2	3	0.1	1	0	1	20.9	3	98.1	1	10.0	1	0	5

Table 2. Results and Ratings for individual Metrics and Final Benthic Scores. Separated by Reservoir Class and Type of Sample Location.

Run-of-River Reservoirs -- Transition Sites

Reservoir	Q	Mile	Year	Score	TAXA		LLIVED		EPT		% OLIGO		DOMN		TOTNONCT		ZEROS	
Chickamauga	Q	8.5	94	17	2.6	3	0.4	3	0.4	3	39.2	1	85.2	3	61.7	1	0.1	3
Chickamauga		8.5	94	17	2.9	3	0.5	3	0.6	3	21.7	3	89.4	1	203.3	1	0.1	3
Chickamauga		8.5	95	27	5.5	5	0.9	5	0.9	5	33.8	1	75.9	5	166.7	1	0	5
Chickamauga		8.5	97	25	5.9	5	0.6	3	0.8	5	37.0	1	78.4	5	191.7	1	0	5
Chickamauga		8.5	99	21	4.6	5	0.6	3	0.6	3	54.3	1	81.7	3	81.7	1	0	5
Chickamauga	Q	490.5	94	33	5.5	5	1	5	1	5	5.0	5	73.7	5	480.0	3	0	5
Chickamauga		490.5	94	33	5.7	5	0.9	5	1	5	10.8	5	70.8	5	373.3	3	0	5
Chickamauga		490.5	95	29	5.4	5	0.9	5	0.9	5	23.0	3	74.6	5	170.0	1	0	5
Chickamauga		490.5	97	31	5.9	5	1	5	0.7	3	10.4	5	69.7	5	428.3	3	0	5
Chickamauga		490.5	99	31	5.5	5	1	5	0.9	5	13.7	5	78.6	5	270.0	1	0	5
Chickamauga	Q	490.5	99	25	5.5	5	1	5	0.3	1	11.9	5	80.3	3	266.7	1	0	5
Chickamauga	SQN	490.5	2000	23	4.7	5	0.9	5	0.3	1	7.7	5	88.4	1	218.3	1	0	5
Fort Loudoun		624.6	94	17	3.9	3	0.4	3	0.4	3	28.6	1	92.8	1	21.7	1	0	5
Fort Loudoun		624.6	95	23	4.9	5	0.7	3	0.7	3	15.3	3	86.2	3	76.7	1	0	5
Fort Loudoun		624.6	96	23	4.6	5	0.4	3	0.4	3	12.7	5	91	1	83.3	1	0	5
Fort Loudoun		624.6	97	27	5.5	5	1	5	1	5	12.4	5	89.2	1	140.0	1	0	5
Fort Loudoun	Q	624.6	98	23	4.2	3	0.7	3	0.7	3	2.9	5	85.5	3	91.7	1	0	5
Fort Loudoun		624.6	98	23	4.7	5	0.6	3	0.6	3	5.5	5	91.8	1	96.7	1	0	5
Fort Loudoun		624.6	99	19	5.4	5	0.3	1	0.4	3	5.3	5	92.9	1	58.3	1	0.1	3
Fort Loudoun		624.6	2000	23	4.6	5	0.5	3	0.5	3	7.2	5	93.8	1	50.0	1	0	5
Guntersville		375.2	94	33	6.3	5	1	5	1	5	7.4	5	78.8	3	610.0	5	0	5
Guntersville		375.2	96	33	5.5	5	1	5	0.8	5	4.1	5	82.7	3	733.3	5	0	5
Guntersville		375.2	98	33	5.2	5	1	5	1	5	5.6	5	86.2	3	768.3	5	0	5
Guntersville		375.2	2000	31	6.1	5	1	5	0.8	5	9.0	5	81.6	3	528.3	3	0	5
Kentucky	Q	85	94	27	5.8	5	0.9	5	0.8	5	14.7	3	79.7	3	253.3	1	0	5
Kentucky		85	94	29	5.3	5	1	5	0.8	5	9.9	5	81	3	255.0	1	0	5
Kentucky		85	95	29	3.9	3	1	5	0.9	5	1.6	5	85.8	3	433.3	3	0	5
Kentucky	Q	85	97	35	6.1	5	1	5	0.8	5	13.3	5	76.6	5	760.0	5	0	5
Kentucky		85	97	35	6.4	5	1	5	1	5	3.7	5	76.9	5	790.0	5	0	5
Kentucky		85	99	31	6	5	1	5	0.8	5	16.5	3	75	5	301.7	3	0	5
Melton Hill		45	94	15	3.2	3	0.3	1	0.3	1	26.0	3	96.7	1	8.3	1	0	5
Melton Hill		45	96	17	3.2	3	0.4	3	0.4	3	41.8	1	90.8	1	26.7	1	0	5
Melton Hill		45	98	17	3.4	3	0.7	3	0.7	3	36.9	1	89	1	35.0	1	0	5
Melton Hill		45	2000	15	3	3	0.6	3	0.6	3	34.0	1	82	3	215.0	1	0.2	1
Pickwick		230	94	31	6	5	1	5	0.8	5	18.4	3	74.6	5	294.8	3	0	5
Pickwick	Q	230	96	33	5.2	5	0.9	5	0.9	5	3.5	5	80.2	3	758.3	5	0	5
Pickwick		230	96	33	5.2	5	1	5	0.8	5	3.7	5	83.7	3	871.7	5	0	5
Pickwick		230	98	31	5.2	5	1	5	0.8	5	8.5	5	82.8	3	403.3	3	0	5
Pickwick		230	2000	21	3.9	3	1	5	0	1	9.8	5	91.6	1	186.7	1	0	5
Tellico		15	94	11	1.5	1	0.3	1	0.3	1	11.3	5	100	1	6.7	1	0.2	1
Tellico	Q	15	95	13	1.3	1	0.2	1	0.2	1	8.3	5	100	1	3.3	1	0.1	3
Tellico		15	95	15	2	1	0.4	3	0.4	3	33.8	1	99	1	10.0	1	0	5
Tellico		15	97	7	1.8	1	0	1	0.2	1	32.6	1	100	1	8.3	1	0.2	1
Tellico		15	99	9	0.7	1	0.1	1	0	1	23.3	3	100	1	3.3	1	0.5	1
Watts Bar		560.8	94	29	4.5	5	0.9	5	1	5	2.7	5	90.2	1	356.7	3	0	5
Watts Bar		560.8	96	25	4.2	3	0.9	5	0.9	5	1.0	5	89.7	1	148.3	1	0	5
Watts Bar		560.8	98	23	4	3	0.7	3	0.7	3	11.3	5	94.8	1	355.0	3	0	5
Watts Bar		560.8	2000	21	4.2	3	0.4	3	0.6	3	7.2	5	96.3	1	178.3	1	0	5
Watts Bar	Q	560.8	2000	17	4.3	3	0.1	1	0.2	1	8.4	5	93.2	1	106.7	1	0	5
Wheeler		6	94	15	4.6	5	0.1	1	0	1	28.4	1	98.9	1	8.3	1	0	5
Wheeler	Q	6	95	13	3.5	3	0	1	0	1	45.2	1	90.4	1	25	1	0	5

Table 2. Results and Ratings for individual Metrics and Final Benthic Scores. Separated by Reservoir Class and Type of Sample Location.

Run-of-River Reservoirs -- Transition Sites

Reservoir	Q	Mile	Year	Score	TAXA		LLIVED		EPT		% OLIGO		DOMN		TOTNONCT		ZEROS	
Wheeler		6	95	13	2.8	3	0	1	0	1	54.5	1	95.2	1	10	1	0	5
Wheeler		6	97	15	6	5	0.1	1	0	1	52.0	1	92.3	1	80.0	1	0	5
Wheeler		6	99	15	4.6	5	0	1	0	1	38.9	1	93	1	38.3	1	0	5
Wheeler		295.9	94	33	5.6	5	1	5	0.8	5	10.4	5	77.3	5	316.7	3	0	5
Wheeler		295.9	95	25	3.3	3	1	5	0.6	3	6.6	5	82.2	3	131.7	1	0	5
Wheeler		295.9	97	31	5.9	5	1	5	1	5	10.1	5	79.5	3	393.3	3	0	5
Wheeler		295.9	99	31	5.6	5	1	5	0.9	5	3.5	5	83.5	3	511.7	3	0	5
Wheeler	Brown	291.7	2000	27	4	3	1	5	0.8	5	6.4	5	79.6	3	125.0	1	0	5
Wheeler	Brown	295.9	2000	31	4.6	5	1	5	0.8	5	6.6	5	77.6	5	190.0	1	0	5

Table 2. Results and Ratings for individual Metrics and Final Benthic Scores. Separated by Reservoir Class and Type of Sample Location.

Run-of-River Reservoirs -- Inflow Sites

Reservoir	Q	Mile	Year	Score	TAXA		LLIVED		EPT		% OLIGO		DOMN		TOTNONCT		ZEROS	
Chickamauga		518	94	19	2.6	1	1	5	0	1	5.28	5	95.7	1	411.7	1	0	5
Chickamauga	Q	518	95	23	4.5	3	0.9	5	0.3	1	2.89	5	79.5	3	155.5	1	0	5
Chickamauga		518	95	31	6.4	5	0.9	5	1	5	3.47	5	68.1	5	249.1	1	0	5
Chickamauga		518	97	25	5.5	3	1	5	0.5	3	1.52	5	84.8	3	345.6	1	0	5
Chickamauga		518	99	21	3.7	3	0.8	5	0.1	1	2.5	5	86.4	1	222.7	1	0	5
Chickamauga	SQN	518	2000	23	5.3	3	0.6	3	0.2	1	2.04	5	70.9	5	388.3	1	0	5
Fort Loudoun		652	94	7	1.2	1	0.1	1	0	1	40.5	1	99.2	1	10.9	1	0.3	1
Fort Loudoun		652	95	11	1.7	1	0	1	0	1	25	3	94.7	1	19.1	1	0.1	3
Fort Loudoun		652	96	7	1.4	1	0	1	0	1	59.9	1	97.1	1	11.7	1	0.2	1
Fort Loudoun		652	97	9	2.4	1	0.1	1	0.2	1	24.3	3	90.9	1	73.3	1	0.2	1
Fort Loudoun		652	98	13	2.5	1	0	1	0	1	35.4	3	94.6	1	11.7	1	0	5
Fort Loudoun		652	99	7	1.5	1	0.2	1	0	1	48.2	1	95.8	1	3.3	1	0.2	1
Fort Loudoun		652	2000	11	2.1	1	0.1	1	0	1	13.3	5	97.8	1	20.0	1	0.2	1
Guntersville		420	94	21	3.3	3	0.9	5	0.1	1	2	5	87.3	1	281.8	1	0	5
Guntersville		420	96	27	4.7	3	1	5	0.5	3	3.14	5	84.1	3	629.1	3	0	5
Guntersville		420	98	23	4.1	3	0.9	5	0.6	3	3.64	5	91	1	364.5	1	0	5
Guntersville		420	2000	25	4.6	3	1	5	0.3	1	6.19	5	84.5	3	920.0	3	0	5
Guntersville	Q	420	2000	29	5.3	3	1	5	0.8	5	9	5	79.8	3	976.7	3	0	5
Guntersville	Widow	407	2000	25	4.1	3	1	5	0.7	3	5.44	5	81.6	3	260.0	1	0	5
Guntersville	Widow	408	2000	23	3.8	3	0.9	5	0.7	3	5.9	5	92.7	1	437.1	1	0	5
Kentucky		15	94	23	5.4	3	1	5	0.7	3	18.1	5	86.4	1	214.5	1	0	5
Kentucky		200	94	27	5.2	3	0.9	5	0.4	3	12.7	5	75.8	5	80.9	1	0	5
Kentucky		200	95	21	3.1	3	0.8	5	0	1	0.63	5	88.3	1	92.7	1	0	5
Kentucky	Q	200	97	21	4.3	3	0.8	5	0.3	1	5.48	5	86.8	1	170.9	1	0	5
Kentucky		200	97	27	4.2	3	0.9	5	0.6	3	12	5	78	5	113.6	1	0	5
Kentucky		200	99	21	3.8	3	1	5	0.3	1	0.19	5	88	1	258.3	1	0	5
Melton Hill		58.8	94	11	1.2	1	0	1	0	1	9	5	100	1	0.0	1	0.2	1
Melton Hill		58.8	96	7	1.5	1	0.1	1	0.2	1	40	1	98.4	1	5.5	1	0.2	1
Melton Hill		58.8	98	7	1.8	1	0	1	0	1	43.2	1	93.7	1	2.7	1	0.3	1
Melton Hill		58.8	2000	13	1.7	1	0	1	0	1	35.3	3	100	1	8.3	1	0	5
Nickajack	Q	469	94	27	5.8	5	1	5	2.1	5	0	5	85.3	1	457.3	1	0	5
Nickajack		469	94	31	7.6	5	1	5	2.4	5	0.49	5	82.2	3	693.6	3	0	5
Nickajack		469	95	31	8.5	5	1	5	2.2	5	2.07	5	79.7	3	1086.4	3	0	5
Nickajack		469	97	33	7	5	1	5	1.7	5	1.62	5	82.3	3	1420.0	5	0	5
Nickajack		469	99	29	6.3	5	1	5	0.7	3	1.07	5	79.9	3	591.8	3	0	5
Nickajack	Q	469	99	31	6.1	5	1	5	1	5	4	5	77.3	5	436.4	1	0	5
Pickwick	Q	253	94	21	3.6	3	0.6	3	0.5	3	10.4	5	91.4	1	183.6	1	0	5
Pickwick		253	94	25	4.2	3	0.4	3	1	5	5.38	5	79.7	3	95.5	1	0	5
Pickwick		253	96	21	3.8	3	0.7	3	0.6	3	0.73	5	85.4	1	131.8	1	0	5
Pickwick	Q	253	98	21	3.6	3	0.9	5	0.3	1	2.17	5	88.9	1	120.0	1	0	5
Pickwick		253	98	23	3.7	3	0.9	5	0.5	3	1	5	88.1	1	109.1	1	0	5
Pickwick		253	2000	25	4.4	3	0.9	5	0.5	3	0.52	5	83.8	3	518.3	1	0	5
Pickwick	Colbert	244	2000	27	6.3	5	0.9	5	0.3	1	2.88	5	74.3	5	395.9	1	0	5
Pickwick	Colbert	246	2000	23	4.7	3	1	5	0.2	1	3.65	5	80.1	3	232.3	1	0	5
Watts Bar		19	94	13	1.8	1	0.3	1	0.2	1	0	5	96.1	1	38.2	1	0.1	3
Watts Bar		600	94	17	2.9	3	0.2	1	0.2	1	4.25	5	89.9	1	65.5	1	0	5
Watts Bar		19	96	15	1.4	1	0.1	1	0	1	7	5	99	1	43.6	1	0	5
Watts Bar		600	96	13	2.5	1	0	1	0.6	3	0.24	5	89.2	1	77.3	1	0.2	1
Watts Bar		19	98	15	2.1	1	0	1	0.3	1	16.4	5	97.9	1	34.5	1	0	5

Table 2. Results and Ratings for individual Metrics and Final Benthic Scores. Separated by Reservoir Class and Type of Sample Location.

Run-of-River Reservoirs -- Inflow Sites

Reservoir	Q	Mile	Year	Score	TAXA		LLIVED		EPT		% OLIGO		DOMN		TOTNONCT		ZEROS	
Watts Bar		600	98	15	2.7	1	0.3	1	0.3	1	0	5	83.1	3	43.6	1	0.1	3
Watts Bar		600	2000	13	2	1	0.3	1	0.3	1	0	5	94	1	703.3	3	0.3	1
Watts Bar		19	2000	13	1.4	1	0.2	1	0	1	2.78	5	94.4	1	38.8	1	0.1	3
Wheeler		347	94	31	6.1	5	0.9	5	1	5	0.91	5	68.7	5	308.2	1	0	5
Wheeler		347	95	21	4.5	3	1	5	0.1	1	0.41	5	86	1	407.3	1	0	5
Wheeler		347	97	25	5.2	3	1	5	0.7	3	1.11	5	91.9	1	610.0	3	0	5
Wheeler		347	99	23	4.9	3	1	5	0.2	1	0.54	5	90.2	1	580.0	3	0	5
Wilson		273	94	25	5.5	3	1	5	0.6	3	1.93	5	80.4	3	359.7	1	0	5
Wilson	Q	273	96	29	5.2	3	1	5	0.9	5	0.53	5	85.4	1	1295.0	5	0	5
Wilson		273	96	27	4.2	3	1	5	0.6	3	0.25	5	90.8	1	1730.0	5	0	5
Wilson		273	98	33	6	5	1	5	0.8	5	2.68	5	83.7	3	1176.7	5	0	5
Wilson		273	2000	25	4.7	3	1	5	0.6	3	0.97	5	86.3	1	836.7	3	0	5

Table 2. Results and Ratings for individual Metrics and Final Benthic Scores. Separated by Reservoir Class and Type of Sample Location.

Blue Ridge Ecoregion -- Forebay Sites

Reservoir	Q	Mile	Year	Score	TAXA		% OLIGO		DOMN		TOTNONCT		ZEROS		SumTaxa		XCHI		EPT	
Apalachia		67	96	19	2.4	3	51.7	3	94.3	3	18.3	1	0	5	6	3	51.7	1	0	0
Apalachia		67	97	17	1.6	3	49.1	3	98.9	1	15.0	1	0	5	6	3	8.18	1	0	0
Apalachia		67	98	11	1.2	1	77.8	1	100	1	11.7	1	0.1	3	3	1	1.82	1	0.2	2
Apalachia		67	99	17	1.8	3	42.1	3	96.5	1	21.7	1	0.1	3	8	3	21.7	1	0.1	2
Apalachia		67	2000	35	3.1	5	24.3	5	85.9	5	73.3	3	0	5	11	5	217	5	0.1	2
Blue Ridge	Q	54.1	94	21	2.7	3	38.7	3	90.5	3	105.0	3	0.2	3	8	3	80	1	0.4	2
Blue Ridge		54.1	94	13	1.5	3	40.5	3	94.8	3	15.0	1	0.5	1	2	1	78.3	1	0	0
Blue Ridge		54.1	95	29	3.5	5	47.4	3	84.6	5	161.7	5	0.1	3	13	5	95	1	0.3	2
Blue Ridge		54.1	97	29	4	5	35.1	3	91.2	3	341.7	5	0	5	12	5	62.7	1	0.1	2
Blue Ridge		54.1	99	23	2.4	3	34.5	3	98.1	1	198.3	5	0	5	8	3	31.7	1	0.1	2
Blue Ridge	Q	54.1	99	23	2.4	3	38.8	3	96	1	135.0	5	0.1	3	10	5	16.7	1	0.1	2
Chatuge		1.5	94	17	1.9	3	23.4	5	98.6	1	4.2	1	0.2	3	3	1	81.7	1	0.1	2
Chatuge		1.5	96	17	1.5	3	40.4	3	98.3	1	6.7	1	0	5	4	1	16.7	1	0.3	2
Chatuge		1.5	98	21	2.4	3	2.09	5	98.4	1	11.7	1	0.1	3	3	1	286	5	0.1	2
Chatuge		1.5	99	13	1.3	1	25	5	100	1	8.3	1	0.3	1	4	1	36.7	1	0.2	2
Chatuge		1.5	2000	11	1.3	1	72.7	1	100	1	5.0	1	0.2	3	3	1	6.67	1	0.2	2
Chatuge		122	94	17	1.5	3	45.1	3	100	1	5.0	1	0	5	2	1	22.4	1	0.2	2
Chatuge	Q	122	96	7	0.9	1	64.3	1	100	1	1.7	1	0.3	1	1	1	5	1	0	0
Chatuge		122	96	17	1.6	3	34.1	3	100	1	8.3	1	0	5	3	1	33.3	1	0.2	2
Chatuge		122	98	21	2.2	3	6.49	5	100	1	3.3	1	0.1	3	1	1	251	5	0.1	2
Chatuge		122	99	11	0.9	1	26.7	5	100	1	1.7	1	0.5	1	1	1	21.7	1	0	0
Chatuge		122	2000	15	1.5	3	33.9	3	100	1	5.0	1	0.2	3	2	1	20	1	0.2	2
Chatuge	Q	122	2000	17	2.1	3	46.7	3	96.8	1	16.7	1	0	5	4	1	31.7	1	0.2	2
Fontana		62	95	7	0.6	1	86.7	1	100	1	3.3	1	0.6	1	2	1	0	1	0	0
Fontana		62	96	7	0.2	1	66.7	1	100	1	0.0	1	0.9	1	0	1	1.67	1	0	0
Fontana		62	98	9	0.3	1	33.3	3	100	1	1.7	1	0.7	1	1	1	0.91	1	0	0
Fontana		62	2000	7	1	1	61.9	1	100	1	1.7	1	0.3	1	1	1	11.7	1	0	0
Hiwassee		77	94	7	0.3	1	66.7	1	100	1	0.0	1	0.7	1	0	1	1.67	1	0	0
Hiwassee		77	96	9	1	1	75	1	99.2	1	25.0	1	0.2	3	2	1	3.33	1	0	0
Hiwassee	Q	77	98	9	1	1	50	3	100	1	6.7	1	0.3	1	3	1	3.64	1	0	0
Hiwassee		77	98	13	1.5	3	63.9	1	99	1	10.0	1	0	5	3	1	5.45	1	0	0
Hiwassee		77	2000	15	2.5	3	70.9	1	98.6	1	26.7	1	0	5	5	3	61.7	1	0	0
Nottely		23.5	94	17	1.7	3	41.5	3	100	1	0.0	1	0.1	3	0	1	200	5	0	0
Nottely		23.5	95	15	2.6	3	40.4	3	100	1	0.0	1	0.1	3	0	1	127	3	0	0
Nottely		23.5	97	15	2.2	3	46.4	3	100	1	0.0	1	0	5	0	1	60.9	1	0	0
Nottely		23.5	99	13	1.4	3	45	3	100	1	0.0	1	0.2	3	0	1	16.7	1	0	0
Parksville-Ocoee No. 1	Q	12.5	94	7	0.4	1	100	1	100	1	0.0	1	0.6	1	0	1	0	1	0	0
Parksville-Ocoee No. 1		12.5	94	7	0.8	1	82.5	1	100	1	3.3	1	0.3	1	1	1	1.67	1	0	0
Parksville-Ocoee No. 1	Q	12.5	95	7	1	1	69.1	1	98	1	15.0	1	0.3	1	2	1	3.33	1	0	0
Parksville-Ocoee No. 1		12.5	95	15	1.5	3	63.4	1	96.7	1	18.3	1	0	5	6	3	3.33	1	0	0
Parksville-Ocoee No. 1		12.5	97	17	1.4	3	50.4	3	100	1	23.3	1	0.1	3	5	3	3.64	1	0.1	2
Parksville-Ocoee No. 1		12.5	99	9	0.4	1	50	3	100	1	1.7	1	0.6	1	1	1	1.67	1	0	0
Watauga		37.4	94	7	0.5	1	60	1	100	1	1.8	1	0.5	1	2	1	0	1	0	0
Watauga		37.4	96	7	1.2	1	69.5	1	100	1	6.7	1	0.4	1	1	1	28.3	1	0	0
Watauga		37.4	98	9	1.8	3	84.3	1	100	1	0.0	1	0.3	1	0	1	19.1	1	0	0
Watauga		37.4	2000	9	1.3	1	81.7	1	100	1	0.0	1	0.2	3	0	1	18.3	1	0	0
Watauga	Q	37.4	2000	9	1.4	3	79	1	100	1	0.0	1	0.3	1	0	1	73.3	1	0	0

Table 2. Results and Ratings for individual Metrics and Final Benthic Scores. Separated by Reservoir Class and Type of Sample Location.

Blue Ridge Ecoregion -- Mid-Reservoir Sites

Reservoir	Q	Mile	Year	Score	TAXA		% OLIGO		DOMN		TOTNONCT		ZEROS		SumTaxa		XCHI		EPT	
Fontana		3	94	17	1.9	3	39.1	3	100	1	0.0	1	0.2	3	0	1	398	5	0	0
Fontana		3	96	9	1.2	3	96.2	1	100	1	0.0	1	0.3	1	0	1	11.7	1	0	0
Fontana		3	98	19	3	5	31.1	5	100	1	0.0	1	0.1	3	0	1	307	3	0	0
Fontana		81.5	94	19	2	3	28.2	5	100	1	0.0	1	0.1	3	0	1	402	5	0	0
Fontana		81.5	96	11	1.2	3	96.1	1	100	1	0.0	1	0.1	3	0	1	6.67	1	0	0
Fontana		81.5	98	15	1.9	3	2.25	5	100	1	0.0	1	0.2	3	0	1	169	1	0	0
Hiwassee	Q	85	94	9	1.3	3	93.7	1	100	1	0.0	1	0.4	1	0	1	65	1	0	0
Hiwassee		85	94	9	1	1	63	3	100	1	0.0	1	0.5	1	0	1	13.3	1	0	0
Hiwassee		85	96	11	1.5	3	90	1	99.6	1	3.3	3	0.4	1	1	1	40	1	0	0
Hiwassee		85	98	15	1.7	3	45.5	3	97.2	5	1.7	1	0.4	1	1	1	97.3	1	0	0
Hiwassee	Q	85	2000	15	2.6	5	62.5	3	100	1	0.0	1	0.1	3	0	1	155	1	0	0
Hiwassee		85	2000	15	2.7	5	65.8	1	99.9	1	1.7	1	0.2	3	1	1	208	3	0	0
Nottely	Q	31	94	29	2.2	3	2.9	5	99.3	1	9.1	5	0	5	5	5	237	3	0.4	2
Nottely		31	94	29	2.6	5	8.23	5	99	1	5.5	3	0	5	6	5	253	3	0.2	2
Nottely	Q	31	95	23	1.3	3	24.4	5	95.8	5	1.7	1	0.2	3	1	1	187	3	0.1	2
Nottely		31	95	15	1.2	3	37.4	3	100	1	1.7	1	0.1	3	1	1	243	3	0	0
Nottely	Q	31	97	31	3.4	5	16.9	5	96.1	5	3.3	3	0	5	2	3	203	3	0.1	2
Nottely		31	97	21	2.9	5	15.5	5	99.2	1	1.7	1	0	5	1	1	200	3	0	0
Nottley		31	99	25	2.5	5	0.48	5	100	1	1.7	1	0	5	1	1	553	5	0.1	2
Watauga	Q	45.5	94	19	1.3	3	7.25	5	100	1	1.7	1	0.1	3	1	1	387	5	0	0
Watauga		45.5	94	21	1.6	3	16.8	5	98.7	1	151.7	5	0.1	3	3	3	152	1	0	0
Watauga	Q	45.5	96	19	2.1	3	23.7	5	100	1	5.0	3	0.2	3	1	1	308	3	0	[illegible]
Watauga		45.5	96	13	1.8	3	32.4	3	100	1	0.0	1	0.3	1	0	1	292	3	0	[illegible]
Watauga		45.5	98	11	1.9	3	33.4	3	100	1	0.0	1	0.3	1	0	1	46.4	1	0	0
Watauga		45.5	2000	21	1.3	3	14	5	100	1	6.7	5	0.2	3	1	1	153	1	0.1	2

Table 2. Results and Ratings for individual Metrics and Final Benthic Scores. Separated by Reservoir Class and Type of Sample Location.

Interior Plateau Tributary Reservoirs -- Forebay Sites

Reservoir	Q	Mile	Year	Score	TAXA		% OLIGO		DOMN		TOTNONCT		ZEROS		SumTaxa		XCHI		EPT	
Bear Creek		75	94	21	1.8	3	4.11	5	100	1	3.3	1	0	5	2	3	100	1	0.1	2
Bear Creek		75	95	19	1.8	3	14.6	5	100	1	0.0	1	0	5	0	1	213	3	0	0
Bear Creek		75	96	17	1.6	3	7.33	5	100	1	0.0	1	0	5	0	1	180	1	0	0
Bear Creek		75	97	11	1.3	1	47.9	3	100	1	0.0	1	0.2	3	0	1	6.36	1	0	0
Bear Creek		75	99	21	1.8	3	6.88	5	100	1	0.0	1	0	5	0	1	613	5	0	0
Bear Creek	Q	75	99	21	1.6	3	2.69	5	100	1	0.0	1	0	5	0	1	562	5	0	0
Beech		36	94	35	4.3	5	11.9	5	96.5	3	23.3	5	0	5	11	5	802	5	0.3	2
Beech		36	95	27	3.1	5	11	5	98.7	1	6.7	1	0	5	3	3	535	5	0.1	2
Beech	Q	36	96	29	3.1	5	4.21	5	98.2	1	23.3	5	0.1	3	6	5	237	3	0.2	2
Beech		36	96	35	3.7	5	4.75	5	93	5	38.3	5	0	5	11	5	240	3	0.4	2
Beech		36	98	33	3.6	5	5.13	5	97.2	3	23.3	5	0	5	8	5	320	3	0.1	2
Beech		36	2000	25	2.9	5	15	5	97.4	3	5.0	1	0	5	3	3	230	3	0	0
Cedar Creek		25.2	94	27	2.4	3	25.7	5	96.5	3	31.7	5	0.1	3	5	5	68.3	1	0.3	2
Cedar Creek		25.2	95	11	1.2	1	5.71	5	100	1	0.0	1	0.3	1	0	1	71.7	1	0	0
Cedar Creek		25.2	96	17	1.6	3	31.8	3	100	1	3.3	1	0.1	3	2	3	66.7	1	0.1	2
Cedar Creek		25.2	97	15	1.5	3	13.9	5	100	1	0.0	1	0.1	3	0	1	49.1	1	0	0
Cedar Creek		25.2	99	29	2	3	4.75	5	97.5	3	15.0	3	0	5	5	5	213	3	0.1	2
Little Bear Cr	Q	12.5	94	21	1.9	3	76.7	1	99.7	1	30.0	5	0	5	2	3	123	1	0.1	2
Little Bear Cr		12.5	94	15	2.2	3	65.7	1	99.3	1	10.0	1	0	5	1	1	48.3	1	0.2	2
Little Bear Cr		12.5	95	15	3.9	5	72.1	1	100	1	1.7	1	0.1	3	1	1	41.7	1	0.1	2
Little Bear Cr		12.5	96	17	1.4	3	83.6	1	96.9	3	15.0	3	0.1	3	3	3	15	1	0	0
Little Bear Cr	Q	12.5	97	15	1.7	3	90.1	1	99.4	1	1.7	1	0	5	1	1	15.5	1	0.1	2
Little Bear Cr		12.5	97	9	1.3	1	86.9	1	100	1	0.0	1	0.1	3	0	1	13.6	1	0	0
Little Bear Cr		12.5	99	19	2	3	78.6	1	97.3	3	11.7	3	0	5	2	3	63.3	1	0	0
Normandy		250	94	15	1.4	3	47.1	3	100	1	0.0	1	0	5	0	1	26.7	1	0	0
Normandy	Q	250	95	7	0.7	1	81.7	1	100	1	0.0	1	0.4	1	0	1	5	1	0	0
Normandy		250	95	7	0.9	1	73.4	1	100	1	0.0	1	0.3	1	0	1	13.3	1	0	0
Normandy		250	96	13	1.7	3	66.3	1	99.3	1	1.7	1	0	5	1	1	30	1	0	0
Normandy		250	98	19	2.5	3	19	5	100	1	0.0	1	0.1	3	0	1	419	5	0	0
Normandy		250	2000	17	2	3	20.8	5	100	1	1.7	1	0.1	3	1	1	260	3	0	0
Upper Bear Creek		115	98	23	2.5	3	45.2	3	100	1	36.7	5	0	5	2	3	323	3	0	0

Table 2. Results and Ratings for individual Metrics and Final Benthic Scores. Separated by Reservoir Class and Type of Sample Location.

Ridge and Valley Ecoregion Tributary Reservoirs -- Forebay Sites

Reservoir	Q	Mile	Year	Score	TAXA		% OLIGO		DOMN		TOTNONCT		ZEROS		SumTaxa		XCHI		EPT	
Boone		19	94	17	2.4	5	86.4	1	98.6	3	1.7	1	0	5	1	1	43	1	0	0
Boone		19	95	11	1.1	3	99.6	1	100	1	1.7	1	0.1	3	1	1	1.67	1	0	0
Boone	Q	19	97	11	1.5	3	78	1	100	1	1.7	1	0.1	3	1	1	17.3	1	0	0
Boone		19	97	13	1.4	3	90	1	100	1	3.3	1	0.2	3	2	3	8.18	1	0	0
Boone		19	99	15	2.1	5	68.4	1	98.4	3	1.7	1	0.1	3	1	1	23.3	1	0	0
Cherokee		53	94	25	2.4	5	43.7	3	99.6	1	3.3	1	0	5	2	3	200	5	0.1	2
Cherokee		53	95	19	2.2	5	51.5	3	100	1	0.0	1	0.1	3	0	1	290	5	0	0
Cherokee		53	96	17	1.9	5	55.6	3	100	1	0.0	1	0.1	3	0	1	103	3	0	0
Cherokee	Q	53	98	21	2.1	5	14.6	5	100	1	0.0	1	0.2	3	0	1	235	5	0	0
Cherokee		53	98	21	2.5	5	25.3	5	100	1	0.0	1	0.2	3	0	1	297	5	0	0
Cherokee		55	2000	21	2.2	5	17.5	5	100	1	0.0	1	0.2	3	0	1	320	5	0	0
Douglas		33	94	17	2.2	5	56.6	3	100	1	0.0	1	0.1	3	0	1	125	3	0	0
Douglas		33	95	11	1.5	3	81.5	1	100	1	0.0	1	0.2	3	0	1	48.3	1	0	0
Douglas		33	97	21	2.5	5	47.2	3	100	1	0.0	1	0	5	0	1	206	5	0	0
Douglas		33	99	19	2	5	20.3	5	100	1	0.0	1	0.3	1	0	1	268	5	0	0
Douglas	Q	33	99	19	1.8	5	20.4	5	100	1	0.0	1	0.3	1	0	1	247	5	0	0
Ft Pat Henry		8.7	94	19	2.3	5	54.8	3	99.6	1	1.7	1	0	5	1	1	133	3	0	0
Ft Pat Henry		8.7	95	15	1.9	5	72.6	1	100	1	0.0	1	0	5	0	1	33.3	1	0	0
Ft Pat Henry		8.7	96	17	1.8	5	61	3	100	1	3.3	1	0	5	1	1	35	1	0	0
Ft Pat Henry		8.7	97	15	2.5	5	55.2	3	100	1	0.0	1	0.1	3	0	1	51.8	1	0	0
Ft. Pat Henry		8.7	99	19	2.6	5	31.7	5	100	1	0.0	1	0.1	3	0	1	120	3	0	0
Norris		80	99	13	1.1	3	66.7	1	100	1	5.0	1	0.1	3	2	3	5	1	0	[illegible]
Norris		80.4	94	19	1.3	3	77.4	1	99	1	40.9	3	0	5	3	5	2.73	1	0	[illegible]
Norris	Q	80.4	95	21	1.1	3	78.9	1	100	1	101.7	5	0	5	3	5	0	1	0	0
Norris		80.4	95	21	1.2	3	73	1	100	1	65.0	3	0	5	4	5	0	1	0.1	2
Norris		80.4	97	25	2.2	5	68.7	1	97.7	5	8.3	1	0	5	3	5	21.8	1	0.1	2
South Holston		51	94	19	1.3	3	73.5	1	96.6	5	4.5	1	0.3	1	3	5	10.9	1	0.1	2
South Holston	Q	51	96	7	0.7	1	85.7	1	100	1	0.0	1	0.3	1	0	1	3.33	1	0	0
South Holston		51	96	9	0.5	1	73.7	1	100	1	3.3	1	0.6	1	2	3	0	1	0	0
South Holston		51	98	7	0.4	1	75	1	100	1	0.0	1	0.6	1	0	1	0.91	1	0	0
South Holston		51	2000	11	0.9	3	45.9	3	100	1	0.0	1	0.4	1	0	1	21.7	1	0	0
Tims Ford		135	94	7	0.8	1	92.5	1	100	1	0.0	1	0.4	1	0	1	3.33	1	0	0
Tims Ford		135	95	11	0.9	3	81.3	1	100	1	0.0	1	0.2	3	0	1	3.33	1	0	0
Tims Ford		135	96	11	0.9	3	80	1	100	1	0.0	1	0.2	3	0	1	6.67	1	0	0
Tims Ford	Q	135	98	7	0.8	1	90.5	1	100	1	0.0	1	0.3	1	0	1	3.64	1	0	0
Tims Ford		135	98	9	0.8	1	100	1	100	1	0.0	1	0.2	3	0	1	0	1	0	0
Tims Ford		135	2000	7	0.6	1	83.3	1	100	1	1.7	1	0.4	1	1	1	0	1	0	0
Tims Ford	Q	135	2000	11	0.8	1	75	1	100	1	3.3	1	0.2	3	2	3	0	1	0	0

Table 2. Results and Ratings for individual Metrics and Final Benthic Scores. Separated by Reservoir Class and Type of Sample Location.

Ridge and Valley Ecoregion Tributary Reservoirs -- Mid-Reservoir Sites

Reservoir	Q	Mile	Year	Score	TAXA		% OLIGO		DOMN		TOTNONCT		ZEROS		SumTaxa		XCHI		EPT	
Boone		6.5	94	13	2	3	76.7	1	100.0	1	0.0	1	0	5	0	1	32.1	1	0	0
Boone		6.5	95	9	1.3	1	83.9	1	100.0	1	1.7	1	0.1	3	1	1	8.33	1	0	0
Boone		6.5	97	13	2.4	3	74.5	1	98.8	1	1.7	1	0	5	1	1	43.6	1	0	0
Boone		6.5	99	9	1.5	1	65.4	1	100.0	1	0.0	1	0.1	3	0	1	20	1	0	0
Boone		27	94	15	2.2	3	47.6	3	99.7	1	0.9	1	0	5	1	1	124	1	0	0
Boone		27	95	11	1.7	3	60.5	1	100.0	1	0.0	1	0.1	3	0	1	70	1	0	0
Boone		27	97	9	2.1	3	57.1	1	99.5	1	1.7	1	0.3	1	1	1	108	1	0	0
Boone		27	99	15	2.4	3	41.9	3	99.1	1	6.7	1	0.2	3	3	3	48.3	1	0	0
Cherokee		76	96	15	2.3	3	13.6	5	100.0	1	0.0	1	0.1	3	0	1	198	1	0	0
Cherokee		76	98	19	3.6	5	4.12	5	100.0	1	0.0	1	0	5	0	1	273	1	0	0
Cherokee		76	2000	21	2.4	3	7.11	5	100.0	1	0.0	1	0	5	0	1	708	5	0	0
Douglas		51	94	17	2.1	3	27.9	5	100.0	1	0.0	1	0	5	0	1	150	1	0	0
Douglas		51	95	15	1.9	3	36.1	3	100.0	1	0.0	1	0	5	0	1	118	1	0	0
Douglas	Q	51	97	19	3.6	5	14.8	5	100.0	1	0.0	1	0	5	0	1	301	1	0	0
Douglas		51	97	17	3.1	3	9.27	5	99.7	1	3.3	1	0	5	1	1	275	1	0	0
Douglas		51	99	21	2.8	3	2.56	5	100.0	1	0.0	1	0	5	0	1	675	5	0	0
Norris		30	94	31	3.9	5	40.3	3	95.7	3	28.3	5	0	5	7	5	365	3	0.1	2
Norris		30	95	23	1.9	3	39.7	3	90.8	5	23.3	5	0.2	3	6	3	40	1	0	0
Norris		30	97	27	4.2	5	25.7	5	97.1	1	25.0	5	0	5	9	5	274	1	0	0
Norris		30	99	33	4.2	5	7.55	5	96.9	3	30.0	5	0	5	7	5	963	5	0	0
Norris	Q	30	99	33	4	5	8.71	5	98.6	1	30.0	5	0	5	8	5	895	5	0.1	2
Norris		125	94	25	3.1	3	22.9	5	98.8	1	11.7	3	0	5	4	3	373	3	0.2	2
Norris		125	95	19	2.8	3	30.9	3	96.5	3	13.3	3	0.1	3	3	3	143	1	0	0
Norris		125	97	23	3.6	5	21.8	5	97.0	1	18.3	3	0.1	3	6	3	375	3	0	0
Norris		125	99	23	4.6	5	4.66	5	99.4	1	8.3	1	0.1	3	4	3	725	5	0	0
South Holston		62.5	94	15	2.7	3	30.9	3	99.3	1	1.8	1	0	5	1	1	70.5	1	0	0
South Holston		62.5	96	7	0.8	1	66.7	1	100.0	1	0.0	1	0.3	1	0	1	6.67	1	0	0
South Holston	Q	62.5	98	11	2	3	30.2	3	100.0	1	0.0	1	0.3	1	0	1	130	1	0	0
South Holston		62.5	98	13	3.1	3	30.3	3	100.0	1	0.0	1	0.2	3	0	1	151	1	0	0
South Holston		62.5	2000	7	0.9	1	68.5	1	100.0	1	0.0	1	0.4	1	0	1	10	1	0	0
Tims Ford		150	94	11	0.7	1	25	5	100.0	1	0.0	1	0.4	1	0	1	16.7	1	0	0
Tims Ford		150	95	7	0.6	1	66.7	1	100.0	1	0.0	1	0.4	1	0	1	8.33	1	0	0
Tims Ford		150	96	7	0.9	1	76.1	1	100.0	1	0.0	1	0.4	1	0	1	10	1	0	0
Tims Ford		150	98	9	1.1	1	57.4	1	100.0	1	0.0	1	0.1	3	0	1	10.9	1	0	0
Tims Ford		150	2000	9	0.6	1	50.7	3	100.0	1	0.0	1	0.6	1	0	1	58.3	1	0	0

Table 3. Results and Ratings for Individual Metrics and Final Benthic Scores for QA/QC Samples Processed in the Laboratory

Tributary Reservoirs																						
CLASS	AREA	RESERVOIR	Mile	QA	YEAR	LAB SCORE	TAXA		SumTaxa		EPT		%OLIGO		DOMN		TOTNONC/O		ZEROS		XCHI	
RV	Forebay	Tims Ford	135		2000	7	0.9	1	3	1	0	0	75	1	100	1	5	1	0.2	1	0.0	1
BR	Forebay	Chatuge	122		2000	27	3.6	5	9	3	0.2	2	13.9	5	96.7	1	18.3	1	0	5	281.7	5
BR	Forebay	Watauga	37.4		2000	11	1.8	3	3	1	0	0	62.1	1	96	3	8.3	1	0.1	1	23.3	1
BR	Mid-res	Hiwassee	85		2000	19	3.4	3	7	3	0	0	67.3	1	96.6	1	25	3	0	5	255.0	3

Run-of-River Reservoirs																				
CLASS	AREA	RESERVOIR	Mile	QA	YEAR	LAB SCORE	TAXA		LLIVED		EPT		%OLIGO		DOMN		TOTNONC/O		ZEROS	
Main	Forebay	Pickwick	207.3		2000	27	4.1	3	0.9	5	0.6	3	15.3	5	85.2	3	190	3	0	5
Main	Transition	Wheeler	291.7		2000	25	6	3	1	5	1.1	3	2.4	5	78.3	3	228.3	1	0	5
Main	Transition	Wheeler	295.9		2000	27	6.6	3	1	5	0.9	3	6.8	5	76.2	5	235	1	0	5
Main	Inflow	Guntersville	420		2000	31	9.9	5	0.9	5	1.4	3	6.5	5	73.4	3	1046.7	5	0	5
Main	Forebay	Chickamauga	472.3		2000	25	5.6	5	0.8	3	0.3	1	17.1	5	82.4	3	163.3	3	0	5
Main	Forebay	Chickamauga	482		2000	23	5.9	5	0.8	3	0.3	1	39.9	3	89.1	3	236.7	3	0	5
Main	Transition	Chickamauga	490.5		2000	19	5.1	3	1	5	0.5	1	14.2	3	90.6	1	215	1	0	5
Main	Inflow	Chickamauga	518		2000	21	6.1	3	0.5	1	0.3	1	3.4	5	74.5	3	491.7	3	0	5
Main	Transition	Watts Bar	560.8		2000	19	4.7	3	0.6	3	0.5	1	5.4	5	91.8	1	123.3	1	0	5

Table 4. Benthic Community Scores for 1994 through 2000 Based on Field Processed Samples Collected in Late Autumn/Early Winter and Scored Against 1999 Criteria

Run-of-the-River Reservoirs

Reservoir		Mile	1994 *	1995 *	1996 *	1997 *	1998 *	1999 *	2000 *
Chickamauga	Forebay	472.3	31	27	.	29	.	25	27**
Chickamauga	Transition	490.5	33	29	.	31	.	31	23**
Chickamauga	Inflow	518	19	31	.	25	.	21	23**
Chickamauga	Embayment	8.5	17	27	.	25	.	21	.
Fort Loudoun	Forebay	605.5	13	13	11	15	13	9	9
Fort Loudoun	Transition	624.6	17	23	23	27	23	19	23
Fort Loudoun	Inflow	652	7	11	7	9	13	7	11
Guntersville	Forebay	350	27	.	35	.	35	.	23
Guntersville	Transition	375.2	33	.	33	.	33	.	31
Guntersville	Inflow	420	21	.	27	.	23	.	25
Kentucky	Forebay	23	27	23	.	27	.	21	.
Kentucky	Transition	85	29	29	.	35	.	31	.
Kentucky	Inflow	200	27	21	.	27	.	21	.
Kentucky	Embayment	7.4	19	19	.	23	.	21	.
Melton Hill	Forebay	24	17	.	11	.	17	.	13
Melton Hill	Transition	45	15	.	17	.	17	.	15
Melton Hill	Inflow	58.8	11	.	7	.	7	.	13
Nickajack	Forebay	425.5	31	29	.	33	.	35	.
Nickajack	Inflow	469	31	31	.	33	.	29	.
Pickwick	Forebay	207.3	29	.	29	.	29	.	27
Pickwick	Transition	230	31	.	33	.	31	.	21
Pickwick	Inflow	253.2	25	.	21	.	23	.	25
Pickwick	Embayment	8.4	17	.	15	.	17	.	15
Tellico	Forebay	1	7	7	.	9	.	7	.
Tellico	Transition	15	11	15	.	7	.	9	.
Watts Bar	Forebay	531	13	.	11	.	13	.	15
Watts Bar	Transition	560.8	29	.	25	.	23	.	21
Watts Bar	Inflow	19	13	.	15	.	15	.	13
Watts Bar	Inflow	600	17	.	13	.	15	.	13
Wheeler	Forebay	277	19	15	.	23	.	17	.
Wheeler	Transition	295.9	33	25	.	31	.	31	31**
Wheeler	Inflow	347	31	21	.	25	.	23	.
Wheeler	Embayment	6	15	13	.	15	.	15	.
Wilson	Forebay	260.8	17	.	15	.	15	.	15
Wilson	Inflow	273	25	.	27	.	33	.	25

*Note: Results for all years are scored on 1999 scoring protocols. Scores for 1991 - 1993 are excluded from this table because they are based on lab processed results.

** VS sites sampled as part of other studies.

Evaluation Criteria:

Benthic Community Score	7-12	13-18	19-23	24-29	30-35
Community Condition	Very Poor	Poor	Fair	Good	Excellent

Table 4. Cont.'

Blue Ridge Ecoregion

Reservoir		Mile	1994*	1995*	1996*	1997*	1998*	1999*	2000*
Apalachia	Forebay	67	.	.	19	17	11	17	35
Blue Ridge	Forebay	54.1	13	29	.	29	.	23	.
Chatuge	Forebay	122	17	.	17	.	21	11	15
Chatuge	Forebay	1.5	17	.	17	.	21	13	11
Fontana	Forebay	62	7	.	9	.	13	.	7
Fontana	Mid-reservoir	81.5	19	.	11	.	15	.	X
Fontana	Mid-reservoir	3	17	.	9	.	19	.	X
Hiwassee	Forebay	77	7	.	9	.	13	.	15
Hiwassee	Mid-reservoir	85	9	.	11	.	15	.	15
Nottely	Forebay	23.5	17	15	.	15	.	13	.
Nottely	Mid-reservoir	31	29	15	.	21	.	25	.
Parksville	Forebay	12.5	7	15	.	17	.	9	.
Watauga	Forebay	37.4	7	.	7	.	9	.	9
Watauga	Mid-reservoir	45.5	21	.	13	.	11	.	21

Interior Plateau Ecoregion

Reservoir		Mile	1994*	1995*	1996*	1997*	1998*	1999*	2000*
Bear Creek	Forebay	75	21	19	17	11	.	21	.
Beech Lake	Forebay	36	35	27	35	.	33	.	25
Cedar Creek	Forebay	25	27	11	17	15	.	29	.
Little Bear Cr.	Forebay	12.5	15	15	17	9	.	19	.
Normandy	Forebay	249.5	15	7	13	.	19	.	17

Ridge and Valley Ecoregion

Reservoir		Mile	1994*	1995*	1996*	1997*	1998*	1999*	2000*
Boone	Forebay	19	17	11	.	13	.	15	.
Boone	Mid-reservoir	27	15	11	.	9	.	15	.
Boone	Mid-reservoir	6.5	13	9	.	13	.	9	.
Cherokee	Forebay	53	25	19	17	.	21	.	15
Cherokee	Mid-reservoir	76	.	.	15	.	19	.	21
Douglas	Forebay	33	17	11	.	21	.	19	.
Douglas	Mid-reservoir	51	17	15	.	17	.	21	.
Fort Pat. Henry	Forebay	8.7	19	15	17	15	.	19	.
Norris	Forebay	80.4	19	21	.	25	.	13	.
Norris	Mid-reservoir	125	25	19	.	23	.	23	.
Norris	Mid-reservoir	30	31	23	.	27	.	33	.
South Holston	Forebay	51	19	.	9	.	7	.	11
South Holston	Mid-reservoir	62.5	15	.	7	.	13	.	7
Tims Ford	Forebay	135	7	11	11	.	9	.	7
Tims Ford	Mid-reservoir	150	11	7	7	.	9	.	9

*Note: Results for all years are scored on 1999 scoring protocols. Scores for 1991 - 1993 are excluded from this table because they are based on lab processed results.

Evaluation Criteria:

Benthic Community Score	7-12	13-18	19-23	24-29	30-35
Community Condition	Very Poor	Poor	Fair	Good	Excellent

Section 6. Fish Community

Philosophical Approach/Background

Many of the same considerations discussed for the benthic macroinvertebrate community (Section 5) also apply for the fish community. These are repeated here, as appropriate, in case the reader does not have access to that information.

Fish are usually included in aquatic monitoring programs because they are important to the aquatic foodweb and because they have a long life cycle which allows them to integrate conditions over time. In streams, fish community monitoring often has found environmental degradation when physical and chemical monitoring have failed to do so. Fish are also important to the public for aesthetic, recreational, and commercial reasons.

Reservoir fish communities are vastly different from that in the river prior to impoundment due to significant habitat alterations. Also, differences are expected along a longitudinal gradient with a more riverine community expected at the upper end or inflow of a reservoir and a more lacustrine community expected in the pool near the dam. Other factors to consider in evaluating biotic communities in reservoirs include reservoir operational characteristics (e.g., water depth, water level fluctuation, depth of drawdown for flood control, retention time, stratification, bottom anoxia, substrate type and stability, and depth of withdrawal for discharge) and physical/chemical features owing to geological characteristics of different ecoregions.

All these factors, plus the fact that a reservoir is a man-made system, must be considered in selecting community characteristics or expectations that will be used to evaluate aquatic resource conditions. Given that reservoirs are artificial systems, it is not possible to use the well accepted Index of Biotic Integrity (IBI) approach of using reference sites to determine characteristics or expectations of a reservoir unaffected by human impacts. By definition, IBI specifies reference conditions should be developed from natural, unaltered habitats (Karr and Dudley, 1981 after Frey 1975). Therefore, other approaches must be used; such as, using historical or preimpoundment conditions, predictive models, best observed conditions, or professional judgment. As stated above, preimpoundment conditions are inappropriate due to significant habitat alterations. Like benthic macroinvertebrates, the state of the understanding of fish communities in reservoirs simply is insufficient for models to effectively predict species composition and relative abundance. This leaves the latter two as the most viable alternatives for establishing appropriate reference conditions or expectations for reservoirs. TVA's experience has found use of best observed conditions adjusted using professional judgment as the best approach. Use of best observed conditions requires an extensive database to determine expectations for each metric, and use of professional judgment to adjust scoring ranges requires substantial experience with the group of reservoirs under consideration. To use this concept, results in the data base which approach desired conditions for a given community characteristic are considered representative of best observed conditions. Monitoring results falling within that range would be considered "good". Details of this approach to developing reference conditions are provided later in this document.

Another important consideration in developing reference conditions is that care must be taken to compare only those reservoirs for which comparison is appropriate. That is, only those in the same ecoregion and comparable physical characteristics should be compared. Hence, separation of reservoirs into appropriate classes is a critical step.

TVA's monitoring program includes 31 reservoirs. For classification purposes these have been divided into two major groups : run-of-the-river reservoirs (those with short retention times and winter drawdown of only a few feet) and tributary reservoirs (those with long retention times and substantial winter drawdown). The tributary reservoirs have been further divided into three groups by ecoregion and reservoir physical characteristics. Fish assemblage expectations for each metric (discussed later) have been developed for each of these four reservoir categories.

	Tributary Reservoirs		
Run-of-River Reservoirs	Blue Ridge Ecoregion	Ridge & Valley Ecoregion	Interior Plateau Ecoregion
Kentucky	Apalachia	Cherokee	Tims Ford
Pickwick	Hiwassee	Ft. Patrick Henry	Normandy
Wilson	Chatuge	Boone	Bear Creek
Wheeler	Nottely	South Holston	Little Bear Creek
Guntersville	Parksville	Douglas	Cedar Creek
Nickajack	Blue Ridge	Norris	Beech
Chickamauga	Fontana		
Watts Bar	Watauga		
Fort Loudoun			
Tellico			
Melton Hill			

Sample Collection Methods

Shoreline electrofishing samples were collected during daylight hours from forebay and transition (mid-reservoir) zones of most reservoirs during autumn (September through November 2000). In addition, inflow areas (generally the tailwater area of the upstream data) were sampled on most run-of-the river reservoirs. Only the forebay was sampled on very small reservoirs or reservoirs where zones were indistinguishable. Location of collection sites in 2000 are identified in Section 1, Table 2.

A total of 15 electrofishing runs, each covering 300m of shoreline, was collected from each of the sampled zones. All habitats were sampled in proportion to their occurrence in the zone. Twelve experimental gill nets with five 6.1m panels (mesh sizes of 2.5, 5.1, 7.6, 10.2, and 12.7 cm) were set for one overnight period in forebay and transition zones. Excessive current prevented use of gill nets in mainstream inflow areas limiting sampling to only electrofishing in these locations. Nets were set in all habitat types, alternating mesh sizes toward the shoreline between sets.

Total length (mm) and weight (g) were obtained for sport species and channel catfish. Remaining species captured were enumerated prior to release. During electrofishing, fish observed but not captured were included if positive identification could be made and counts were estimated when high densities of identifiable fish were encountered. Young-of-year fish were counted separately and, as in stream IBI calculations (Karr 1981), were excluded from proportional and abundance metrics due to sampling inefficiencies. Only fish examined closely as a result of obtaining length and weight measurements were inspected externally for signs of disease, parasites, and anomalies. Other species groups often included several individuals which were observed, but not captured, thus the ratio of diseased, etc. was not obtainable for these groups. Natural hybrids (i.e., those known not to be part of a fisheries management program) were included as an anomaly. Field data loggers or data sheets were used to record all results.

It is important for a monitoring program to demonstrate that the data it produces are reproducible. This is particularly true in this case because it is necessary to use two field crews so all the required sampling can be completed within the desired time frame to minimize seasonal effects—generally the reservoirs to be monitored in a particular year are split equally between the two crews. To evaluate the reproducibility of the RFAI results, 15 - 20 percent of the sites to be monitored in a particular year are selected to be resampled as part of the Quality Control program. An attempt is made to select sites representative of all reservoir classes and reservoir reaches. Selected sites are revisited by a second field crew several days or weeks after the initial sampling to collect a second set of samples. A RFAI score is then developed separately for each of the two sample sets. In 2000, 7 of the 37 sites monitored were selected for resampling as part of the Quality Control program.

Reservoir Fish Assemblage Index (RFAI)

The RFAI uses 12 fish community metrics from five general categories (Hickman and McDonough, 1995). The 12 metrics include:

Species Richness and Composition

1. **Total number of species**--Greater numbers of species are considered representative of healthier aquatic ecosystems. As conditions degrade, numbers of species at a site decline.
2. **Number of piscivore species**--Higher diversity of piscivores is indicative of better quality environment.
3. **Number of sunfish species**--Lepomid sunfish (excludes black basses, crappies, and rock bass) are basically insectivores, and high diversity of this group is indicative of reduced siltation and suitable sediment quality in littoral areas.
4. **Number of sucker species**--Suckers are also insectivores but inhabit the pelagic and more riverine sections of reservoirs.
5. **Number of intolerant species**--This group is made up of species that are particularly intolerant of habitat degradation. Higher densities of intolerant individuals represent better environmental quality.
6. **Percentage of tolerant individuals** (excluding Young-of-Year)--This metric signifies poorer quality with increasing proportions of individuals tolerant of degraded conditions.
7. **Percentage dominance by one species**--Ecological quality is considered reduced if one species dominates the resident fish community.

Trophic Composition

8. **Percentage of individuals as omnivores**--Omnivores are less sensitive to environmental stresses due to their ability to vary their diets. As trophic links are disrupted due to degraded conditions, specialist species such as insectivores decline while opportunistic omnivorous species increase in relative abundance.
9. **Percentage of individuals as insectivores**--Due to the special dietary requirements of this group of species and the limitations of their food source in degraded environments, proportion of insectivores increases with environmental quality.

Reproductive Composition

10. **Number of lithophilic spawning species**--Lithophilic broadcast spawners spawn over rocky substrate and do not provide parental care. This guild is expected to be sensitive to siltation. Numbers of lithophilic spawning species increase in reservoirs providing suitable conditions reflective of good environmental quality.

Abundance

11. **Total catch per unit effort** (number of individuals)--This metric is based upon the assumption that high quality fish assemblages support large numbers of individuals.

Fish Health

12. **Percentage individuals with anomalies**--Incidence of diseases, lesions, tumors, external parasites, deformities, blindness, and natural hybridization are noted for all fish measured, with higher incidence indicating poor environmental conditions.

Establishing scoring criteria (i.e., expectations or reference conditions) requires a substantial data base for each class of reservoir and assumes the data base contains reservoirs with conditions ranging from poor to good for each metric. The smaller the number of reservoirs within a class, the less likely these assumptions can be met and the greater the need for sound professional judgment based on extensive knowledge of reservoir communities being studied. One way to help alleviate this problem is to use several years of results from reservoirs within a class. This not only helps establish baseline conditions for each reservoir, but also has the desirable effect of increasing the data base from which scoring criteria can be developed. However, care must be taken to keep this time period as short as possible; otherwise, constantly changing criteria will prevent recognition of improvements or degradation, if they occur. This potential problem was realized as this monitoring program was being conceived. As a result, it was decided that the maximum desired period to establish baseline conditions and provide the data base to develop scoring criteria would be five years, assuming variations of low, normal, and high flows were experienced in that time frame. This proved to be the case. In practice, scoring criteria for RAFI metrics were reevaluated each year from 1990 through 1994 as new data were added. Scoring criteria have not been adjusted since 1994.

In developing scoring criteria, a slightly different approach was used for species richness metrics than for abundance and proportional metrics. For species richness metrics, a list was made of all species collected from comparable locations within a reservoir class from 1990 - 1994. This species list was adjusted using inferences of experienced biologists knowledgeable of the reservoir system, resident fish species, susceptibility of each species to collection methods being used, and effects of human-induced impacts on these species. This effort resulted in a list of the maximum number of species expected to occur at a sampling location and be captured by collection devices in use. Given that only one collection effort is exerted each year, this maximum number of species would not be expected to be represented in that one collection. Therefore, the range from zero to 95% of the maximum was trisected to provide the three scoring ranges (good, fair, and poor). Although even 95% of the maximum number of species at a site would not be expected to be collected in one sampling event, this "high" expectation was adopted to keep these metrics conservative in light of potential uncertainties introduced by relying heavily on professional judgment.

Scoring criteria for proportional metrics and the abundance metric were determined by trisecting observed ranges after omitting outliers. Next, cutoff points between the three ranges were adjusted based on examination of frequency distributions of observed data for each metric along with professional judgment. In some cases, the narrow range of observed conditions required further adjustment based on knowledge of metric responses to human-induced impacts observed in other reservoir classes. Scoring criteria for the fish health metric are those described by Karr et.al. (1986). Scoring criteria are detailed in Table 1.

Scoring criteria are used to separate results for each metric into three categories assumed to represent relative degrees of condition of the fish assemblage ranging from good to poor. Each category has a corresponding value: good = 5; fair = 3; and poor = 1. The sum of the 12 metrics constitutes the RFAI score.

Scoring criteria were applied differently to results from the two collections methods (electrofishing and experimental gill netting) depending on the type metric. For the taxa richness, reproductive composition, and fish health metrics, sampling results were pooled prior to scoring. For abundance and proportional metrics, electrofishing and gill netting results were scored separately, then the two scores averaged to arrive at a final metric value.

To arrive at an evaluation of the condition of the fish assemblage at a sample location, scores were evaluated as follows:

RFAI Score	12-21	22-31	32-40	41-50	51-60
Community Condition	Very Poor	Poor	Fair	Good	Excellent

The contribution of the fish community results for each sample site to the overall reservoir Ecological Health Index was as follows:

RFAI Score	12-21	22-31	32-40	41-50	51-60
Contribution to Reservoir Ecological Health Index	1	2	3	4	5

Fish assemblage results along with results from the other four indicators and overall the ecological health score for each reservoir are used to keep the public informed on the conditions of Tennessee Valley reservoirs. In publications intended for the public, results for each of the five environmental indicators at each sample site are presented using one of three colors -- green (good), yellow (fair), or red (poor). This necessitated dividing the RFAI scores into three ranges as follows:

RFAI Score	12-28	29-44	45-60
Color	Poor (Red)	Fair (Yellow)	Good (Green)

Results from 2000 Monitoring

RFAI scores for 1990 through 2000 are summarized by reservoir class and type of location in Table 2. (Note: 10 electrofishing runs were used from 1990 to 1992 and 15 were used from 1993 to 2000.) Appendix D summarizes results and ratings for individual metrics and final

RFAI scores for each sample location based on 2000 data. Appendix E provides mean catch per effort by species for electrofishing and gill netting efforts at each location in 2000.

An important step in evaluating results is to determine the reproducibility of the RFAI scores. The RFAI scores from the original and repeat sampling form the basis of this comparison as described above. The first step in evaluating the QC results is to determine the magnitude of difference between the two scores which is acceptable. We have chosen 10 (out of a maximum RFAI score of 60) as the desired maximum difference between the two sample sets. A difference greater than this could cause the RAFI to change two rating categories (e.g., very poor-1 point to fair-3 points or fair-3 points to good-5 points). A shift of two categories in the RFAI could cause a change of 2 points contributed to the overall Reservoir Ecological Health Score. For reservoirs with only one sample location, a 2 point change translates into a change of 8.8 percent change in the Ecological Health Score, which is deemed unacceptable.

Comparison of Scores from Initial and Repeat Sampling in 2000:

	Initial Score	QC Score	Difference
Run of the River Reservoirs			
Pickwick Forebay	32 (Fair)	40 (Fair)	8
Watts Bar Transition	48 (Good)	38 (Fair)	10
Guntersville Inflow	30 (Poor)	48 (Good)	18
Tributary Reservoirs			
Blue Ridge Ecoregion			
Chatuge Forebay	33 (Fair)	28 (Poor)	5
Hiwassee Mid Reservoir	47 (Good)	46 (Good)	1
Ridge and Valley Ecoregion			
Watauga Forebay	26 (Poor)	26 (Poor)	0
Interior Plateau Ecoregion			
Tims Ford Forebay	40 (Fair)	44 (Fair)	4

The maximum observed difference in RAFI scores between the original and repeat collection efforts in 2000 was 18 (1 sample set). Only 1 of the 7 QC sample sets had a difference more than the desired maximum of 10. The mean difference for all reservoirs in 2000 and associated 95 percent confidence limits were 6.6 $\pm$ 5.5 (1.1 - 12.1). Means and 95 percent confidence limits for all years with repeat sample sets are shown below.

Year	Maximum Observed Difference	Mean	95% CL	Lower Limit	Upper Limit
1994	10	2.6	± 1.8	0.8	4.3
1995	6	3.1	± 1.9	1.2	5.0
1996	12	4.4	± 3.5	0.8	8.0
1997	14	4.3	± 5.5	-1.2	9.8
1998	16	5.3	± 4.9	0.4	10.2
1999	12	7.8	± 5.0	2.8	12.8
2000	18	6.6	± 5.5	1.1	12.1

Mean differences were relatively low in 1994 and 1995. There was a slight increase in 1996 and 1997, yet the differences were still acceptable. Results for 1998 marked the first time the upper limit of the 95% CL included 10, the maximum difference deemed acceptable. Mean difference between the original scores and repeat samples were relatively high in 1999 and again in 2000 and the upper 95% CL exceeded 10 in both years. Discussion of the greater differences in 1998 QC results focused on differences in repeat sample sets at run-of-river inflow sites because the maximum difference between replicate sample sets in 1996, 1997, and especially 1998 occurred at those sites each year, whereas, this had not been the case in 1994 and 1995 (Dycus and et. al., 1999). The difference in RFAI scores for the repeat sample set from the inflow site was also high in 1999, but not the highest that year. In 2000 the run-of-river inflow site exhibited a large difference in RFAI scores between the repeat samples. In fact, the difference between repeat samples from the inflow QC site in 2000 was the greatest difference between any sample set found to date as shown below.

1994 Pickwick Inflow	Difference = 2
1995 Chickamauga Inflow	Difference = 4
1996 Wilson Inflow	Difference = 12
1997 Kentucky Inflow	Difference = 14
1998 Pickwick Inflow	Difference = 16
1999 Nickajack Inflow	Difference = 8
2000 Guntersville Inflow	Difference = 18

It is understandable that the greatest variation between sets of replicates occurs at inflow sites because this is such a dynamic part of the reservoir. Hydrologic condition can vary greatly in both the short and long term. Variations in flow patterns as well as seasonal factors affect fish movement. It is possible that more comparable conditions existed between sample sets in 1994, 1995, and 1998 than occurred the other years, thereby allowing more similar sampling results and hence similar RFAI scores. The chart below shows yearly differences in RFAI scores between repeat sample sets if results for repeat sample sets at inflows sites were excluded.

Year	Maximum Observed Difference	Mean	95% CL	Lower Limit	Upper Limit
1994	10	2.6	± 1.8	0.8	4.4
1995	6	3.0	± 2.1	0.9	5.1
1996	6	3.6	± 2.4	1.2	6.0
1997	6	2.4	± 1.1	1.3	3.5
1998	8	3.6	± 2.6	1.0	6.2
1999	12	8.0	± 6.1	1.9	14.1
2000	10	4.7	± 3.9	0.8	8.6

When inflow sites are excluded, both mean and 95% confidence limits decrease. Only one year (1999) would exceed the upper limit of the 95% CL (14.1). Recognizing that inflows present a special challenge, the task then is to determine how best to obtain a representative sample on multiple sample dates, thereby providing a reliable (reproducible) estimate of fish assemblage health. One approach could be to expand the number of sample sets taken throughout the sampling season and then average RFAI scores for all dates. Another option is to re-sample within a short time period in an effort to help eliminate as many differences in hydrologic and weather conditions as possible. A third option would be to coordinate sampling activities with Reservoir Operations to insure an "ideal" duplicate set of flow conditions exists when both sample sets are collected. The first two options are not realistic given scheduling difficulties to complete all planned sampling before the on-set of winter, given that the preferred sample period for the fish assemblage is autumn. This leaves the third alternative as the most practical. The primary consideration for implementing this recommendation in 2001 will be for the two samples sets to be collected under similar flow regimes and with as little time separation as practical considering all monitoring demands.

A new issue emerged from evaluation of the 1999 QC sample results that had not been apparent before. That evaluation recognized a consistent difference in RFAI between the two fish assemblage sample crews (Dycus and Baker, 2000). QC procedures call for a different crew to collect the second set of samples at each site (unless scheduling mandates otherwise). Evaluation of the 1999 QC results showed one crew (labeled Crew A) consistently had lower RFAI scores at repeat sample sites than the other crew (labeled Crew B) regardless of which crew was the original sampling crew.

These issues were again evident in 2000. During the past two years (1999 & 2000) there have been a total of 13 repeat sample sets. Of the 13 repeat sets Crew A had lower RFAI scores 10 times and consistently scored lower in several metrics. Catch rates also exhibited a similar bias in that Crew A had a lower catch rate for all 13 replicate sample sets. The difference was pronounced in some cases. For example, catch rates for Chatuge forebay in 2000 were 35.1 and 173.5 for Crews A and B, respectively and 170.7 and 248.9 at Watts Bar forebay. Results for number of species exhibited a bias as well, 11 of 13 times Crew A collected fewer species than Crew B.

Sampling protocol requires that all fish in a 300m sample run be collected in reference to their true relative abundance without species bias, regardless of time. Differences in RFAI scores can result if different crews implement these protocols inconsistently or if sampling equipment (i.e., electro-fishing equipment) does not sample with comparable efficiency. All sampling equipment used in the Vital Signs Monitoring Program has been tested and found that little variability exists among sampling units. Given that equipment is not the issue , implementation of protocols is the suspected cause of observed differences. Implementation differences could include boat sample depth, boat speed, dipping fish efficiency and/or fish identification. Differences between crews in any of these areas could be subtle but could still affect sampling efficiency and thus RFAI score. It should be noted that, even though these differences have been recognized, QC results for 2000 were within acceptable ranges except at the intake sample location.

Recognition that differences exist between crews necessitates two reactions – one is to implement changes which will reduce differences in future sampling efforts, and the other is to determine if potentially biased RFAI scores had implications to the overall reservoir ecological health scores for 2000. A plan of action has been implemented to reduce differences between crews in 2001. To achieve this goal, all aspects of sampling protocols for the upcoming RFAI sampling season will be reviewed for consistency between sampling crews.

To evaluate implications of the observed differences between crews on 2000 monitoring results, it is necessary to first determine if the potential bias of Crew A did in fact manifest itself in lower RFAI scores, and, if so, did the lower RFAI scores have implications to overall reservoir ecological health scores. Crew A sampled 7 reservoirs with a total of 14 sites in 2000. Of the 14 sites, 10 (71%) had a score within the long term range for that site, 4 sites (29%) had RFAI scores lower than had ever measured before, and none of the sites in 2000 exceeded the highest found to date. Crew B sampled 9 reservoirs with a total of 23 sites. Of those 23 sites, 18 (78%) had a score within the long term range, 2 sites (9%) had a lower score than ever been measured before, and 3 sites (13%) were the highest found to date. From this it would appear that Crew B did not have a bias, and that Crew A did have had a slight negative bias.

The next step is to determine if the slight bias in RFAI scores had measurable implications to the overall ecological health scores for the seven reservoirs sampled by Crew A. The 14 sites at which crew A conducted fish assemblage sampling in 2000 were distributed among the 7 reservoirs as follows: 1 site on Apalachia, Beech, and Normandy; 2 sites on Tims Ford and Wilson; 3 sites on Guntersville; and 4 sites on Pickwick. Five of the reservoirs(Apalachia, Beech, Guntersville, Pickwick, and Normandy) had RFAI scores similar to past years indicating little, if any potential impact of the bias on the overall ecological health scores. RFAI scores for the other two reservoirs (Tims Ford and Wilson) were generally lower in 2000 than in past years. For each site in these reservoirs, the RFAI score was lower than in the past by one rating category (e.g., "Fair" in 2000 compared to a long-term average in the "Good" category). A shift of one rating category would decrease the contribution of RFAI to the overall reservoir ecological score by 1 point per site. When this difference is figured into the overall reservoir ecological health score, it would have the potential to reduce the score for Tims Ford, by 4 percentage points (1 point for each of 2 sample locations divided by the maximum of 45.0 points = 0.04 or 4 percentage points). Likewise, the overall ecological health score for Wilson

Reservoir potentially could have been "artificially reduced by 6 points (1 point for each of 2 sample locations divided by maximum of 32.5 =0.06 or 6 percentage points.

As discussed above and detailed in Section 1, the overall ecological health score is divided into three categories - Poor (scores 22.5 - 58); Fair (scores 59 - 72); and Good (scores 73 - 100). If the percentage points described above for each reservoir were added to the reservoir ecological health score for 2000 and compared to these categories, neither of the reservoirs would change categories:

Reservoir	Initial 2000 Score / Initial Category	RFAI Points to Add	New Reservoir Score / New Category
Tims Ford	49 - Poor	4	53 - Poor
Wilson	52 - Poor	6	58 - Poor

From this evaluation it appears that RFAI scores for a few reservoirs may have been negatively influenced by the bias of one field crew. Fortunately, the magnitude of influence was relatively small and buffered by the other four indicators. As a result, the influence of the bias on the overall reservoir ecological scores was negligible when compared to the ultimate rating categories of Good-Fair-Poor.

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Table 1. Scoring criteria for forebay and transition sections of mainstream reservoirs in the Tennessee River valley. Lower mainstream reservoirs include: Kentucky, Pickwick, Wilson and Wheeler Reservoirs. Upper mainstream reservoirs include: Guntersville, Nickajack, Chickamauga, Watts Bar and Fort Loudoun Reservoirs. Other reservoirs include: Melton Hill and Tellico Reservoirs.

			Scoring Criteria					
			Forebay			Transition		
Metric	Reservoir Group	Gear	1	3	5	1	3	5
1. Number of species	Lower mainstream	Combined	<14	14-27	>27	<16	16-30	>30
	Upper mainstream	Combined	<14	14-27	>27	<15	15-29	>29
	Other reservoirs	Combined	<13	13-24	>24	<13	13-26	>26
2. Number of Lepomid sunfish species	Lower mainstream	Combined	<2	2-3	>3	<2	2-3	>3
	Upper mainstream	Combined	<2	2-4	>4	<2	2-4	>4
	Other reservoirs	Combined	<2	2-4	>4	<2	2-4	>4
3. Number of sucker species	Lower mainstream	Combined	<4	4-6	>6	<4	4-7	>7
	Upper mainstream	Combined	<4	4-7	>7	<4	4-7	>7
	Other reservoirs	Combined	<4	4-6	>6	<4	4-6	>6
4. Number of intolerant species	Lower mainstream	Combined	<2	2-4	>4	<3	3-4	>4
	Upper mainstream	Combined	<2	2-4	>4	<2	2-4	>4
	Other reservoirs	Combined	<2	2-3	>3	<2	2-4	>4
5. Percent tolerant individuals	All	Electrofishing	>45%	20-45%	<20%	>50%	25-50%	<25%
	All	Gill netting	>40%	20-40%	<20%	>40%	20-40%	<20%
6. Percent dominance	All	Electrofishing	>60%	40-60%	<40%	>60%	40-60%	<40%
	All	Gill netting	>50%	30-50%	<30%	>50%	30-50%	<30%
7. Number of piscivore species	Lower mainstream	Combined	<4	4-7	>7	<4	4-7	>7
	Upper mainstream	Combined	<4	4-7	>7	<4	4-7	>7
	Other reservoirs	Combined	<4	4-7	>7	<4	4-7	>7
8. Percent omnivores	All	Electrofishing	>45%	20-45%	<20%	>50%	25-50%	<25%
	All	Gill netting	>45%	30-45%	<30%	>45%	30-45%	<30%
9. Percent invertivores	All	Electrofishing	<35%	35-70%	>70%	<30%	30-60%	>60%
	All	Gill netting	<5%	5-15%	>15%	<7%	7-15%	>15%
10. Number of Lithophilic spawning species	Lower mainstream	Combined	<4	4-6	>6	<4	4-7	>7
	Upper mainstream	Combined	<3	3-6	>6	<4	4-7	>7
	Other reservoirs	Combined	<4	4-7	>7	<4	4-7	>7
11. Total number of individuals	All	Electrofishing	<50	50-100	>100	<50	50-100	>100
	All	Gill netting	<15	15-35	>35	<15	15-35	>35
12. Percent anomalies	All	Combined	<2%	2-5%	>5%	<2%	2-5%	>5%

Table 1, continued. Scoring criteria for inflow sections of Mainstream Reservoirs in the Tennessee River valley. Lower mainstream reservoirs include: Kentucky, Pickwick, Wilson and Wheeler Reservoirs. Upper mainstream reservoirs include: Guntersville, Nickajack, Chickamauga, Watts Bar and Fort Loudoun Reservoirs.

Metric	Reservoir Group	Gear	Scoring Criteria		
			1	3	5
1. Number of species	Lower mainstream	Electrofishing	<14	14-27	>27
	Upper mainstream	Electrofishing	<14	14-27	>27
	Melton Hill	Electrofishing	<13	13-24	>24
2. Number of Lepomid sunfish species	Lower mainstream	Electrofishing	<2	2-4	>4
	Upper mainstream	Electrofishing	<3	3-4	>4
	Melton Hill	Electrofishing	<3	3-4	>4
3. Number of sucker species	Lower mainstream	Electrofishing	<4	4-7	>7
	Upper mainstream	Electrofishing	<3	3-6	>6
	Melton Hill	Electrofishing	<3	3-6	>6
4. Number of intolerant species	Lower mainstream	Electrofishing	<3	3-6	>6
	Upper mainstream	Electrofishing	<2	2-4	>4
	Melton Hill	Electrofishing	<2	2-4	>4
5. Percent tolerant individuals	All	Electrofishing	>55%	30-55%	<30%
6. Percent dominance	All	Electrofishing	>60%	40-60%	<40%
7. Number of piscivore species	Lower mainstream	Electrofishing	<4	4-7	>7
	Upper mainstream	Electrofishing	<3	3-6	>6
	Melton Hill	Electrofishing	<4	4-7	>7
8. Percent omnivores	All	Electrofishing	>55%	30-55%	<30%
9. Percent invertivores	All	Electrofishing	<25%	25-50%	>50%
10. Number of Lithophilic spawning species	Lower mainstream	Electrofishing	<4	4-7	>7
	Upper mainstream	Electrofishing	<4	4-7	>7
	Melton Hill	Electrofishing	<3	3-5	>5
11. Total number of individuals	All	Electrofishing	<50	50-100	>100
12. Percent anomalies	All	Electrofishing	<2%	2-5%	>5%

Table 1, continued. Scoring criteria for reservoirs in the Interior Plateau Ecoregion of the Tennessee River valley. Other reservoirs include: Beech, Bear Creek, Little Bear Creek, and Cedar Creek Reservoirs.

			Scoring Criteria					
			Forebay			Transition		
Metric	Reservoir Group	Gear	1	3	5	1	3	5
1. Number of species	Normandy	Combined	<8	8-17	>17	<8	8-17	>17
	Tims Ford	Combined	<10	10-20	>20	<11	11-20	>20
	Other reservoirs	Combined	<10	10-19	>19			
2. Number of Lepomid sunfish species	Normandy	Combined	<2	2-3	>3	<2	2-3	>3
	Tims Ford	Combined	<2	2-3	>3	<2	2-3	>3
	Other reservoirs	Combined	<2	2-3	>3			
3. Number of sucker species	Normandy	Combined	<3	3-4	>4	<2	2-2	>2
	Tims Ford	Combined	<4	4-6	>6	<4	4-6	>6
	Other reservoirs	Combined	<3	3-5	>5			
4. Number of intolerant species	Normandy	Combined	<2	2-2	>2	<2	2-2	>2
	Tims Ford	Combined	<2	2-2	>2	<2	2-2	>2
	Other reservoirs	Combined	<2	2-2	>2			
5. Percent tolerant individuals	All	Electrofishing	>30%	15-30%	<15%	>30%	15-30%	<15%
	All	Gill netting	>35%	20-35%	<20%	>35%	20-35%	<20%
6. Percent dominance	All	Electrofishing	>60%	40-60%	<40%	>60%	40-60%	<40%
	All	Gill netting	>50%	30-50%	<30%	>50%	30-50%	<30%
7. Number of piscivore species	Normandy	Combined	<3	3-6	>6	<3	3-6	>6
	Tims Ford	Combined	<4	4-6	>6	<4	4-6	>6
	Other reservoirs	Combined	<3	3-6	>6			
8. Percent omnivores	All	Electrofishing	>25%	10-25%	<10%	>25%	10-25%	<10%
	All	Gill netting	>60%	40-60%	<40%	>60%	40-60%	<40%
9. Percent invertivores	All	Electrofishing	<60%	60-80%	>80%	<50%	50-70%	>70%
	All	Gill netting	<3%	3-6%	>6%	<3%	3-6%	>6%
10. Number of Lithophilic spawning species	Normandy	Combined	<3	3-6	>6	<3	3-6	>6
	Tims Ford	Combined	<4	4-6	>6	<4	4-6	>6
	Other reservoirs	Combined	<3	3-6	>6			
11. Total number of individuals	All	Electrofishing	<40	40-80	>80	<40	40-80	>80
	All	Gill netting	<10	10-18	>18	<10	10-18	>18
12. Percent anomalies	All	Combined	<2%	2-5%	>5%	<2%	2-5%	>5%

Table 1, continued. Scoring criteria for reservoirs in the Ridge and Valley Ecoregion of the Tennessee River valley.

		Scoring Criteria					
		Forebay			Transition		
Metric	Gear	1	3	5	1	3	5
1. Number of species	Combined	<10	10-19	>19	<11	11-20	>20
2. Number of Lepomid sunfish species	Combined	<2	2-3	>3	<2	2-3	>3
3. Number of sucker species	Combined	<3	3-5	>5	<3	3-6	>6
4. Number of intolerant species	Combined	<2	2-2	>2	<2	2-2	>2
5. Percent tolerant individuals	Electrofishing	>30%	15-30%	<15%	>30%	15-30%	<15%
	Gill netting	>50%	30-50%	<30%	>50%	30-50%	<30%
6. Percent dominance	Electrofishing	>60%	40-60%	<40%	>60%	40-60%	<40%
	Gill netting	>50%	30-50%	<30%	>50%	30-50%	<30%
7. Number of piscivore species	Combined	<3	3-6	>6	<4	4-6	>6
8. Percent omnivores	Electrofishing	>25%	10-25%	<10%	>25%	10-25%	<10%
	Gill netting	>60%	40-60%	<40%	>60%	40-60%	<40%
9. Percent invertivores	Electrofishing	<60%	60-80%	>80%	<50%	50-70%	>70%
	Gill netting	<3%	3-6%	>6%	<3%	3-6%	>6%
10. Number of Lithophilic spawning species	Combined	<2	2-4	>4	<3	3-6	>6
11. Total number of individuals	Electrofishing	<40	40-80	>80	<40	40-80	>80
	Gill netting	<15	15-30	>30	<15	15-30	>30
12. Percent anomalies	Combined	<2%	2-5%	>5%	<2%	2-5%	>5%

Table 1, continued. Scoring criteria for reservoirs in the Blue Ridge Ecoregion of the Tennessee River valley.

		Scoring Criteria					
			Forebay			Transition	
Metric	Gear	1	3	5	1	3	5
1. Number of species	Combined	<8	8-15	>15	<8	8-15	>15
2. Number of Lepomid sunfish species	Combined	<2	2-3	>3	<2	2-3	>3
3. Number of sucker species	Combined	<2	2-3	>3	<2	2-3	>3
4. Number of intolerant species	Combined	<2	2-2	>2	<2	2-2	>2
5. Percent tolerant individuals	Electrofishing	>30%	15-30%	<15%	>30%	15-30%	<15%
	Gill netting	>20%	10-20%	<10%	>20%	10-20%	<10%
6. Percent dominance	Electrofishing	>60%	40-60%	<40%	>60%	40-60%	<40%
	Gill netting	>50%	30-50%	<30%	>50%	30-50%	<30%
7. Number of piscivore species	Combined	<3	3-5	>5	<3	3-5	>5
8. Percent omnivores	Electrofishing	>10%	5-10%	<5%	>10%	5-10%	<5%
	Gill netting	>30%	15-30%	<15%	>30%	15-30%	<15%
9. Percent invertivores	Electrofishing	<75%	75-85%	>85%	<75%	75-85%	>85%
	Gill netting	<3%	3-6%	>6%	<3%	3-6%	>6%
10. Number of Lithophilic spawning species	Combined	<3	3-4	>4	<3	3-4	>4
11. Total number of individuals	Electrofishing	<30	30-60	>60	<30	30-60	>60
	Gill netting	<10	10-18	>18	<10	10-18	>18
12. Percent anomalies	Combined	<2%	2-5%	>5%	<2%	2-5%	>5%

Table 2. Summary of RFAI Scores for 1990-2000 Based on 1994 Scoring Methods.

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Apalachia	Forebay	.	.	.	.	.	.	32	27	36	26	30
Bear Creek	Forebay	.	.	47	45	44	38	48	45	.	44	
Beech Lake	Forebay	.	.	.	.	29	27	28	.	32	.	30
Blue Ridge	Forebay	.	40	37	39	42	44	.	36	.	45	
Boone	Forebay	.	30	35	24	34	35	.	32	.	32	
	Mid-res. So. Holston	.	41	30	36	36	27	.	36	.	34	
	Mid-res. Watauga	.	34	34	34	37	39	.	40	.	31	
Cedar Creek	Forebay	.	.	42	41	50	44	48	51	.	42	
Chatuge	Forebay	.	35	43	40	43	.	36	.	28	40	33
	Shooting Creek	.	.	.	40	39	.	41	.	25	38	32
Cherokee	Forebay	38	42	35	42	38	37	32	.	36	.	38
	Mid-reservoir	39	36	34	38	38	32	35	.	32	.	36
Chickamauga	Forebay	45	44	46	45	41	47	.	38	.	41	
	Inflow	48	48	42	56	52	44	38	52	.	44	
	Transition	45	45	41	51	43	50	44	40	.	41	
	Sequoyah	.	.	.	.	.	.	48	.	.	43	
	Hiw. R. Embayment	.	.	.	48	42	39	.	44	.	47	
Douglas	Forebay	41	33	39	40	42	36	.	46	.	42	
	Mid-reservoir	41	42	38	43	44	37	.	49	.	45	
Fontana	Forebay	.	.	.	42	43	.	29	.	37	.	40
	Mid-res. L'Tenn. R.	.	.	.	44	42	37	36	.	47	.	44
	Mid-res. Tuck. River	.	.	.	40	40	33	40	.	41	.	39
Fort Loudoun	Forebay	39	35	41	41	37	36	33	42	49	46	45
	Inflow	40	32	24	34	36	32	26	22	40	46	48
	Transition	33	33	33	34	38	27	38	37	41	40	47
	Little R. Embayment	.	.	.	.	.	35	.	.	.	.	
Ft Patrick Henry	Forebay	.	.	.	46	33	20	26	27	.	26	
Guntersville	Forebay	42	46	39	46	30	.	44	.	39	.	34
	Inflow	52	46	40	38	42	.	46	.	32	.	30
	Transition	40	33	40	38	35	.	36	.	30	.	34
Hiwassee	Forebay	.	42	39	48	52	.	51	.	49	.	45
	Mid-reservoir	.	49	40	47	43	.	50	.	47	.	47
Kentucky	Forebay	37	44	38	42	38	41	.	41	.	39	
	Embayment	.	.	.	31	31	28	.	34	.	32	
	Inflow	44	46	36	38	34	36	.	38	.	42	
	Transition	48	44	49	44	43	42	.	44	.	40	
Little Bear Cr.	Forebay	.	.	42	45	46	42	46	52	.	47	
Melton Hill	Forebay	37	42	31	40	49	.	41	.	51	.	48
	Inflow	40	20	18	22	28	.	36	.	36	.	32
	Transition	40	36	30	43	43	.	38	.	41	.	47

Table 2. Continued

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Nickajack	Forebay	46	45	36	49	45	44	.	35	.	34	
	Inflow	54	48	48	58	50	54	.	46	.	46	
	Transition	43	40	.	.	.	.	.	.	.	.	
Normandy	Forebay	.	.	41	53	48	45	58	.	53	.	47
	Mid-reservoir	.	.	51	.	.	.	.	.	.	.	
Norris	Forebay	33	34	34	34	43	31	.	38	.	38	
	Mid-res. Clinch R.	44	40	43	47	51	39	.	45	.	51	
	Mid-res. Powell R.	48	48	44	48	52	41	.	45	.	53	
Nottely	Forebay	.	37	35	37	38	36	.	35	42	39	
	Mid-reservoir	.	.	.	40	37	37	.	43	41	39	
Parksville	Forebay	.	32	36	34	42	37	.	37	.	25	
Pickwick	Forebay	43	40	34	50	43	.	42	.	44	.	32
	Bear Cr. Embayment	.	.	.	42	44	.	51	.	40	.	43
	Inflow	48	44	42	50	46	.	48	.	42	.	50
	Transition	45	45	40	47	47	.	53	.	37	.	47
South Holston	Forebay	.	34	39	51	43	.	42	.	47	.	40
	Mid-reservoir	.	41	40	44	44	.	39	.	40	.	42
Tellico	Forebay	37	38	36	36	47	37	.	45	.	46	
	Transition	36	31	31	41	44	37	.	46	.	45	
Tims Ford	Forebay	.	.	40	46	50	33	42	.	46	.	40
	Mid-reservoir	.	.	48	51	47	49	44	.	49	.	35
Upper Bear Creek	Forebay	.	.	31	34	.	.	.	.	31	.	
Watauga	Forebay	.	33	29	30	31	.	37	.	26	.	26
	Mid-reservoir	.	32	31	42	35	.	43	.	46	.	41
Watts Bar	Forebay	42	42	35	39	43	.	41	.	44	39	45
	Inflow Tennessee	34	40	42	38	46	.	40	.	50	.	44
	Inflow Clinch	46	40	34	44	40	.	48	.	46	.	42
	Transition	46	46	44	53	46	.	42	.	48	.	48
Wheeler	Forebay	40	43	40	49	41	50	.	41	.	39	
	Inflow	44	44	40	44	48	42	.	50	.	36	
	Transition	40	36	31	47	43	37	.	38	.	30	
	Elk River Embayment	.	.	.	41	50	39	.	46	.	38	
Wilson	Forebay	33	44	39	44	45	.	42	.	47	.	38
	Inflow	38	38	46	54	40	.	46	.	44	.	28

Table 3. Core Fish Species List with Trophic Guild, Tolerance, and Reproductive Designations* for use in Reservoir Fish Assemblage Index (RAFI) for TVA Reservoirs

Species	Tropic Guild	Tolerance	Lithophilic Spawner
Chestnut Lamprey	PS		L
Spotted Gar	PI		
Longnose Gar	PI	TOL	
Shortnose Gar	PI	TOL	
Bowfin	PI		
American Eel	PI		
Skipjack Herring	PI	INT	
Gizzard Shad	OM	TOL	
Threadfin Shad	PL		
Mooneye	IN		L
Chain Pickerel	PI		
Central Stoneroller	HB		
Common Carp	OM	TOL	
Goldfish	OM	TOL	
Silver Chub	IN	INT	
Golden Shiner	OM	TOL	
Emerald Shiner	IN		
Ghost Shiner	IN		
Spotfin Shiner	IN		
Mimic Shiner	IN	INT	
Steelcolor Shiner	IN		
Pugnose Minnow	IN		
Bluntnose Minnow	OM		
Fathead Minnow	OM		
Bullhead Minnow	IN		
River Carpsucker	OM		
Quillback	OM		
Northern Hog Sucker	IN	INT	L
Smallmouth buffalo	OM		
Bigmouth Buffalo	PL		
Black Buffalo	OM		
Spotted Sucker	IN	INT	L
Silver Redhorse	IN		L
Shorthead Redhorse	IN		L
River Redhorse	IN	INT	L
Black Redhorse	IN	INT	L
Golden Redhorse	IN		

Table 3. Continued

Species	Tropic Guild	Tolerance	Lithophilic Spawner
Blue Catfish	OM		
Black Bullhead	OM	TOL	
Yellow Bullhead	OM	TOL	
Brown Bullhead	OM	TOL	
Channel Catfish	OM		
Flathead Catfish	PI		
Blackstripe Topminnow	IN		
Blackspotted Topminnow	IN		
Mosquitofish	IN	TOL	
Brook Silverside	IN		
White Bass	PI		L
Yellow Bass	PI		L
Rock Bass	PI	INT	
Redbreast Sunfish	IN	TOL	
Green Sunfish	IN	TOL	
Warmouth	IN		
Orangespotted Sunfish	IN		
Bluegill	IN		
Longear Sunfish	IN	INT	
Redear Sunfish	IN		
Spotted Sunfish	IN		
Smallmouth Bass	PI		
Spotted Bass	PI		
Largemouth Bass	PI		
White Crappie	PI		
Black Crappie	PI		
Yellow Perch	IN		
Logperch	IN		L
Sauger	PI		L
Walleye	PI		L
Freshwater Drum	IN		

*Designations:
Trophic Guild: HB = Herbivore; PS = Parasitic; PL = Planktivore; OM = Omnivore
IN = Insectivore: PI = Piscivore
Tolerance: TOL = Tolerant; INT = Intolerant
Lithophilic Spawning Species = L

Appendix A.

Watershed and Reservoir Physical Description Including Summary of Ecological Health Results for Each Reservoir Sampled in 2000

Kentucky Watershed

Duck Watershed

Pickwick - Wilson Watershed

Wheeler - Elk Watershed

Guntersville - Sequatchie Watershed

Nickajack - Chickamauga Watershed

Hiwassee Watershed

Fort Loudoun Reservoir - Melton Hill - Watts Bar Watershed

Clinch - Powell Watershed

Little Tennessee Watershed

French Broad Watershed

Holston Watershed

KENTUCKY RESERVOIR WATERSHED

The Kentucky Reservoir watershed area includes all streams flowing into the Tennessee River downstream of Pickwick Landing Dam at Tennessee River mile (TRM) 206.7 to the confluence of the Tennessee River with the Ohio River. The one exception is the Duck River which is considered a separate watershed. The Kentucky Reservoir watershed area is relatively large (4590 square miles) and has an average annual discharge of about 67,200 cfs. Of that, about 83 percent (56,000 cfs) comes into Kentucky Reservoir from Pickwick Landing Dam. The Duck River supplies about 6 percent (4075 cfs), with the remaining 11 percent coming from local inflows.

Kentucky Reservoir is the dominant feature of this watershed. There are four monitoring sites on Kentucky Reservoir--forebay, transition zone, inflow, and Big Sandy River embayment

The watershed also includes the seven small reservoirs on the Beech River. The largest, Beech Reservoir, is the only one included in Vital Signs monitoring. Given its small size, the forebay is the only site monitored.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activities have occurred on reservoirs in this watershed. It also provides planned activities in the future .

Kentucky Reservoir

Kentucky Reservoir is the largest reservoir on the Tennessee River. The dam is located at Tennessee River Mile (TRM) 22.4, and the reservoir extends 184 miles upstream to Pickwick Dam at TRM 206.7. At full pool the surface area is 160,300 acres, and the shoreline is 2280 miles. Average annual discharge is about 67,200 cfs, which provides an average hydraulic retention time of about 21 days.

The Duck River, a major tributary to the Tennessee River (and Kentucky Reservoir), provides about 6 percent of the total flow through Kentucky Reservoir. The confluence of the Duck River with the Tennessee River is at TRM 110.7.

The transition zone sample location was moved prior to the 1992 sample season from TRM 112.0 to TRM 85.0. Results for 1990 and 1991 at TRM 112.0 indicated that location was more representative of a riverine environment than a transition environment. Results of sampling since then indicate the new transition zone site is correctly located.

Vital Signs monitoring was expanded in 1993 to include a sample site in four of the largest embayments in the Tennessee Valley. One, the Big Sandy River embayment on Kentucky Reservoir, is the largest embayment in the Tennessee Valley. It covers 15,238 surface acres and has over 93 miles of shoreline. Because its watershed is only 629 square miles, there is very little water exchange.

Beech Reservoir

Beech Reservoir, the largest of seven small flood control projects on the Beech River system in western Tennessee, is formed by Beech Dam at Beech River mile 35.0. Beech Reservoir is only 5.3 miles long and averages only about 12 feet deep. It has no hydropower generating facilities, but is the primary source of water for the city of Lexington. The reservoir is an urban lake with considerable residential lakefront development. Consequently, it receives a large amount of recreational use relative to its small size (about 900 acres). Discharge from Beech Dam averages only about 14 cfs per day, resulting in a long hydraulic residence times of 300 to 400 days.

Reservoir: Beech 		**2000 Score: 42%**

---Previous Scores---
2000 Criteria

1991	n/s
1992	n/s
1993	69[1]
1994	54
1995	50
1996	51
1997	n/s
1998	53
1999	n/s
2000	42

1. no fish

Beech	2000 Results					Change between 1998 and 2000				
	FB	MR	Emb	Inf	Total	FB	MR	Emb	Inf	Total
Chlorophyll	P 1.0				1.0	0.0				0.0
DO	P 1.0				1.0	0.0				0.0
Fish	F 2.0				2.0	-1.0				-1.0
Benthos	F 4.0				4.0	-1.0				-1.0
Sediment	F 1.5				1.5	-0.5				-0.5
Total	9.5				9.5	-2.5				-2.5

Summary/Key Ecological Health Findings for 2000: Beech Reservoir rated poor in 2000. All indicators rated either fair or poor. Chlorophyll rated poor because concentrations were high throughout the study period. DO concentrations were low near bottom from late May through October with anoxia present much of the time, hence the poor rating. The fish assemblage rated fair -- five metrics (sucker species, intolerant species, percent of individuals as omnivores, lithophilic spawning species, and average number of individuals) all received the lowest possible rating; the predominant species was gizzard shad. Benthos rated fair; relatively few intolerant taxa and individuals were collected. Sediment quality rated fair because the concentration of arsenic exceeded the expected background by a small amount.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: The overall ecological health score for Beech Reservoir was poor in 1994, 1995, 1996, 1998, and 2000. The score has been quite consistent between 1994 and 1998 with a range of only 50 - 54. The score of 42 for 2000 was the lowest to date for Beech Reservoir. Consistent problems are high chlorophyll concentrations and low DO levels. The fish assemblage usually rates "low-fair" or poor. Absence or low numbers of sucker species, intolerant species, and lithophilic spawning species typically drive the fish assemblage score and rating down. The benthos rating for Beech Reservoir usually rates good and is often one of the highest found among all the reservoirs in the Interior Plateau ecoregion. This needs to be interpreted with caution because the ratings are on a relative system (i.e., compared only to other reservoirs in the same ecoregion). The benthos in all the reservoirs in this ecoregion (including Beech) would be considered poor by most other standards. The benthos rating for 2000 was the lowest to date for Beech because fewer organisms were collected, especially those considered intolerant.

Aquatic Macrophytes in 2000: Not an issue on Beech.

Status of Fish Consumption Advisories in 2000: There are no fish consumption advisories on Beech Reservoir. Channel catfish and largemouth bass were collected from Beech Reservoir in autumn 1998. Channel catfish fillets were analyzed for pesticides, PCBs, and metals and largemouth bass fillets for mercury. The results were provided to state agencies in Tennessee. All contaminant levels were either below detection levels or below the levels used by the state to issue fish consumption advisories. Beech Reservoir will be sampled again in 2002.

Status of Swimming Advisories in 2000: There are no State of Tennessee swimming advisories along the Beech River. Three Beech River sites were sampled ten times each for fecal coliform bacteria in 2000. The three sites sampled were: Beech Lake Dam Beach, Beech Lake Campground Beach, and Pine Lake Beach. All of the sites sampled met Tennessee's bacteriological water quality criteria for water contact recreation.

DUCK RIVER WATERSHED

The Duck River Watershed includes all streams flowing into the Duck River. It has an area of 3500 square miles and an average annual discharge of 4075 cfs to Kentucky Reservoir on the Tennessee River. The Duck River basin is underlain almost entirely by limestone, or phosphatic limestone; consequently, waters in the streams draining this basin are fairly hard and contain large concentrations of minerals. Large deposits of phosphate ores permit phosphate mining and refining operations in the basin. Phosphate concentrations in surface and groundwater are significantly higher than in most of the Tennessee Valley. The soils are thin with limestone outcrops at the surface in many places, and sinkholes are common throughout the watershed.

Normandy Reservoir is the only reservoir in this watershed. This is a relatively small reservoir and only the forebay is included in the Vital Signs monitoring program.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activities have occurred on Normandy Reservoir. It also provides planned activities in the future .

Normandy Reservoir

Normandy Reservoir is formed by Normandy Dam at Duck River mile (DRM) 248.6. Normandy Reservoir, constructed primarily for flood control and water supply, has a drainage area of 195 square miles and no electric power generation capacity. One of TVA's smaller reservoirs, Normandy at full pool elevation has about 3200 surface acres, 73 miles of shoreline, and about 17 miles of impounded backwater. The reservoir has an average depth of about 35 feet and an average annual drawdown of about 11 feet. The average annual discharge from Normandy Dam is about 344 cfs, providing an average annual retention time of about 161 days.

Reservoir: Normandy **2000 Score: 55%**

—Previous Scores—
2000 Criteria

1991	n/s
1992	n/s
1993	62
1994	64
1995	59
1996	69
1997	n/s
1998	63
1999	n/s
2000	55

Normandy	2000 Results					Change between 1998 and 2000				
	FB	MR	Emb	Inf	Total	FB	MR	Emb	Inf	Total
Chlorophyll	P 2.9				2.9	0.1				0.1
DO	P 1.0				1.0	0.0				0.0
Fish	G 4.0				4.0	-1.0				-1.0
Benthos	F 2.0				2.0	-1.0				-1.0
Sediment	G 2.5				2.5	0.0				0.0
Total	12.4				12.4	-1.9				-1.9

Summary/Key Ecological Health Findings for 2000: Ecological conditions in Normandy Reservoir rated poor in 2000. The main issue was low DO levels. Typically, much of the water column (generally all but the top few meters) has low DO concentrations throughout most of the summer with extended periods of anoxia near bottom. Normandy has one of the more severe DO problems of all TVA reservoirs. The low DO in turn affects the benthic community which rated a low fair (one point above poor), due to low overall density, a lack of diversity, and being dominated by tolerant taxa. Chlorophyll rated poor because of high concentrations throughout summer. The fish assemblage and sediment quality both rated good in 2000.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: Normandy Reservoir rated poor for the first time in 2000 having rated fair in all previous years. Little variation in reservoir condition was observed during the first four years (1993, 1994, 1995, and 1996). However, this was not the case during the two most recent monitoring periods – 1998 and 2000 (monitoring was changed to an every other year rotation following 1996). Dryer and warmer weather conditions are thought to have played an important role in these differences. Sediment quality and the fish assemblage have rated good during all monitoring periods. However, the other three indicators exhibited a change between 1993-1996 and 1998-2000. For example, good ratings for chlorophyll changed to poor in 1998 and 2000 due to a substantial increase in concentrations. DO continued to rate poor in 1998 and 2000 as it had in the past, but the volume of low-DO water was about half that which existed during the 1993-1996 period. The consistently poor rating for benthos changed to fair in 1998 and 2000 due to collection of a greater variety and abundance of organisms. Increases in chlorophyll concentration have been observed in other reservoirs during recent years and may indicate nutrient over-enrichment. The decrease in volume of low-DO water is interesting. Intuitively, it would seem that the increased algal biomass would have increased oxygen demand for decomposition, which it probably did. However, warm winters during 1998 and 2000 did not cool reservoir temperatures as much as in the earlier years so differences between bottom and surface temperatures were not as great. This reduced stratification would have allowed surface and bottom waters to remain mixed later in the spring/early summer and allow destratification to occur earlier in late summer/early fall. It is possible that the improved rating for benthos is related to improved DO conditions.

Aquatic Macrophytes in 2000: Not an issue on Normandy Reservoir.

Status of Fish Consumption Advisories in 2000: There are no fish consumption advisories on Normandy Reservoir. The last time TVA sampled Normandy Reservoir was in autumn 1998. Channel catfish fillets were analyzed for pesticides, PCBs, and metals and largemouth bass fillets for mercury. The results were provided to state agencies in Tennessee. All contaminant levels were either below detection levels or below the levels used by the state to issue fish consumption advisories. Normandy Reservoir will be sampled again in 2002.

Status of Swimming Advisories in 2000: There are no State of Tennessee swimming advisories on Tims Ford Reservoir. Two sites at Tims Ford Reservoir were sampled ten times each for fecal coliform bacteria in 2000. These sites were also analyzed for *E. coli* bacteria using three different methods. Both locations met the state of Tennessee bacteriological water quality criteria for water contact recreation.

PICKWICK RESERVOIR - WILSON RESERVOIR WATERSHED

Pickwick Reservoir and Wilson Reservoir on the Tennessee River are the most notable features of this drainage area. Only a small part of the flow leaving this watershed actually originates within the watershed itself. The average annual discharge from Pickwick Dam is about 56,000 cfs. Of that, 52,500 cfs (94 percent) is the discharge from Wheeler Dam into Wilson Reservoir. About 1840 cfs enters Wilson Reservoir through local tributaries and about 3500 cfs originates in tributaries to Pickwick Reservoir. The streams within this watershed drain an area of about 3230 square miles. The largest tributaries are Bear Creek, a tributary to Pickwick Reservoir with a drainage area of about 945 square miles, and Shoal Creek, a tributary to Wilson Reservoir, with a drainage area of about 445 square miles.

Four small reservoirs were built on Bear Creek in the late 1970s and early 1980s for flood control and recreation. These are Bear Creek, Little Bear Creek, Cedar Creek, and Upper Bear Creek Reservoirs.

Reservoir monitoring activities occur at the forebay, transition zone, and inflow on Pickwick Reservoir and at the forebay and inflow on Wilson Reservoir. Wilson is relatively short and has no definable transition zone. Because of their smaller size, only the forebays of Bear Creek, Little Bear Creek, and Cedar Creek Reservoirs are monitored. No monitoring activities are conducted on Upper Bear Creek because of TVA's program to destratify and oxygenate water in the forebay.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activities have occurred on reservoirs in this watershed. It also provides planned activities in the future .

Pickwick Reservoir

Pickwick Reservoir is immediately upstream of Kentucky Reservoir on the Tennessee River. Pickwick Dam is located at TRM 206.7. Like the rest of the mainstream, run-of-the-river reservoirs, Pickwick is much shorter (53 miles long) and smaller (43,100 acres and shoreline of 496 miles) than Kentucky Reservoir. Average annual discharge is about 56,000 cfs, which provides an average hydraulic retention time of about eight days.

A major tributary, Bear Creek, joins the Tennessee River in Pickwick Reservoir at about mile 225. Bear Creek provides, on the average, about 2.5 percent of the flow through Pickwick Reservoir.

Reservoir Monitoring activities were expanded on Pickwick Reservoir in 1993 to include a Vital Signs monitoring site in Bear Creek embayment. This rather large embayment (7200 acres) extends from the mouth of Bear Creek upstream about 17 miles to the point where flow is not affected by backwater from Pickwick Dam.

Wilson Reservoir

Wilson Reservoir is quite different from other mainstream Tennessee River reservoirs in both length and depth. Wilson Dam is located at TRM 259.4 and Wheeler Dam is at TRM 274.9, providing a length of only 15.5 miles, a shoreline of 154 miles, and surface area of 15,500 acres. Water depth in the forebay is slightly over 100 feet. This short, deep pool, coupled with the largest hydroelectric generating plant in the TVA system, provides for short hydraulic retention times (six days). Average annual discharge from Wilson is 52,500 cfs. Because of the physical characteristics, design, and operation of Wilson Dam (primarily upper strata withdrawal for hydropower generation), low DO conditions develop in deeper strata of the forebay during summer months.

Bear Creek Reservoir

With a surface of only 700 acres, Bear Creek is one of the smallest reservoirs in the TVA system. It is relatively long (16 miles), narrow, and deep (74 feet at the dam). The average annual discharge is 406 cfs providing an average hydraulic retention time of about 12 days. Average annual drawdown is about 11 feet. Bear Creek Reservoir stratifies in the summer and develops hypolimnetic anoxia. Another water quality concern is abandoned strip mines in the watershed.

Little Bear Creek Reservoir

Little Bear Creek Reservoir is relatively short (7.1 miles long) and deep (84 feet at the dam). It has a surface area of 1600 acres. With an average annual discharge of 109 cfs, the hydraulic retention time is 209 days. Compared to Bear Creek Reservoir, the lower flow into the reservoir and larger reservoir volume make the retention time much longer in Little Bear Creek Reservoir. Average annual drawdown is about 12 feet.

Cedar Creek Reservoir

Like the other reservoirs in the Bear Creek watershed, Cedar Creek Reservoir is small (only nine miles long and 4200 acres surface area) and deep (79 feet at the dam). The low average annual discharge from the dam (313 cfs) creates a relatively long average retention time (152 days). This combination of physical features lead to thermal stratification and hypolimnetic anoxia in the summer. Average annual drawdown is about 14 feet.

Reservoir: **Pickwick** 2000 Score:71%

—Previous Scores—
2000 Criteria

1991	77	no embayment
1992	80	no embayment
1993	70	74 if Emb excluded
1994	81	86 if Emb excluded
1995	n/s	
1996	72	76 if Emb excluded
1997	n/s	
1998	74	81 if Emb excluded
1999	n/s	
2000	71	76 if Emb excluded

Pickwick	2000 Results									Change between 1998 and 2000				
	FB		TZ		Emb		Inf		Total	FB	TZ	Emb	Inf	Total
Chlorophyll	P	2.8	P	2.3	P	1.0			6.2	0.1	-2.7	0.0		-2.6
DO	G	4.5	G	5.0	F	4.0			13.5	-0.5	0.0	-0.5		-1.0
Fish	F	3.0	G	4.0	F	4.0	G	4.0	15.0	-1.0	1.0	1.0	0.0	1.0
Benthos	G	4.0	F	3.0	P	2.0	F	4.0	13.0	0.0	-2.0	0.0	1.0	-1.0
Sediment	G	2.5	G	2.5	G	2.5			7.5	0.5	0.5	0.5		1.5
Total		16.8		16.8		13.5		8.0	55.2	-0.9	-3.2	1.0	1.0	-2.1

Summary/Key Ecological Health Findings for 2000: Overall ecological conditions in Pickwick Reservoir rated fair in 2000; the rating was just two points below the good category. Three of the five indicators used to evaluate ecological condition rated good or fair at all locations. The only poor ratings were for chlorophyll and benthos. Chlorophyll rated poor at all three sampling sites where chlorophyll is monitored due to high concentrations during most of the monitoring period. Benthos rated poor at only one site: Bear Creek embayment. The sample site in Bear Creek embayment generally had lower rating for individual indicators than the other sites. Chlorophyll and benthos rated poor; dissolved oxygen and fish rated fair; and only sediment quality rated good. This area receives ample nutrients to stimulate algal growth resulting in high chlorophyll levels and has relatively little water exchange which tends to allow oxygen depletion to occur in lower strata during summer. The consistency of poor chlorophyll ratings was the primary factor which caused the overall ecological condition score for Pickwick Reservoir to be fair rather than good.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: The fair, almost good, ecological health score for Pickwick Reservoir in 2000 was generally similar to past years. Scores were good in 1991, 1992, 1994, and 1998 and fair, near the good category, in 1993 and 1996. The factors which seem to dictate whether a good or "high" fair score will occur are chlorophyll ratings at all sites and lower ratings for most indicators in Bear Creek embayment. Years with low reservoir flows such as 2000 tend to allow high chlorophyll concentrations to develop as long as ample nutrients are present, which is typically the case for most reservoirs on the mainstem of the Tennessee River. Fluctuations in chlorophyll levels are particularly evident at the transition zone where a poor rating occurred in 2000 compared to good in 1998, the last time Pickwick was monitored. Higher chlorophyll levels generally occur in this portion of the reservoir during years with low flows.

Aquatic Macrophytes in 2000: Aquatic plants on Pickwick Reservoir in 2000 covered an estimated 400 acres.

Status of Fish Consumption Advisories in 2000: There are no fish consumption advisories on Pickwick Reservoir. The last time TVA sampled Pickwick Reservoir was in autumn 1998. Channel catfish and largemouth bass fillets were analyzed for pesticides, PCBs, and metals. The results were provided to the Alabama Department of Public Health. All contaminant levels were either below detection levels or below the levels used by the state to issue fish consumption advisories. Pickwick Reservoir will be sampled again in autumn 2002.

Status of Swimming Advisories in 2000: There are no state swimming advisories on Pickwick Reservoir. Ten sites along Pickwick Reservoir were sampled ten times each for fecal coliform bacteria in 2000. All of the sites sampled met bacteriological water quality criteria for water contact recreation in the state in which they were sampled (Tennessee, Alabama, or Mississippi).

Reservoir: Wilson **2000 Score: 52%**

Previous Scores
2000 Criteria

1991	58
1992	67
1993	76
1994	70
1995	n/s
1996	75
1997	n/s
1998	78
2000	52

Wilson	2000 Results					Change between 1998 and 2000				
	FB	TZ	Emb	Inf	Total	FB	TZ	Emb	Inf	Total
Chlorophyll	P 2.5				2.5	-1.8				-1.8
DO	P 1.0				1.0	-3.0				-3.0
Fish	F 3.0			P 2.0	5.0	-1.0			-2.0	-3.0
Benthos	P 2.0			F 4.0	6.0	0.0			-1.0	-1.0
Sediment	G 2.5				2.5	0.5				0.5
Total	11.0			6.0	17.0	-5.3			-3.0	-8.3

Summary/Key Ecological Health Findings for 2000: Overall, ecological conditions in Wilson Reservoir rated poor in 2000. Only one indicator, sediment quality, received a good rating; all others rated fair or poor. Three indicators (Chlorophyll, DO, and Benthos) received a poor rating at the forebay sample site, and the fish assemblage rate poor the inflow. Dry weather conditions and resulting low reservoir flows were probably the primary contributors to observed conditions in 2000, especially at the forebay. Low flows tend to allow algae to increase as long as ample nutrients are present resulting in relatively high chlorophyll levels. Also, low flows do not provide sufficient energy to mix surface and bottom waters in relatively deep reservoirs like Wilson (90 - 100 feet). When this occurs, oxygen concentrations in lower strata are reduced as natural decomposition processes occur. In absence of mixing with oxygen-rich surface waters, oxygen concentrations in lower strata become progressively lower as the summer progresses. Low oxygen levels, in turn, have a negative affect on benthic macroinvertebrates. The poor rating for fish at the inflow was due to collection of fewer species than in the past, primarily piscivores and lithophilic spawning species. Also, the proportion of fish collected which are tolerant poor water quality conditions was relatively high.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: The poor rating for Wilson Reservoir in 2000 was lower than in most preceding years – a poor rating had only occurred once (in 1991), fair rating twice (in 1992 and 1994), and good in three years (1993, 1996, and 1998). Fluctuations in reservoir ratings have generally followed reservoir flow conditions as described above. It is notable that all three indicators (chlorophyll, DO, and benthos) which rated poor at the forebay in 2000 have also rated poor in previous years, generally irrespective of flow conditions; however, all three have not concurrently rated poor in any previous year as they did in 2000. In addition, the fish assemblage rated poor for the first time at the inflow (discussed above). The occurrence of so many poor ratings, in absence of several good ratings as in past years, resulted in the lowest reservoir ecological health score for Wilson observed to date. A return to more normal flow conditions should allow a return to the typical fair-good ecological conditions observed in previous years.

Aquatic Macrophytes in 2000: Only an estimated 10 acres of aquatic plants were present on Wilson in 2000, about the same as the past three to five years.

Status of Fish Consumption Advisories in 2000: There are no fish consumption advisories on Wilson Reservoir. The last time TVA sampled Wilson Reservoir was in autumn 1998. Channel catfish and largemouth bass fillets were analyzed for pesticides, PCBs, and metals. The results were provided to the Alabama Department of Public Health. All contaminant levels were either below detection levels or below the levels used by the state to issue fish consumption advisories. Wilson Reservoir will be sampled again in autumn 2002.

Status of Swimming Advisories in 2000: There are no State of Alabama swimming advisories on Wilson Reservoir. Two sites (Fleet Hollow Boat Ramp and Lock Six Day Use Area Boat Ramp) along Wilson Reservoir were sampled ten times each for fecal coliform bacteria in 2000. Both sites met Alabama's bacteriological water quality criteria for water contact recreation.

WHEELER RESERVOIR - ELK RIVER WATERSHED

The Wheeler Reservoir - Elk River watershed drains about 5140 square miles in north central Alabama and south central Tennessee. Wheeler Reservoir is the fourth of nine reservoirs on the Tennessee River. About 24,500 square miles of the Tennessee Valley are upstream of this watershed. Wheeler Reservoir receives an average annual inflow of 41,790 cfs from Guntersville Dam. Discharges from Wheeler Dam average 50,630 cfs on an annual basis leaving 8840 cfs which originate within the watershed.

The largest tributary to Wheeler Reservoir is the Elk River, which has a drainage area of about 2250 square miles and contributes about 3000 cfs. The remaining flow enters from tributaries directly to Wheeler Reservoir.

Wheeler Reservoir is the largest reservoir within this watershed followed by Tims Ford Reservoir on the Elk River. There are four Vital Signs monitoring sites on Wheeler Reservoir--forebay, transition zone, inflow, and the Elk River embayment. Two sites are monitored for Vital Signs on Tims Ford Reservoir--forebay and mid-reservoir. Woods Reservoir on the Elk River is not included in this monitoring program because it is property of the Arnold Engineering Development Center, Arnold Air Force Base.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activities have occurred on reservoirs in this watershed. It also provides planned activities in the future .

Wheeler Reservoir

Wheeler Reservoir has the third-largest surface area (67,100 acres) of all reservoirs in the TVA system. It is 74 miles long (dam at TRM 274.9) and has 1063 miles of shoreline. Average annual discharge is about 50,630 cfs which provides an average hydraulic retention time of about 12 days. Information collected in 1990 and 1991 indicated a more riverine than transition environment at TRM 307.5; consequently, in 1992 the transition zone sampling location was relocated further downstream to TRM 295.9. Results since the relocation indicate the new site is at the upstream end of the transition zone area. This means that the site may be too far upstream under moderate to high flow conditions.

The Elk River joins the Tennessee River in the downstream portion of Wheeler Reservoir at about mile 284 and provides, on the average, about 6 percent of the flow through Wheeler Reservoir.

Vital Signs monitoring activities were expanded in 1993 to include a site in the Elk River embayment. The Elk River embayment covers about 4900 acres. Given the relatively high flows in the Elk River (about 3000 cfs annual average), there is substantial water exchange in this embayment.

Tims Ford Reservoir

Tims Ford Reservoir in middle Tennessee is formed by Tims Ford Dam at Elk River mile (ERM) 133.3. The reservoir is 34 miles long at full pool and has a surface area of 10,600 acres. The depth at the dam is 143 feet and the average depth is about 50 feet. Average annual discharges from Tims Ford Dam are about 980 cfs, resulting in a hydraulic residence time of about 270 days. Tims Ford Reservoir is designed for a useful controlled drawdown of 30 feet (895-865 feet MSL) for flood protection; however, annual drawdowns average about 18 feet.

Reservoir: Tims Ford   2000 Score: 49%

—Previous Scores—
2000 Criteria

1992	63[1]
1993	60
1994	58
1995	56
1996	53
1997	n/s
1998	49
1999	n/s
2000	49

1. only Chl, DO, and Fish

Tims Ford	2000 Results					Change between 1998 and 2000				
	FB	MR	Emb	Inf	Total	FB	MR	Emb	Inf	Total
Chlorophyll	G 5.0	P 2.6			7.6	1.6	0.0			1.6
DO	P 1.0	P 1.0			2.0	0.0	0.0			0.0
Fish	F 3.0	F 3.0			7.0	-1.0	-2.0			-3.0
Benthos	P 1.0	P 1.0			2.0	0.0	0.0			0.0
Sediment	F 2.0	G 2.5			4.5	0.5	1.0			1.5
Total	12.0	10.1			22.1	1.1	-1.0			0.1

Summary/Key Ecological Health Findings for 2000: The overall ecological health rating for Tims Ford Reservoir was poor in 2000. The only good ratings were for chlorophyll at the forebay and sediment quality at the mid-reservoir site. DO and benthos rated poor at both sampling locations. DO levels, as in past years, were less than 2 mg/l throughout most of the lower water column during summer and at or near zero on the bottom from July through October. The poor ratings for the benthos community were probably tied to the low DOs near bottom. Virtually all metrics used to evaluate the benthic community rated poor at both sample locations. Chlorophyll levels were high and rated poor at the mid-reservoir site with lower levels and a good rating at the forebay. Sediment quality rated fair at the forebay and good at the mid-reservoir site. The fair rating at the forebay was due to elevated levels of nickel, which has been found in all previous years of monitoring. The fish assemblage rated fair at both sites.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: The overall ecological condition of Tims Ford Reservoir was poor again in 2000; same as in all monitoring years since 1994. Consistent problems for Tims Ford throughout this time period have been low DO concentrations near bottom and a poor benthic community. Chlorophyll concentrations at the forebay in 2000 were within the expected range and rated good; similar to all past years except 1998 when elevated concentrations resulted in a fair rating. Chlorophyll concentrations were again high and rated poor at the mid-reservoir site in 2000, same as in 1998 when this site rated poor for the first time. Fish assemblage scores were lower in 2000 than in most previous years with the lowest score found to date at the mid-reservoir site. This is contrary to observations in 1998 when fish assemblage scores were higher at both sites than they had been in most previous years. The lower scores in 2000 were reflected in eight of the 12 metrics used to evaluate the fish assemblage, but the greatest change was in number of sucker species and number of intolerant species.

Aquatic Macrophytes in 2000: Not an issue on Tims Ford Reservoir.

Status of Fish Consumption Advisories in 2000: There are no fish consumption advisories on Tims Ford Reservoir. Channel catfish and largemouth bass were collected autumn 1998. Channel catfish fillets were analyzed for pesticides, PCBs, and metals, and largemouth bass were analyzed for mercury. The results were provided to state agencies in Tennessee. All contaminant levels were either below detection levels or below the levels used by the state to issue fish consumption advisories. Tims Ford will be sampled again in 2002.

Status of Swimming Advisories in 2000: There are no State of Tennessee swimming advisories on Tims Ford Reservoir. Two sites at Tims Ford Reservoir were sampled ten times each for fecal coliform bacteria in 2000. These sites were also analyzed for *E. coli* bacteria using three different methods. Both locations met the State of Tennessee bacteriological water quality criteria for water contact recreation. The sites sampled were Dry Creek Embayment Swimming Beach and Estill Springs Park Boat Ramp.

GUNTERSVILLE RESERVOIR - SEQUATCHIE RIVER WATERSHED

This watershed includes Guntersville Reservoir and all tributaries draining directly to Guntersville Reservoir. As with the other watershed areas on the mainstem of the Tennessee River, most of the water leaving the watershed through Guntersville Dam enters the watershed area through discharges from the upstream dam (Nickajack). About 37,200 cfs enter from Nickajack Dam and about 41,800 cfs is discharged from Guntersville Dam on an annual average basis. The remaining 4600 cfs originates with the Guntersville Reservoir-Sequatchie River watershed area. The largest contributor of this flow is the Sequatchie River (about 800 cfs). The total watershed area is 2669 square miles. The area drained by the Sequatchie River is about 600 square miles.

Guntersville Reservoir is the dominant characteristic of this watershed. There are three Vital Signs monitoring site on Guntersville Reservoir: forebay, transition zone, and inflow.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activities have occurred on Guntersville Reservoir. It also provides planned activities in the future .

Guntersville Reservoir

Guntersville Dam, located at TRM 349.0, creates a 76 mile long reservoir with a surface area of 67,900 acres and a shoreline of 949 miles at full pool. Average annual discharge is about 41,800 cfs, corresponding to an average hydraulic retention time of about 12 days.

Guntersville Reservoir is similar to Wheeler Reservoir in several size characteristics, but it differs in one important feature. The average controlled storage volume of Guntersville is about half that of Wheeler. This is due to the shallow nature of Guntersville Reservoir at the inflow area and extensive shallow overbank areas. As a result, winter drawdown on Guntersville Reservoir is nominal to maintain navigation. The shallow drawdown allows the large overbank areas to be permanently wetted creating good habitat for aquatic macrophytes. Guntersville has the greatest area coverage of aquatic plants of any TVA reservoir.

The Sequatchie River joins the Tennessee River at about TRM 423, in the upstream portion of Guntersville Reservoir, just downstream from Nickajack Dam. On the average the Sequatchie River contributes less than 2 percent to the total flow of the Tennessee River through Guntersville Reservoir.

Data collected in 1990 and 1991, indicated a more riverine than transition environment at TRM 396.8. Consequently, in 1992 the transition zone sampling location was relocated further downstream to TRM 375.2.

Reservoir: **Guntersville** 2000 Score:77%

Previous Scores
2000 Criteria

1991	84[1]
1992	85
1993	79
1994	81
1995	n/s
1996	86
1997	n/s
1998	82
1999	n/s
2000	77

1. No transition Zone

Guntersville	2000 Results					Change between 1998 and 2000				
	FB	TZ	Emb	Inf	Total	FB	TZ	Emb	Inf	Total
Chlorophyll	F 3.6	G 5.0			8.6	-1.4	0.0			-1.4
DO	G 5.0	G 5.0			10.0	0.0	0.0			0.0
Fish	F 3.0	F 3.0		F 2.0	8.0	0.0	1.0		-1.0	0.0
Benthos	F 3.0	G 5.0		F 4.0	12.0	-2.0	0.0		1.0	-1.0
Sediment	F 1.5	G 2.5			4.0	0.0	0.0			0.0
Total	16.1	20.5		6.0	42.6	-3.4	1.0		0.0	-2.4

Summary/Key Ecological Health Findings for 2000: Guntersville Reservoir received a good ecological condition rating in 2000. All indicators rated either good or fair; there were no poor ratings at any location. The transition zone was the area with the highest ratings; chlorophyll, DO, benthos, and sediment quality all rated good. Ratings were not as good at the forebay where only DO received a good rating, and the other four indicators rated fair. The fair rating for chlorophyll occurred because of slightly elevated concentrations during several sample periods. These higher concentrations were likely related to the low flow conditions during 2000. Low catch rates contributed to fair ratings for the fish and benthos. Sediment quality rated fair because of presence of PCBs. Concentrations were low, just above the laboratory detection limit, similar to that found in 1998 at the same site.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: As in all past years of Vital Signs Monitoring, ecological conditions in Guntersville Reservoir rated good, with ecological condition scores among the highest observed for all TVA reservoirs monitored. Chlorophyll concentrations have varied over the last three monitoring cycles – they were slightly elevated at the forebay and rated fair in 1996 and 2000; whereas in 1998 concentrations were within the expected range and rated good. The fair rating for the benthos at the forebay was the lowest observed to date compared to a consistently good rating in all previous years. Fewer animals, and in particular fewer mayflies, were collected in 2000 than previously found. This affected several characteristics used to evaluate the benthic community and thus resulted in the lower rating. Monitoring in subsequent years will help determine if this was a sampling anomaly or a true change in the community. Ratings for the fish assemblage in 2000 were fair, generally similar to past years.

Aquatic Macrophytes in 2000: Aerial coverage of aquatic macrophytes in 2000 was about 15,000 acres, comparable to 1999 and 1998, and slightly higher than in 1997 (13,000), 1996 (10,500), 1995 (8,800), and 1994 (9,600).

Status of Fish Consumption Advisories in 2000: There are no fish consumption advisories on Guntersville Reservoir. Channel catfish and largemouth bass from Guntersville Reservoir were collected in autumn 2000 for analysis of pesticides, PCBs, and metals. Results are expected to be available in spring 2001. Prior to that, Guntersville was last sampled in autumn 1996. All contaminant levels were either below detection levels or below the levels used by the state to issue fish consumption advisories. The results were provided to the Alabama Department of Public Health.

Status of Swimming Advisories in 2000: There are no State of Alabama swimming advisories on Guntersville Reservoir. Twenty-six sites were sampled ten times each for fecal coliform bacteria in 2000. All sites met the State of Alabama bacteriological water quality criteria for water contact recreation.

NICKAJACK RESERVOIR - CHICKAMAUGA RESERVOIR WATERSHED

Nickajack and Chickamauga Reservoirs are primary features of this watershed. The Hiwassee River is the only sizeable tributary which merges with the Tennessee River within the watershed area. The drainage basin of the Hiwassee River is large enough to be designated a separate watershed. The remaining area drained by tributaries to these two reservoirs is 1780 square miles. On an annual average basis, about 3900 cfs is contributed to the Tennessee River from streams within this watershed. This compares to 27,700 cfs entering the upper end of Chickamauga Reservoir from Watts Bar Dam and 5600 cfs from the Hiwassee River, for a total average annual discharge from Nickajack Dam of 37,200 cfs.

There are two Vital Signs monitoring sites on Nickajack Reservoir, one at the forebay and one at the inflow. There is no transition zone site on Nickajack because the reservoir is short and water exchange is quite rapid. This causes conditions at the location which might be considered the transition zone to be similar to conditions at the forebay. Chickamauga Reservoir has four Vital Signs monitoring sites--the forebay, the transition zone, the inflow, and a new site established in 1993 in the Hiwassee River embayment.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activities have occurred on reservoirs in this watershed. It also provides planned activities in the future .

Nickajack Reservoir

Nickajack Reservoir is one of the smallest reservoirs on the mainstem of the Tennessee River. With the dam at TRM 424.7, Nickajack has a length of 46 miles, surface area of 10,370 acres, and a shoreline of 192 miles at full pool. Average annual discharge from Nickajack is approximately 37,200 cfs which provides an average hydraulic retention time of only about three or four days, the shortest retention time among the reservoirs monitored in this program.

Results from the 1990 and 1991 monitoring indicated that both the forebay and transition zone sampling sites had quite similar water quality. This was expected since the two sites are relatively close together (separated by only 7.5 river miles), and Nickajack is a well-mixed, run-of-the-river reservoir. Therefore, sampling at the transition zone in Nickajack Reservoir was discontinued in 1992.

Chickamauga Reservoir

Chickamauga Dam is located at TRM 471.0. The reservoir is 59 miles long, has 810 miles of shoreline, and has a surface area of 35,400 acres at full pool. The average annual discharge is approximately 34,900 cfs which provides an average hydraulic retention of nine to ten days.

The Hiwassee River, a major tributary to the Tennessee River, flows into the middle portion of Chickamauga Reservoir at about TRM 499. The flow from the entire Hiwassee River watershed contributes approximately 16 percent of the flow through Chickamauga Reservoir. About 10 percent of the 16 percent is from the Ocoee River and tributaries in the lower end of the Hiwassee watershed (i.e., downstream of Apalachia Dam).

Vital Signs monitoring activities were expanded in 1993 to include a site in the Hiwassee River embayment, which covers about 6500 acres. Given the relatively high flows in the Hiwassee River (about 5600 cfs annual average), there is substantial water exchange in this embayment, much greater than in any of the other three embayments monitored.

HIWASSEE RIVER WATERSHED

The headwaters of the Hiwassee River extend into the Blue Ridge Mountains in Tennessee, North Carolina, and Georgia. Streams in this watershed have naturally low concentrations of nutrients and dissolved minerals. These streams change from steep gradient, cold water trout streams in the mountains to lower gradient warm water streams in the valley.

The Hiwassee River Watershed has an area of 2700 square miles and an average annual discharge to the Tennessee River of 5640 cfs. The confluence of the Hiwassee River with the Tennessee River is in Chickamauga Reservoir at Tennessee River Mile 499.4. The lower portion of the Hiwassee River is impounded by backwater from Chickamauga Dam. The impounded portion of the Hiwassee River forms a large embayment (about 6500 surface acres) which extends over 20 miles up the Hiwassee River.

The largest tributary to the Hiwassee River is the Ocoee River, with a drainage area of about 640 square miles. Due to past copper mining and industrial activities in the Copperhill area, several streams and reservoirs in the Ocoee River basin have degraded water quality.

There are eight TVA reservoirs in the Hiwassee River. Through 1996, Vital Signs monitoring activities were conducted on only the five largest reservoirs: Hiwassee Reservoir (forebay and mid-reservoir); Chatuge Reservoir (forebay sites on the Hiwassee River and Shooting Creek arms); Nottely Reservoir (forebay and mid-reservoir); Ocoee Reservoir No. 1 (forebay only); and Blue Ridge Reservoir (forebay only). Beginning in 1997, Apalachia (forebay only) was added to the sampling schedule for the full complement of indicators; two indicators (benthic community and fish assemblage had been sampled in 1996). Ocoee No. 2 and Ocoee No. 3 Reservoirs are not included in this monitoring because of their small size.

Vital Signs monitoring also includes a site on the Hiwassee River embayment (at HiRM 10) of Chickamauga Reservoir with results reported with the Chickamauga/Nickajack Watershed.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activities have occurred on reservoirs in this watershed. It also provides planned activities in the future .

Apalachia Reservoir

Apalachia Reservoir is formed by Apalachia Dam at Hiwassee River mile 66.0 in western North Carolina near the Tennessee state line. At full pool elevation, the reservoir is 10 miles long, covers 1100 acres, and has a maximum depth of about 110 feet at the dam. Long-term flows from

Apalachia Dam average about 2090 cfs which result in an average hydraulic retention time of about 14 days. The annual drawdown averages about 4 feet on Apalachia Reservoir.

Hiwassee Reservoir

Hiwassee Reservoir, in the southwestern corner of North Carolina, is the second-largest of the five reservoirs in the Hiwassee River watershed included in the Vital Signs monitoring program. Hiwassee Reservoir is impounded by Hiwassee Dam at river mile 75.8. At full pool level, its backwater storage pool is about 22 miles long, 6100 acres in surface area, and has a mean depth of about 69 feet (with a maximum depth of about 255 feet at the dam). It has an average annual discharge of about 2060 cfs and average residence time of about 103 days. Hiwassee Reservoir has an average annual drawdown of 45 feet.

Chatuge Reservoir

Chatuge Reservoir is located on the Georgia-North Carolina state line in northeastern Georgia and is formed by Chatuge Dam at Hiwassee River mile (HiRM) 121.0. At full pool elevation, the reservoir is 13 miles long and has a surface area of about 7000 acres. Its maximum depth at the dam is 124 feet, and it has a mean depth of 33 feet. An average annual discharge of 464 cfs results in an average hydraulic residence time of about 254 days. Chatuge Reservoir has a potential useful controlled storage of 23 feet (1928-1905 feet MSL), however, the annual drawdown averages only ten feet.

Only the forebay of Chatuge Reservoir was monitored prior to 1993. A new monitoring site was added in 1993 in the Shooting Creek arm to further evaluate this rather large part of the lake. Because of its physical features, the Shooting Creek site would be expected to be representative of forebay conditions.

Nottely Reservoir

Nottely Reservoir is formed by Nottely Dam at Nottely River mile 21.0 in northern Georgia. At full pool elevation, the reservoir is 20 miles long, covers 4200 acres, and has a mean depth of 40 feet, with a maximum depth of about 165 feet at the dam. Long-term flows from Nottely Dam average about 420 cfs which result in an average hydraulic retention time of about 205 days. The annual drawdown averages about 24 feet on Nottely Reservoir.

Blue Ridge Reservoir

Blue Ridge Dam impounds the Toccoa River at mile 53.0 in rural northwest Georgia. The watershed is mountainous and forested, with a significant portion of the basin lying within the Chattahoochee National Forest. At full pool, Blue Ridge Reservoir is about 11 miles long, 3300 acres in surface area, and 155 feet deep at the dam, with a average depth of 59 feet. The rate of discharge of water from Blue Ridge Reservoir averages about 615 cfs, which results in an average theoretical residence time of 158 days. The annual drawdown of Blue Ridge Reservoir averages 36 feet.

Ocoee Reservoir No. 1 (Parksville Reservoir)

Ocoee No. 1 Reservoir, also known as Parksville Reservoir, is formed by Ocoee No. 1 Dam at Ocoee River mile 11.9. At full pool elevation, the reservoir has a surface area of about 1900 acres and length of 7.5 miles. Ocoee No. 1 Reservoir is located downstream from the Copper Basin, and decades of erosion have caused significant filling of the reservoir. Ocoee No. 1 Reservoir has lost about 25 percent of its original volume, has an average depth of 45 feet and is about 115 feet deep at the dam. An average annual discharge of about 1426 cfs from Ocoee No. 1 Dam results in a reservoir retention time of approximately 30 days. Although Ocoee No. 1 Reservoir is not operated for flood control (only for peaking power generation), its annual drawdown averages about seven feet.

Reservoir: Apalachia **2000 Score: 68%**

----Previous Scores----
2000 Criteria

1991	n/s
1992	n/s
1993	n/s
1994	n/s
1995	n/s
1996	60[1]
1997	69
1998	61
1999	59
2000	68

1. only fish and benthos

Apalachia	2000 Results					Change between 1999 and 2000				
	FB	MR	Emb	Inf	Total	FB	MR	Emb	Inf	Total
Chlorophyll	P 2.7				2.7	-0.6				-0.6
DO	F 3.5				3.5	0.0				0.0
Fish	F 2.0				2.0	0.0				0.0
Benthos	G 5.0				5.0	3.0				3.0
Sediment	F 2.0				2.0	-0.5				-0.5
Total	15.2				15.2	1.9				1.9

Summary/Key Ecological Health Findings for 2000: The overall ecological health rating for Apalachia Reservoir was fair in 2000. Benthos was the only indicator to rate good. DO, fish, and sediment rated fair and chlorophyll poor. The good rating for benthos resulted from a good density and variety of organisms. Chlorophyll concentrations were higher than expected for a reservoir in this nutrient poor watershed. The higher chlorophyll concentrations in 2000 may have been related to low reservoirs flows. Apalachia has a short retention time under normal flow conditions. This would tend to limit increases in algal populations and hence chlorophyll. However, during dry years like 2000, low flows occur and retention time is increased thereby allowing algae to reach more of their growth potential. DO rated fair due to a small zone of low DO (<2mg/L) water along the bottom in late summer. The fair rating for the fish assemblage resulted from the collection of relatively few fish, which in turn had a negative effect on several of the characteristics (metrics) used to evaluate the fish community. Sediment rated fair due to slightly elevated concentrations of copper.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: The ecological health score for Apalachia has been consistently in the fair category. DO has rated fair each year due to a small zone of low DO water at the bottom in late summer. Chlorophyll concentrations were within the expected range in 1997 and 1998 and rated good. However, elevated concentration in 1999 resulted in a fair rating and even higher concentration in 2000 resulted in a poor rating. Apalachia typically has short retention time, but low flow conditions experienced in 1999 and 2000 could have increased retention time and allowed higher algal productivity. The fish assemblage has rated poor three of the four years due to low fish density and diversity. Sediment quality has fluctuated between good and fair. Low levels of chlordane were detected in 1998 and, in 1999, copper concentration equaled the threshold limit (50 ppm) for expected background levels. Copper concentrations are slightly elevated in much of the Hiwassee watershed due in part to the geology of the area. Interestingly, the benthic community had rated in the poor to low fair range until 2000 when the community received a good rating. The improvement resulted from an increase in the density and diversity of organisms.

Aquatic Macrophytes in 2000: Not an issue on Apalachia.

Status of Fish Consumption Advisories in 2000: There are no fish consumption advisories on Apalachia Reservoir. TVA last collected fish from Apalachia Reservoir in autumn 1998. Results were provided to North Carolina agencies. All contaminant levels were either below detection levels or below the levels used by the state to issue fish consumption advisories. Fish from Apalachia will be collected for tissue analysis again in autumn 2002

Status of Swimming Advisories in 2000: There are no swimming advisories on Apalachia Lake. No sites were sampled for fecal coliform bacteria in 2000. The boat launch in the tailwater of Hiwassee Dam was sampled in 1999 and results were well within State of North Carolina guidelines for water contact. This site will be sampled again in summer 2001.

Reservoir: Hiwassee **2000 Score: 69%**

—Previous Scores—
2000 Criteria

1991	72[1]
1992	71[1]
1993	69
1994	62
1995	n/s
1996	62
1997	n/s
1998	67
1999	n/s
2000	69

1. only Chl, DO, and Fish

Hiwassee	2000 Results					Change between 1998 and 2000				
	FB	MR	Emb	Inf	Total	FB	MR	Emb	Inf	Total
Chlorophyll	F 3.9	P 2.6			6.5	-1.0	0.3			-0.7
DO	P 2.5	G 5.0			7.5	-1.0	1.5			0.5
Fish	G 4.0	G 4.0			8.0	0.0	0.0			0.0
Benthos	P 2.0	P 2.0			4.0	0.0	0.0			0.0
Sediment	G 2.5	G 2.5			5.0	0.5	0.5			1.0
Total	14.9	16.1			31.0	-1.5	2.3			0.8

Summary/Key Ecological Health Findings for 2000: The overall ecological condition of Hiwassee Reservoir was fair in 2000. The forebay and mid-reservoir sites rated good for fish and sediments and poor for benthos. Fewer fish were collected at both sites than expected, however, community composition was good; whereas, the benthic communities were composed primarily of tolerant oligochaetes and received poor ratings. DO rated poor at the forebay due to low concentrations (<2 mg/l) in late summer. Although low DO water encompassed only a small percentage of the water column, a large percentage of the bottom was exposed to DOs below 1mg/l resulting in a poor rating. The mid-reservoir location rated good for DO. Chlorophyll rated fair at the forebay due to slightly elevated concentration and poor at the mid-reservoir site.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: Hiwassee has rated fair in all years. The more consistent characteristics (indicators) of the reservoir are a good fish community and poor benthic community (dominated by tolerant oligochaetes). Low DO levels have been a consistent issue in the forebay which usually rates poor. DO received a fair rating in 1998 due to a malfunction of the oxygenation system that influenced near-bottom oxygen levels further upstream in the reservoir than planned. Mid-reservoir has experienced only limited low DO, rating a "high" fair in previous years; 2000 was the first year for DO to rate good. Very low levels of chlordane were detected in 1993 and 1998 at both reservoir locations; no other contaminates have had concentrations of concern. An issue of concern is the apparent increase in chlorophyll at the mid-reservoir site. Chlorophyll has shown a fairly consistent increase at the mid-reservoir site since monitoring began in 1991. This increase has not occurred at the forebay. Chlorophyll concentrations bear watching in future monitoring.

Aquatic Macrophytes in 2000: Not an issue on Hiwassee.

Status of Fish Consumption Advisories in 2000: There are no fish consumption advisories on Hiwassee Reservoir. Channel catfish and largemouth bass were last collected in autumn 1996. Channel catfish fillets were analyzed for pesticides, PCBs, and metals and largemouth bass fillets for mercury. All contaminant levels were either below detection levels or below the levels typically used by the states to issue fish consumption advisories. These species were sampled again in autumn 2000 and results are expected in spring 2001.

Status of Swimming Advisories in 2000: There are no State of North Carolina swimming advisories along Hiwassee Reservoir and River. Four locations along Hiwassee Reservoir and River in North Carolina were sampled ten times each for fecal coliform bacteria in 2000. All sites sampled met North Carolina bacteriological water quality criteria for water contact recreation.

Reservoir: Chatuge **2000 Score: 58%**

—Previous Scores—
2000 Criteria

1991	**59**[1]
1992	**79**[1]
1993	**79**
1994	**72**
1995	**n/s**
1996	**78**
1997	**n/s**
1998	**49**
1999	**49**
2000	**58**

1. FB only and no sediment, no benthos

Chatuge	2000 Results					Change between 1999 and 2000				
	FB	Sh.Cr.	Emb	Inf	Total	FB	Sh.Cr.	Emb	Inf	Total
Chlorophyll	G 4.8	G 4.5			9.3	0.4	0.7			1.2
DO	F 3.0	P 2.5			5.5	1.5	1.0			2.5
Fish	F 3.0	F 3.0			6.0	0.0	0.0			0.0
Benthos	P 2.0	P 1.0			3.0	1.0	-1.0			0.0
Sediment	F 1.5	P 1.0			2.5	0.0	0.5			0.5
Total	14.3	12.0			26.3	2.9	1.2			4.2

<u>Summary/Key Ecological Health Findings for 2000:</u> The overall ecological health rating for Chatuge Reservoir was poor in 2000. At both sampling locations, chlorophyll rated good, fish rated fair, and benthos rated poor. The DO levels were slightly better at the forebay (fair) than Shooting Creek (poor); both locations had DOs below 2 mg/l in the lower water column August through October (the greatest volume below 2 mg/l occurring in October). Sediment rated fair at the forebay due to high concentrations of copper and poor at Shooting Creek due to high levels of copper, chromium, and nickel. The poor rating for the benthic macroinvertebrates occurred because very few animals were collected. The fish assemblage rated fair at both monitoring locations—lower catch rates than expected but relatively good species diversity.

<u>Explanation of Differences in Ecological Health Scores in 2000 and Previous Years:</u> The 2000 ecological health score for Chatuge Reservoir was at the upper end of the poor range (58, one point from fair); a nine point increase over 1999 (49) and 1998 (49), but still much lower than the good ratings for previous years when scores were often in the upper 70s. Chatuge had a substantial decrease in ecological health score in 1998 due to low DO levels, relatively high chlorophyll, and poor ratings for the fish assemblage. In addition, elevated levels of nickel were found for the first time at the Shooting Creek location. Similar issues were found in 1999 and 2000; the primary exception being improved ratings for the fish assemblage (fair) yet a decline in ratings for the benthos (poor). Also, anoxic conditions did not occur in 1999 or 2000. DO and chlorophyll scored higher in 2000 as compared to 1998 and 1999, but scores remained below those of earlier years. It was speculated that the unusually dry, hot weather in the late summer of 1998 was a likely contributing factor. This unusual weather pattern occurred again in 1999 and 2000, and Chatuge was again characterized by poor ecological conditions. Chatuge will be monitored again in 2002.

<u>Aquatic Macrophytes in 2000:</u> Not an issue on Chatuge Reservoir.

<u>Status of Fish Consumption Advisories in 2000:</u> There are no fish consumption advisories on Chatuge Reservoir. Channel catfish and largemouth bass were last collected in autumn 1996. Channel catfish fillets were analyzed for pesticides, PCBs, and metals and largemouth bass fillets for mercury. The results were provided to state agencies. All contaminant levels were either below detection levels or below the levels used by the state to issue fish consumption advisories. These species were sampled again in autumn 2000 and results are expected in spring 2001.

<u>Status of Swimming Advisories in 2000:</u> There are no swimming advisories along Chatuge Reservoir. Nine locations were sampled ten times each for fecal coliform bacteria in 2000. All sites sampled met the bacteriological water quality criteria for water contact recreation in the state in which they were sampled (North Carolina or Georgia).

WATTS BAR RESERVOIR, FORT LOUDOUN RESERVOIR, AND MELTON HILL RESERVOIR WATERSHED

This watershed area is relatively small (2860 square miles) and includes three reservoirs: Fort Loudoun and Watts Bar Reservoirs on the Tennessee River and Melton Hill Reservoir on the Clinch River. All three are run-of-the-river reservoirs with relatively short retention times and annual pool drawdowns of only a few feet. The inflow of Fort Loudoun Reservoir is actually the origin of the Tennessee River. The Holston and French Broad Rivers merge at that point to form the Tennessee River. The Little Tennessee River, another major tributary to the Tennessee River, enters Fort Loudoun Reservoir near the forebay. Watts Bar Reservoir is immediately downstream of Fort Loudoun. The Clinch River, another major tributary, merges with the Tennessee River upstream of the transition zone on Watts Bar Reservoir. Melton Hill Dam bounds the upper end of Watts Bar Reservoir on the Clinch River and Fort Loudoun Reservoir bounds it on the Tennessee River.

Like the other watershed areas formed around one or more of the reservoirs on the mainstream of the Tennessee River, very little of the water leaving this watershed area originates from within. The average annual discharge through Watts Bar Reservoir is about 27,700 cfs. Of this, about 25 percent (6800 cfs) enters from the French Broad River, 16 percent (4500 cfs) from the Holston River, 21 percent (5700 cfs) from the Little Tennessee River, and 17 percent (4600 cfs) from Norris Dam on the Clinch River. Another five percent (1400 cfs) is contributed by the Emory River, a tributary to the Clinch River near the confluence with the Tennessee River. The remaining 17 percent (4700 cfs) originates from streams which drain directly to one of these reservoirs.

Vital Signs monitoring activities are conducted at the forebays, transition zones, and inflows of all three of these reservoirs. Watt Bar Reservoir has two inflow sites, one near Fort Loudoun Dam and one near Melton Hill Dam.

Table 1 of this appendix identifies the years when Vital Signs Monitoring activities have occurred on reservoirs in this watershed. It also provides planned activities in the future .

Watts Bar Reservoir

Watts Bar Reservoir impounds water from both the Tennessee River and one of the major tributaries to the Tennessee River, the Clinch River. The three dams which bound Watts Bar Reservoir are: Watts Bar Dam located at Tennessee River Mile (TRM) 529.9, Fort Loudoun Dam located at TRM 602.3, and Melton Hill Dam located at Clinch River mile (CRM) 23.1. The total length of Watts Bar Reservoir, including the Clinch River arm is 96 miles, the shoreline length is 783 miles, and the surface area is 39,000 acres. The average annual discharge from Watts Bar is approximately 27,700 cfs, providing an average hydraulic retention time of about 18 days.

The confluence of the Clinch and Tennessee Rivers is upstream of the transition zone sampling location in Watts Bar, so biological sampling was conducted at the forebay, transition zone, and both the Tennessee River and Clinch River inflows. Water entering Watts Bar from Melton Hill Reservoir is quite cool due to the hypolimnetic withdrawal from Norris Reservoir (a deep storage impoundment) upstream from Melton Hill. Water entering Watts Bar Reservoir from Fort Loudoun Dam is usually warmer and lower in DO during summer months than water entering from Melton Hill Dam.

The Emory River is a major tributary to the Clinch River arm of Watts Bar Reservoir and supplies about 5 percent of the average annual flow through Watts Bar Reservoir. The Tennessee and Little Tennessee Rivers (i.e., discharge from Fort Loudoun Dam) account for about 75 percent of the flow, and the Clinch River (i.e., discharge from Melton Hill Dam) accounts for about 15 percent through Watts Bar Reservoir.

Fort Loudoun Reservoir

Fort Loudoun Reservoir is the ninth and uppermost reservoir on the Tennessee River with the dam located at TRM 602.3. The surface area and shoreline are relatively small (14,600 acres and 360 miles, respectively) considering the length (61 miles), indicating it is mostly a run-of-the-river reservoir. The average annual discharge from Fort Loudoun Dam is 18,900 cfs which provides an average hydraulic retention time of about ten days.

Fort Loudoun Reservoir (and the Tennessee River) is formed by the confluence of the French Broad and Holston Rivers, with both of these rivers having a major reservoir upstream. Douglas Dam, 32.3 miles up the French Broad River, and Cherokee Dam, 52.3 miles up the Holston River, form deep storage impoundments, each having long retention times. Both of these deep storage impoundments become strongly stratified during summer months resulting in the release of cool, low DO, hypolimnetic water during operation of the hydroelectric units. Some warming and reaeration of the water occurs downstream from Cherokee and Douglas Dams, but both temperature and DO levels are sometimes low when the water reaches Fort Loudoun Reservoir. Installation of aeration facilities at both these dams has helped abate this situation.

Fort Loudoun Reservoir also receives surface waters from the Little Tennessee River, via the Tellico Reservoir canal, which connects the forebays of the two reservoirs. (Since Tellico Dam has no outlet, under most normal conditions, water flows into Fort Loudoun Reservoir from Tellico Reservoir.) Water from Tellico Reservoir (Little Tennessee River) is often cooler and higher in DO, and has a much lower conductivity than water in Fort Loudoun Reservoir (Tennessee River). In 1992, the forebay sampling location on Fort Loudoun Reservoir (originally located at TRM 603.2) was moved upstream to TRM 605.5. This resulted in a better assessment of the water quality conditions of the Tennessee River in the forebay portion of Fort Loudoun Reservoir by minimizing the effects of the Little Tennessee River and Tellico Reservoir on the data gathered in the forebay of Fort Loudoun Reservoir.

Although Fort Loudoun Reservoir is a mainstream reservoir, its complex set of hydrologic conditions (cool water inflows from the Holston, French Broad, and Little Tennessee Rivers) often causes it to exhibit several characteristics that are more typical of a storage impoundment. In fact, analysis of historical fisheries data for the Tennessee Valley indicates the fish community of Fort Loudoun Reservoir is more similar to that in Valley storage impoundments than in other mainstream reservoirs.

Melton Hill Reservoir

Melton Hill Dam is located at mile 23.1 on the Clinch River and is 56.7 miles downstream of Norris Dam. Impounded water extends upstream from Melton Hill Dam about 44 miles. Melton Hill Reservoir has about 170 miles of shoreline and 5690 surface acres at full pool. Average flow through Melton Hill is about 5140 cfs resulting in an average retention time of approximately 12 days. Melton Hill is TVA's only tributary dam with a navigation lock.

The predominant factor influencing the aquatic resources of Melton Hill Reservoir, especially the inflow and mid-reservoir areas, is the cold water entering from Norris Dam discharges. During summer, water discharged from Norris is cold and low in oxygen content. Oxygen concentrations are improved by a re-regulation weir downstream of Norris Dam and by atmospheric reaeration in the river reach between Norris Dam and upper Melton Hill Reservoir. However, water is warmed little and is still quite cool when it enters upper Melton Hill Reservoir. Bull Run Steam Plant, located at about CRM 47, warms the water some, but water temperatures are still marginally low to support warm water biota and marginally warm to support cold water biota.

Reservoir: Watts Bar **2000 Score: 59%**

—Previous Scores—
2000 Criteria

1991	72
1992	79
1993	76
1994	72
1995	n/s
1996	68
1997	n/s
1998	64
1999	n/s
2000	59

Watts Bar	2000 Results				
	FB	TZ	TR-Inf	CR-Inf	Total
Chlorophyll	P 2.1	P 2.5			4.6
DO	P 1.5	G 4.5			6.0
Fish	G 4.0	G 4.0	F 4.0	F 4.0	16.0
Benthos	P 2.0	F 3.0	P 2.0	P 2.0	9.0
Sediment	F 1.5	F 1.5			3.0
Total	11.1	15.5	6.0	6.0	38.6

Change between 1998 and 2000				
FB	TZ	TR-Inf	CR-Inf	Total
1.1	0.1			1.2
-3.0	-0.5			-3.5
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0			0.0
-1.9	-0.4	0.0	0.0	-2.3

Summary/Key Ecological Health Findings for 2000: Overall, Watts Bar Reservoir had a fair ecological condition rating in 2000, but near the poor range. The biggest issues were elevated chlorophyll at both the forebay and transition zone; low DO at the forebay; and low scores for benthos at three of the four sample sites. Chlorophyll rated poor because concentrations were high, particularly in late summer. Low DO concentrations at the forebay, primarily in July but also in June and September, resulted in a poor rating for DO. Low rainfall amounts and resulting low reservoir flows were the main contributing factors for the low DO levels. Benthos rated poor at the forebay and both inflow sites due to low overall density and the lack of intolerant organisms. Good numbers and diversity of fish were collected at all sites and resulted in good or "high" fair fish scores at all sites. Sediments rated fair due to presence of PCBs and DDTr at the forebay and PCBs and chlordane at the transition zone.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: The overall ecological condition score for Watts Bar Reservoir was fair in 2000; the lowest overall score to date and near the poor range. Prior to 1996, Watts Bar had rated good or at least at the upper end of the fair range. Three of the five ecological health indicators have changed substantially over time: chlorophyll, benthos, and sediment quality. The decrease in chlorophyll ratings has occurred because concentrations have increased substantially during this period. Chlorophyll concentrations were high again in 2000, but not as high as in 1998. Ratings for benthos have also decreased as benthic index scores have declined due to collection of fewer organisms and absence of intolerant, long-lived animals. The decrease in sediment quality ratings has resulted from a greater frequency of occurrence of organic chemicals (mostly PCBs and chlordane), probably more due to sampling variability rather than a true increase of these chemicals because of their historical, rather than current, use. The factor which drove the overall rating for Watts Bar Reservoir down in 2000 was a lower rating for DO at the forebay – most probably related to low reservoir flows. Low DOs have occurred at the forebay in the past, usually in drought years like 2000.

Aquatic Macrophytes in 2000: Aquatic macrophytes covered about 25 acres in 2000.

Status of Fish Consumption Advisories in 2000: The State of Tennessee has issued several advisories for fish in Watts Bar Reservoir because of PCB contamination. Striped bass, catfish, and striped bass/white bass hybrids caught in the Tennessee River arm of the reservoir should not be eaten. Largemouth bass, white bass, sauger, carp, and smallmouth buffalo caught in the Tennessee River arm and catfish and sauger caught in the Clinch River arm should not be eaten by pregnant women, nursing mothers, and children. Other individuals should limit their consumption to no more than one meal per month. Additional fish were collected in autumn 2000; channel catfish fillets will be analyzed for pesticides, PCBs, and metals and largemouth bass fillets for mercury. Results are expected in spring 2001. Prior to that, fish were last collected in 1998. The results, which were provided to state agencies in Tennessee for appropriate action, were similar to previous years, or slightly lower.

Status of Swimming Advisories in 2000: There are no State of Tennessee swimming advisories on Watts Bar Reservoir. Twenty-seven sites were sampled ten times each for fecal coliform bacteria in 2000. All but one site met the State bacteriological water quality criteria for water contact recreation. Eden on Lake Beach exceeded the state criteria because a single sample exceeded 1,000 colonies per 100 milliliters.

Reservoir: Fort Loudoun **2000 Score: 57%**

—Previous Scores—	2000 Criteria
1991	
1992	
1993	
1994	62
1995	47
1996	52
1997	57
1998	62
1999	49
2000	57

Ft Loudoun	2000 Results					Change between 1999 and 2000				
	FB	TZ	Emb	Inf	Total	FB	TZ	Emb	Inf	Total
Chlorophyll	P 1.0	P 1.0			2.0	0.0	0.0			0.0
DO	G 4.5	G 5.0			9.5	3.0	0.0			3.0
Fish	G 4.0	G 4.0		G 4.0	12.0	0.0	1.0		0.0	1.0
Benthos	P 1.0	F 3.0		P 1.0	5.0	0.0	0.0		0.0	0.0
Sediment	F 1.5	F 1.5			3.0	0.0	0.5			0.5
Total	12.0	14.5		5.0	31.5	3.0	1.5		0.0	4.5

Summary/Key Ecological Health Findings for 2000: The overall ecological condition of Fort Loudoun Reservoir was poor in 2000. The year was characterized by low flows and increased retention time. Indicators affected most by these conditions responded as expected and resulted in poor ratings. Chlorophyll concentrations were quite high at both monitoring sites and rated poor, whereas, DO concentrations were reduced in bottom strata at the forebay but they did not go below 2 mg/l; the level at which the rating is affected. Benthos rated poor at the forebay and inflow due to low diversity and abundance with only tolerant, short-lived animals present. Sediment quality rated fair at both sample sites due to presence of chlordane. Fish rated good at all three sites due to presence of a good mix of species. This marks the first time that the fish assemblage on Fort Loudoun Reservoir has rated good at all three monitoring sites.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: The ecological condition of Fort Loudoun has rated poor during most previous years. Primary issues in Fort Loudoun are consistently high chlorophyll concentrations, low diversity and abundance of benthic macroinvertebrates, presence of one or a combination of the following contaminants in bottom sediments: chlordane, PCBs, or zinc. Ratings for these three indicators reduce the overall ecological health rating each year. The fish assemblage has typically rated in the fair range but has had higher ratings the past few years and even rated good at all three locations for the first time in 2000. The remaining indicator (DO) has consistently rated good at the transition zone as well as at the forebay except during exceptionally low flow years when the DO rates poor at the forebay which was the case in 1995 and 1998. Similarly low flows also occurred in 2000 and DO concentrations were reduced at the forebay, but not to the point that the rating was reduced.

Aquatic Macrophytes in 2000: Only nominal amounts of macrophytes occur on Fort Loudoun (about 25 acres).

Status of Fish Consumption Advisories in 2000: The State of Tennessee advises against eating catfish from Fort Loudoun Reservoir because of PCB contamination. The state also has issued an advisory for largemouth bass that weigh more than two pounds and for all largemouth bass caught in the Little River embayment. The last time TVA analyzed fish from Fort Loudoun Reservoir for a broad array of contaminants was in autumn 1998 when channel catfish fillets were analyzed (pesticides, PCBs, and metals) and largemouth bass fillets were analyzed for mercury. In addition, channel catfish are collected from the middle part of the reservoir annually and the fillets analyzed for selected pesticides and PCBs. The results, which were provided to state agencies for appropriate action, were similar to previous years. The broad array of contaminants will be analyzed again in 2002.

Status of Swimming Advisories in 2000: There are no State of Tennessee swimming advisories on Fort Loudoun Reservoir. Seven sites on Ft. Loudoun Reservoir were sampled ten times each for fecal coliform bacteria in 2000. All sites met State of Tennessee bacteriological water quality criteria for water contact recreation.

Reservoir: **Melton Hill** 2000 Score: 68%

Previous Scores
2000 Criteria

1991	67
1992	65
1993	66
1994	71
1995	61
1996	69
1997	n/s
1998	69
1999	n/s
2000	68

Melton Hill	2000 Results					Change between 1998 and 2000				
	FB	TZ	Emb	Inf	Total	FB	TZ	Emb	Inf	Total
Chlorophyll	P 2.7	G 5.0			7.7	-0.5	0.5			0.0
DO	F 3.0	G 5.0			8.0	-2.0	0.0			-2.0
Fish	G 4.0	G 4.0		F 3.0	11.0	-1.0	0.0		0.0	-1.0
Benthos	P 2.0	P 2.0		P 2.0	6.0	0.0	0.0		1.0	1.0
Sediment	G 2.5	G 2.5			5.0	1.0	1.0			2.0
Total	14.2	18.5		5.0	37.7	-2.5	1.5		1.0	0.0

Summary/Key Ecological Health Findings for 2000: The overall ecological health score for Melton Hill Reservoir was fair in 2000. Only two indicators used to evaluate ecological conditions showed consistent results among sample sites. Sediment quality rated good at both sample sites, whereas the benthos rated poor at all three sample sites (where that indicator was monitored). Otherwise, chlorophyll rated poor at the forebay (due to elevated concentrations) and good at the transition zone; DO rated fair at the forebay (due to low DO concentrations in late spring and early summer) and good at the transition zone; and the fish assemblage rated good at the forebay and transition zone and fair at the inflow site. Dry weather conditions and resulting low reservoir flows significantly affected Melton Hill in 2000. These effects were most evident at the forebay as characterized by high chlorophyll levels and low DO levels in lower strata, neither of which typically occur in Melton Hill.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: The fair overall ecological health score for Melton Hill Reservoir was similar to previous years. Although the overall scores have been similar, results for 2000 and, to some extent those for 1998, were vastly differently from previous years. High chlorophyll and low DO concentrations at the forebay during these years are uncharacteristic of this reservoir. For 2000, lower ratings for these indicators were off-set by higher ratings for sediment quality (chlordane had been detected at concentrations near the laboratory detection limit in most previous years) and the fish assemblage. The changes observed and the location where they occurred (the forebay) are the type of changes expected to be related to weather/low flow conditions. Low flows not only increase retention time thereby allowing algae sufficient time to fully utilize available nutrients, but they also do not provide energy to mix upper and lower strata (particularly at the forebay) allowing the reservoir to stratify and oxygen depletion to occur in lower strata. Hopefully, a return to more normal flow conditions in subsequent years will alleviate these issues in Melton Hill.

Aquatic Macrophytes in 2000: Aquatic macrophytes covered an estimated 10 acres on Melton Hill Reservoir in 2000.

Status of Fish Consumption Advisories in 2000: The state of Tennessee advises against eating catfish from Melton Hill Reservoir because of PCB contamination. Channel catfish were collected in autumn 1998 and analyzed for selected pesticides and PCBs. The results, which were provided to state agencies in Tennessee for appropriate action, were similar to previous years. Additional channel catfish and largemouth bass were collected in autumn 2000 for analysis of a broader array of analytes (pesticides, PCBs, and metals). Results from analysis of those fish are expected in spring 2001.

Status of Swimming Advisories in 2000: There are no swimming advisories on Melton Hill Reservoir. Six sites were sampled ten times each for fecal coliform bacteria in 2000. Three of these sites exceeded State of Tennessee bacteriological water quality criteria for water contact recreation either because one sample exceeded 1,000 colonies per 100 milliliters or because the geometric mean of ten samples exceeded 200/100mL. Large numbers of water fowl (Canadian geese) were present, which is a likely source of contamination, at all three sites, and samples with elevated counts typically followed rain events.

CLINCH RIVER AND POWELL RIVER WATERSHED

This long, narrow watershed lies in southwest Virginia and northeast Tennessee. Streams in the watershed have high concentrations of dissolved minerals and generally low concentrations of nutrients.

For management purposes, an artificial ending point of the watershed has been established at Norris Dam, which is near Clinch River mile 80. The remainder of the Clinch River is associated with the Watts Bar, Fort Loudoun, and Melton Hill Reservoir Watershed area. As defined, this watershed drains an area of 2912 square miles and has an average annual discharge of about 4300 cfs. The Clinch and Powell Rivers contribute about 80 percent of this flow.

Norris Reservoir is the only major reservoir in the watershed; essentially all streams upstream from Norris are free flowing. There are three Vital Signs monitoring sites in Norris Reservoir (forebay and mid-reservoir sites on the Clinch and Powell arms).

Table 1 of this appendix identifies the years when Vital Signs Monitoring activities have occurred on Norris Reservoir. It also provides planned activities in the future .

Norris Reservoir

Norris Reservoir is formed by Norris Dam at Clinch River mile (CRM) 79.8. It is a large, dendritic, tributary storage impoundment of the Clinch and Powell Rivers which flow together about nine miles upstream of the dam. Norris is one of the deeper TVA tributary reservoirs, with depths over 200 feet. Annual drawdown averages about 32 feet. At full pool, the surface area of the reservoir is 34,200 acres, the shoreline is about 800 miles in length, and water is impounded 73 miles upstream on the Clinch River and 53 miles upstream on the Powell River. Norris Reservoir has a long average retention time (about 239 days) and an average annual discharge of approximately 4300 cfs. Due to the great depth and long retention time of Norris Reservoir, significant vertical stratification is expected.

Because of the confluence of the Clinch and Powell Rivers relatively close to the dam, three reservoir sampling locations were established: one forebay site; and two mid-reservoir sites--one on the Clinch River and one on the Powell River.

LITTLE TENNESSEE RIVER WATERSHED

The Little Tennessee River Watershed encompasses 2672 square miles, mostly in Tennessee and North Carolina with a small area in Georgia. Much of the watershed is forested, with the headwaters in the Blue Ridge Mountains. The basin is underlain mostly by crystalline and metasedimentary rocks of the Blue Ridge province. This watershed is home to a large variety of federally listed threatened and endangered species.

Most of the streams in the watershed are steep gradient and generally have low concentrations of both dissolved minerals and nutrients. The two largest tributaries to the Little Tennessee River are the Tuckasegee River which merges with the Little Tennessee in Fontana Reservoir and the Tellico River which merges with the Little Tennessee in Tellico Reservoir.

There are several reservoirs in the watershed but only Fontana Reservoir in the mountainous area and Tellico Reservoir at the lower end of the watershed are monitored. TVA does not monitor the other reservoirs either because of their small size or because they are owned by the Aluminum Company of America (ALCOA).

Two sites are monitored on Tellico Reservoir (the forebay and transition zone) and three sites on Fontana Reservoir (the forebay and mid-reservoir sites on the Little Tennessee River and Tuckasegee River).

Table 1 of this appendix identifies the years when Vital Signs Monitoring activities have occurred on reservoirs in this watershed. It also provides planned activities in the future .

Tellico Reservoir

Tellico Dam is located on the Little Tennessee River just upstream of the confluence of the Little Tennessee and Tennessee Rivers. It is the last dam completed in the TVA system with dam closure in 1979. Tellico Reservoir is 33 miles long, has a shoreline of 373 miles, and has a surface area of about 16,000 acres at full pool. The average estimated flow through Tellico Reservoir is approximately 6200 cfs which provides an average retention time of about 34 days. Very little of this water is discharged through Tellico Dam. Rather, it is diverted through a navigation canal to Fort Loudoun Reservoir near the dam for hydroelectric power production. Water characteristics in these two reservoirs differ considerably. The hydrodynamics and exchange of water via the inter-connecting canal significantly affect water quality within Tellico Reservoir (and Fort Loudoun Reservoir). The canal is only 20-25 feet deep, but the depth of Tellico Reservoir at the forebay is about 80 feet. Thus, water in deeper strata in the forebay is essentially trapped and becomes anoxic during the summer.

The impounded water of Tellico Reservoir extends upstream of the confluence of the Little Tennessee and Tellico Rivers. The transition zone site selected for sample collection in 1990, 1991, and 1992 was in the Little Tennessee River, just upstream of the confluence with the Tellico River at Little Tennessee River Mile (LTRM) 21.0. Water conditions at that site are largely controlled by discharges from Chilhowee Dam at LTRM 33.6. This water is cold, nutrient poor, and has a low mineral content, conditions that are not conducive to establishing a diverse, abundant aquatic community. In 1993, the transition zone sampling location in Tellico Reservoir was moved six miles downstream to LTRM 15.0, just below the confluence of the Tellico River--a site more characteristic of a transition environment rather than riverine conditions.

Fontana Reservoir

Fontana Reservoir is located in the Blue Ridge Mountains of western North Carolina. Fontana is the deepest reservoir in the TVA system. At full pool it has a maximum depth of 460 feet, a length of 29 miles, a shoreline of 248 miles, and a surface area of 10,640 acres. Fontana Reservoir has a relatively large drawdown, which averages about 64 feet annually. Every fifth year Fontana is drawn even deeper to allow sluice gate access for maintenance.

Fontana Dam is located at Little Tennessee River Mile 61.0. Average annual discharge is 3950 cfs which provides an average hydraulic retention time in the reservoir of 181 days.

Water in Fontana Reservoir is quite clear due to limited photosynthetic activity and a mostly forested watershed. Water entering the reservoir is low in nutrients and dissolved minerals.

Reservoir: Fontana **2000 Score: 70%**

—Previous Scores—
2000 Criteria

1991	n/s
1992	n/s
1993	71
1994	77[1]
1995	72[2]
1996	62
1997	n/s
1998	68
1999	n/s
2000	70[3]

Fontana	2000 Results					Change between 1998 and 2000				
	FB	LTR-MR	TkR-MR	Inf	Total	FB	LTR-MR	TkR-MR	Inf	Total
Chlorophyll	G 5.0	P 2.9	F 3.2		11.0	0.0	-1.6	-0.7		-2.3
DO	F 3.5	G 4.5	F 3.0		11.0	0.0	1.0	0.5		1.5
Fish	F 3.0	F 4.0	F 3.0		10.0	0.0	0.0	-1.0		-1.0
Benthos	P 1.0	ns	ns		1.0	0.0				0.0
Sediment	G 2.5	G 2.5	F 2.0		7.0	0.5	0.5	0.0		1.0
Total	15.0	13.9	11.2		40.0	0.5	-0.1	-1.2		-0.8

1. no benthos at forebay
2. no benthos at either mid-res site, no fish at forebay
3. no benthos at either mid-res site

Summary/Key Ecological Health Findings for 2000: The overall ecological condition in Fontana Reservoir was fair in 2000 with a score at the upper end of the fair range. However, this score is somewhat misleading because the indicator which usually rates in the poor category, benthic macroinvertebrate community, could not be sampled at two locations in 2000 due to the extraordinary reservoir draw-down to allow for the scheduled 5-year safety check and maintenance at Fontana Dam. Had that indicator been monitored at all sites and the results comparable to past years, the score would have been several points lower but still in the fair range. Of particular interest in 2000 were elevated chlorophyll levels at the two mid-reservoir sample locations. Chlorophyll rated fair on the Tuckaseege River arm and poor on the Little Tennessee River arm. This poor rating for chlorophyll marks the first time chlorophyll has rated poor at any location on Fontana since this monitoring program began.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: Fontana Reservoir rated fair in 2000, similar to most previous years. The 2000 score was near the upper end of the fair range, but the score would have been lower had all indicators been sampled at all locations as discussed above. The slight increase in chlorophyll concentrations from year-to-year, especially at the mid-reservoir sample sites, continues to be the most notable observation from these monitoring results. These increases have caused chlorophyll to change from a good rating at all locations in the early 1990's to fair and even poor ratings at some sites in 2000. These results may indicate Fontana Reservoir is beginning to change from the expected oligotrophic conditions to a more productive state, possibly due to nutrient enrichment. Another troublesome observation is the increase in low DO volume in lower strata of Fontana which was evident in 1998 and 2000, the two most recent monitoring periods. Both observations (for chlorophyll and DO) bear watching in future years monitoring.

Aquatic Macrophytes in 2000: Aquatic macrophytes are prevented from becoming established on Fontana by the water level drawdown for flood control.

Status of Fish Consumption Advisories in 2000: There are no fish consumption advisories on Fontana Reservoir. Channel catfish and largemouth bass were collected in autumn 2000 for analysis of pesticides, PCBs, and metals. Results are expected to be available in spring 2001. Prior to that, Fontana was last sampled in autumn 1996. All contaminant levels were either below detection levels or below the levels used by the state to issue fish consumption advisories.

Status of Swimming Advisories in 2000: Four locations on Fontana Reservoir were sampled ten times each for fecal coliform bacteria in 2000. All of these sites sampled met the bacteriological water quality criteria for water contact recreation in North Carolina. There are no State of North Carolina swimming advisories along the Blue Ridge Reservoir.

FRENCH BROAD RIVER WATERSHED

The French Broad River watershed is one of the largest (5124 square miles) watersheds in the Tennessee Valley. About half the watershed is in Tennessee and half is in North Carolina. The French Broad River and its two large tributaries (Nolichucky and Pigeon Rivers) originate in the Blue Ridge Mountains. All three of these rivers merge at the upper end of Douglas Reservoir, the only sizable reservoir in the watershed. The water in the French Broad River is moderately hard and relatively high in nutrients.

There are two reservoir Vital Signs monitoring sites on Douglas. Table 1 of this appendix identifies the years when Vital Signs Monitoring activities have occurred on Douglas Reservoirs. It also provides planned activities in the future .

Douglas Reservoir

Douglas Reservoir is a deep storage impoundment (tributary reservoir) on the French Broad River. Douglas Dam is located 32.3 miles upstream of the confluence of the French Broad and Holston Rivers which form the Tennessee River. Reservoir drawdown during late summer and autumn is rather large, with an annual average of about 48 feet. The large annual fluctuation in surface water elevation causes other physical characteristics such as surface area, reservoir length, and retention time to vary greatly during the year. At full pool, maximum depth at the dam is 127 feet, surface area is 30,400 acres, the shoreline is 555 miles, and the length is 43 miles. Average annual discharge is approximately 6800 cfs, which provides an average hydraulic retention time of about 104 days.

Lengthy retention times and lack of mixing due to their deep nature tend to cause storage impoundments to have strong thermal stratification during summer months. Undesirable conditions often develop in the hypolimnion due to anoxia, which in most cases extends from the forebay to the mid-reservoir sampling location.

HOLSTON RIVER WATERSHED

The Holston River Watershed encompasses 3776 square miles, mostly in upper east Tennessee and southwest Virginia and a small area in North Carolina. The area is relatively highly populated with substantial industrial development.

Much of the area is underlain with limestone and dolomite which results in high concentrations of dissolved minerals in the streams. There is also substantial zinc mining in the watershed.

There are several reservoirs in the watershed with varying size, depth, flow, and water quality characteristics. The largest is Cherokee Reservoir on the Holston River near the lower end of the watershed. The uppermost reservoirs are Watauga Reservoir on the Watauga River and South Holston Reservoir on the South Fork Holston River. Downstream from these reservoirs, the Watauga and South Holston Rivers merge in Boone Reservoir. Immediately downstream from Boone Dam is Fort Patrick Henry Reservoir, the smallest of the five reservoirs in this watershed included in the Vital Signs Monitoring Program. A few miles downstream from Fort Patrick Henry Dam the South Fork and North Fork Holston Rivers merge to form the Holston River.

The average annual discharge from Cherokee Dam is 4600 cfs. The Holston River merges with the French Broad River at Knoxville to form the Tennessee River.

Vital Signs monitoring activities are conducted at one, two, or three locations depending on reservoir size and characteristics. Table 1 of this appendix identifies the years when Vital Signs Monitoring activities have occurred on reservoirs in this watershed. It also provides planned activities in the future .

Cherokee Reservoir

Cherokee Reservoir is formed by Cherokee Dam at Holston River mile (HRM) 52.3. Like Norris and Douglas Reservoirs, it is a large, relatively deep, tributary storage impoundment with a substantial drawdown which begins in late summer. When the water surface is at full pool, maximum depth at the dam is 163 feet and winter drawdown is 53 feet. However, full pool is not reached most years, and the long-term average drawdown is about 28 feet. At full pool, Cherokee Reservoir is 54 miles long, has a surface area of 30,300 acres, and a shoreline of 393 miles. Average annual discharge is about 4600 cfs which provides an average hydraulic retention time (at full pool) of approximately 162 days.

Like other deep storage impoundments with long retention times, Cherokee Reservoir exhibits strong vertical stratification during summer months. The hypolimnetic oxygen deficit on Cherokee is one of the worst of all Vital Signs monitoring reservoirs and has been well documented in numerous past studies (Iwanski, 1978; Iwanski et al., 1980; Hauser et al., 1987).

Fort Patrick Henry Reservoir

Fort Patrick Henry Reservoir is one of the smaller reservoirs included in the Vital Signs Monitoring Program. It is only ten miles long, has a surface area of about 870 acres, and has a shoreline of 37 miles. Although it is a tributary reservoir, it has characteristics of a run-of-river reservoir, rather than a storage reservoir. Annual fluctuation in elevation is only five feet. Also, retention time is short; with an average discharge of 2690 cfs, the hydraulic retention time is only about five days. Maximum depth is about 80 feet. Fort Patrick Henry Dam is located at South Fork Holston River mile 8.2.

This reservoir had not been sampled as part of this monitoring effort prior to 1993. Because of its small size, only the forebay is monitored for Vital Signs.

Boone Reservoir

Boone Dam is located at South Fork Holston River mile (SFHRM) 18.6, approximately 1.4 miles downstream of the confluence of the South Fork Holston and the Watauga Rivers. At normal maximum pool (1384 feet MSL), Boone Reservoir extends upstream approximately 17.4 miles on the South Fork Holston River and 15.3 miles on the Watauga River for a total reservoir length of approximately 32.7 miles. Boone Reservoir has a surface area of 4300 acres, a shoreline length of approximately 122 miles, an average depth of 44 feet, and a maximum depth of 129 feet near the dam. Annual average discharge from Boone Dam is about 2700 cfs, which results in an average hydraulic residence time of about 37 days. Annual drawdowns of Boone Reservoir usually average about 25 feet.

Three locations were selected for ecological health monitoring in Boone Reservoir, one at the forebay and two mid-reservoir sampling locations, one on the Watauga River arm and one on the South Fork Holston River arm. Sediment and benthic macroinvertebrate sampling were added for the first time in 1993.

South Holston Reservoir

South Holston Reservoir in northeastern Tennessee and southwestern Virginia is created by South Holston Dam, located on the South Fork of the Holston River at mile 49.8. The dam creates a storage pool approximately 24 miles long, over 230 feet deep near the dam, with an average depth of 86.5 feet and approximately 7600 acres in surface area. With an average annual discharge of about 990 cfs from the dam, the average hydraulic residence time is almost one year (334 days)--one of the longest residence times of any TVA reservoir. Average annual drawdown of South Holston Reservoir is about 33 feet.

Two locations are monitored for Vital Signs--the forebay and mid-reservoir. Sediment and benthic macroinvertebrate sampling were added for the first time in 1993.

Watauga Reservoir

Watauga Dam in the northeastern corner of Tennessee impounds the Watauga River at mile 36.7. It forms a pool 16 miles in length, approximately 6400 acres in surface area, about 274 feet deep at the dam, and an average depth of about 89 feet, making it the second-deepest reservoir sampled as part of TVA's Vital Signs Monitoring Program. With an annual average discharge of about 720 cfs, Watauga Reservoir also has the longest hydraulic residence time of any of the Vital Signs reservoirs (about 400 days). Average annual drawdown of Watauga Reservoir is about 26 feet.

Two locations are monitored on Watauga Reservoir, the forebay and mid-reservoir. Sediment quality and benthic macroinvertebrates were examined for the first time in 1993.

Reservoir: Cherokee **2000 Score: 47%**

Previous Scores
2000 Criteria

1991	57	
1992	57	
1993	65	
1994	51	
1995	54	
1996	49	--1st year benthos
1997	n/s	collected at MR
1998	50	
1999	n/s	
2000	47	

Cherokee	2000 Results					Change between 1998 and 2000				
	FB	MR	Emb	Inf	Total	FB	MR	Emb	Inf	Total
Chlorophyll	P 2.8	P 1.0			3.8	-1.0	0.0			-1.0
DO	P 1.0	P 1.0			2.0	0.0	0.0			0.0
Fish	F 3.0	F 3.0			6.0	0.0	0.0			0.0
Benthos	F 3.0	F 3.0			6.0	0.0	0.0			0.0
Sediment	F 2.0	F 1.5			3.5	0.0	0.0			0.0
Total	11.8	9.5			21.3	-1.0	0.0			-1.0

Summary/Key Ecological Health Findings for 2000: The overall ecological condition of Cherokee Reservoir was poor again in 2000. All ecological indicators rated either poor or fair. High concentrations and therefore a poor rating for chlorophyll at the mid-reservoir site was expected based on previous monitoring, but 2000 was the first time chlorophyll had rated poor at the forebay. Poor ratings for DO at both sites (very low concentrations during summer with anoxic conditions in the lower part of the water column for extended periods) were expected occurrences based on previous monitoring results. The fish assemblage rated fair at both locations – the assemblage was comprised of mostly tolerant species, there was a high percentage of omnivores, and a low percentage of insectivorous individuals. Sediments also rated fair at both locations due to presence of chlordane at the forebay and chlordane and copper at the mid-reservoir site.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: Ecological conditions in Cherokee Reservoir in 2000 were quite similar to those found in previous years. The consistent problems – low DO and high chlorophyll – occurred at both sample sites in 2000 (poor chlorophyll ratings had not previously occurred at the forebay). Cherokee is a relatively deep storage impoundment with a long retention time and plenty of nutrients – all the ingredients necessary to produce the characteristics described above. Copper and chlordane present in the sediments (resulting in fair ratings) have been observed in previous years.

Aquatic Macrophytes in 2000: Aquatic macrophytes are not an issue on Cherokee because of the substantial drawdown in reservoir elevation each winter for flood storage.

Status of Fish Consumption Advisories in 2000: There are no fish consumption advisories on Cherokee Reservoir. TVA collected channel catfish and largemouth bass from Cherokee Reservoir in autumn 1998. Fillets from these fish were analyzed for pesticides, PCBs, and metals. The results, which were provided to state agencies in Tennessee for appropriate action, were similar to previous years. Cherokee Reservoir will be sampled again in 2002

Status of Swimming Advisories in 2000: Six sites on Cherokee Reservoir were sampled ten times each for fecal coliform bacteria in 2000. All sites met the State of Tennessee bacteriological water quality criteria for water contact recreation. There are no State of Tennessee swimming advisories on Cherokee Reservoir.

Reservoir: So. Holston **2000 Score: 52%**

—Previous Scores—
2000 Criteria

1991	63[1]
1992	59[1]
1993	66
1994	66
1995	n/s
1996	55
1997	n/s
1998	52
1999	n/s
2000	52

1. only Chl, DO, and Fish

So. Holston	2000 Results					Change between 1998 and 2000				
	FB	MR	Emb	Inf	Total	FB	MR	Emb	Inf	Total
Chlorophyll	G 5.0	P 2.9			7.9	0.7	-0.7			0.0
DO	P 1.5	P 1.0			2.5	0.5	0.0			0.5
Fish	F 3.0	F 4.0			7.0	-1.0	1.0			0.0
Benthos	P 1.0	P 1.0			2.0	0.0	-1.0			-1.0
Sediment	G 2.5	F 1.5			4.0	1.0	-0.5			0.5
Total	13.0	10.4			23.4	1.2	-1.2			0.0

Summary/Key Ecological Health Findings for 2000: Overall ecological conditions in South Holston Reservoir were poor in 2000. The only good ratings were for chlorophyll and sediment quality at the forebay. All other indicators rated either fair or poor. DO and benthos rated poor at both sample sites. Low DO levels occurred in portions of the metalimnion and hypolimnion from July through October but these areas never became anoxic. The benthos community received the lowest possible score at the mid-reservoir site. All seven metrics used to evaluate the community received the lowest possible rating of one. Benthic animals collected were tolerant and short-lived; also, several samples had no animals at all. The poor rating for chlorophyll at the mid-reservoir site is possibly the most significant component of the 2000 monitoring results for South Holston Reservoir. The summer average was the highest observed to date for the mid-reservoir site. Chlorophyll concentrations at the forebay were within the expected range and rated good. Sediments rated fair at the mid-reservoir site because chlordane was found just above the detection limit.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: The overall ecological health condition for South Holston Reservoir was poor again in 2000, comparable to 1996 and 1998 results. The lake had rated fair in previous years (1993 and 1994). The most notable observations from 2000 results were elevated chlorophyll concentrations at the mid-reservoir site compared to previous years – the highest to date for South Holston. As expected, low DO concentrations and poor benthic macroinvertebrate communities were found in 2000.

Aquatic Macrophytes in 2000: Aquatic macrophytes are not an issue on South Holston Reservoir because the winter drawdown for flood control limits suitable habitat.

Status of Fish Consumption Advisories in 2000: There are no fish consumption advisories on South Holston Reservoir. Channel catfish and largemouth bass from South Holston Reservoir were last collected in autumn 1996. Channel catfish fillets were analyzed for pesticides, PCBs, and metals and largemouth bass fillets for mercury. The results were provided to state agencies in Tennessee. All contaminant levels were either below detection levels or below the levels used by the state to issue fish consumption advisories. These species were sampled again in autumn 2000 and results are expected in spring 2001.

Status of Swimming Advisories in 2000: Four sites along the South Holston River were sampled ten times each for fecal coliform bacteria in 2000. Samples were collected at the Canoe Access Site at the Weir (SHRM 48.3L), Laurel Yacht Club Marina, Painter Creek Dock Swimming Area, and Observation Knob Park Swimming Area. All but one site met the State of Tennessee bacteriological water quality criteria for water contact recreation. The Canoe Access Site at the Weir exceeded the Tennessee bacteriological water quality criteria because a single sample exceeded 1,000 colonies per 100 milliliters. Large numbers of water fowl (Canadian geese) were present at this site, which is a likely source of contamination. There are no State of Tennessee swimming advisories along the South Holston River.

Reservoir: **Watauga** 2000 Score: **66%**

—Previous Scores—
2000 Criteria

1991	**75**[1]
1992	**72**[1]
1993	**63**
1994	**63**
1995	**n/s**
1996	**72**
1997	**n/s**
1998	**58**
1999	**n/s**
2000	**66**

1. only Chl, DO, and Fish

Watauga	2000 Results							Change between 1998 and 2000				
	FB		MR		Emb	Inf	Total	FB	MR	Emb	Inf	Total
Chlorophyll	G	5.0	G	5.0			10.0	0.0	0.0			0.0
DO	F	4.0	P	1.5			5.5	0.0	0.5			0.5
Fish	P	2.0	F	4.0			6.0	0.0	0.0			0.0
Benthos	P	1.0	F	3.0			4.0	0.0	2.0			2.0
Sediment	G	2.5	F	1.5			4.0	1.0	0.0			1.0
Total		14.5		15.0			29.5	1.0	2.5			3.5

Summary/Key Ecological Health Findings for 2000: The overall ecological rating for Watauga Reservoir was fair in 2000. Chlorophyll was the only indicator to rate good at both sample sites – concentrations were within the expected range for this lake. The only other good rating for any indicator was for sediment quality at the forebay. Sediment quality rated fair at the mid-reservoir site due to presence of low levels of chlordane. The rating for DO was fair at the forebay and poor at the mid-reservoir site. The poor rating at the mid-reservoir site was caused by low summer DO concentrations in a substantial proportion of the hypolimnion. The fish assemblage rated poor at the forebay and fair at the mid-reservoir site. Five of the 12 metrics used to evaluate the fish assemblage received the lowest possible rating of one at the forebay, whereas a greater abundance and diversity of fish at the mid-reservoir site resulted in a fair rating. The rating for benthic organisms was poor at the forebay and fair at the mid-reservoir site. Few organisms were collected at the forebay and those present were short-lived and tolerant of poor conditions. The community at the mid-reservoir site was slightly more diverse and abundant and rated fair.

Explanation of Differences in Ecological Health Scores in 2000 and Previous Years: The fair overall ecological health rating for Watauga Reservoir in 2000 was similar to most previous years. Chlorophyll ratings have been consistently good throughout the monitoring period, whereas the benthos have typically rated poor and the fish assemblage fair. Sediment quality has rated either fair or good depending on presence/absence of chlordane. DO has rated either good or fair at the forebay and fair or poor at the mid-reservoir site. Monitoring results for 2000 matched these past observations in most cases. Two noteworthy observations from the 2000 results were a poor rating for the fish assemblage at the forebay, which represents the first poor rating for this indicator in Watauga Reservoir, and a fair rating for benthos at the mid-reservoir site, which usually rates poor. The poor rating for the fish assemblage is more a mathematical than an environmental change. The fish assemblage score in several past years had been just above the poor-fair cut-off value and it was just below that value in 2000. The higher benthos score in 2000 was due to collection of a slightly greater number and variety of organisms.

Aquatic Macrophytes in 2000: Not an issue on Watauga Reservoir due to winter drawdown.

Status of Fish Consumption Advisories in 2000: There are no fish consumption advisories on Watauga Reservoir. Channel catfish and largemouth bass were last collected in autumn 1996. Channel catfish fillets were analyzed for pesticides, PCBs, and metals and largemouth bass fillets for mercury. The results were provided to state agencies in Tennessee. All contaminant levels were either below detection levels or below the levels used by the state to issue fish consumption advisories. These species were sampled again in autumn 2000 and results are expected in spring 2001.

Status of Swimming Advisories in 2000: There are no State of Tennessee swimming advisories on Watauga Reservoir. One site (Watauga Dam Beach) was sampled ten times for fecal coliform bacteria in 2000. This site met the State of Tennessee bacteriological water quality criteria for water contact recreation.

Appendix B.

Temperature and Dissolved Oxygen Isopleths for All Sample Locations Monitored in 2000

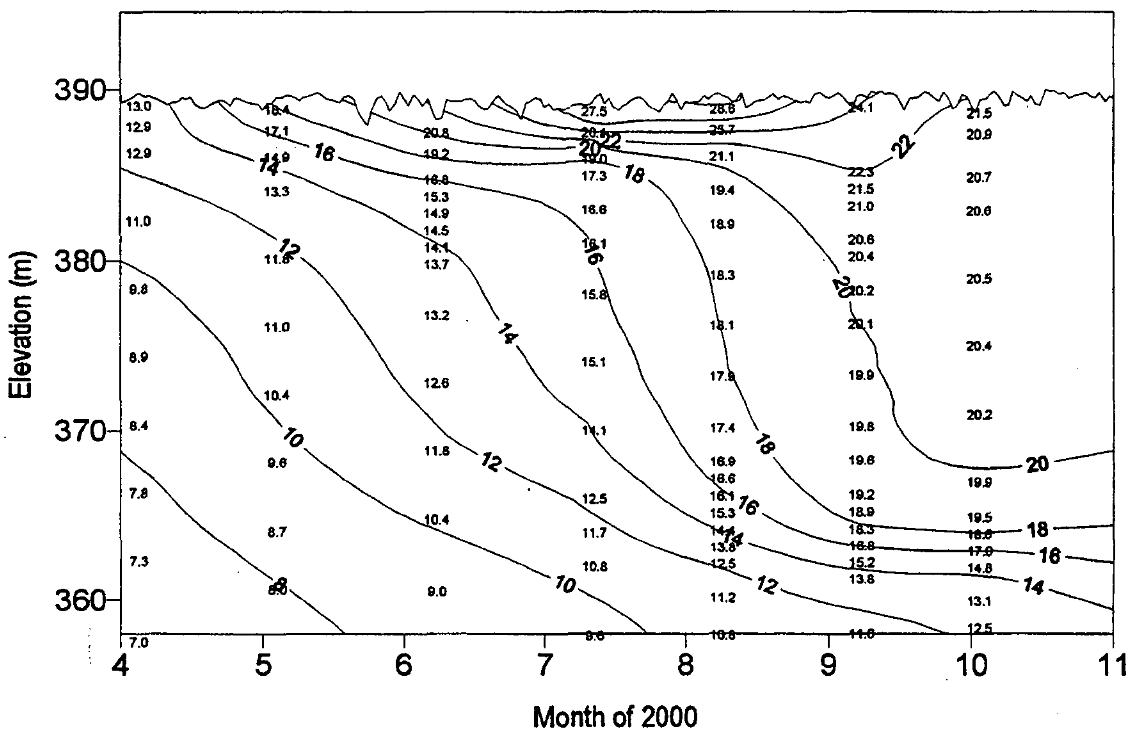
Most Locations Were Monitored as Part of Routine Vital Signs Monitoring. Water Quality Measurements Including Temperature and DO Were Taken at Several Additional Locations to Meet Specific Needs. Isopleths for Locations Monitored as Part of Routine Vital Signs Monitoring Are Provided at the Front of This Appendix Followed by Isopleths for the Additional Locations.

Appendix B

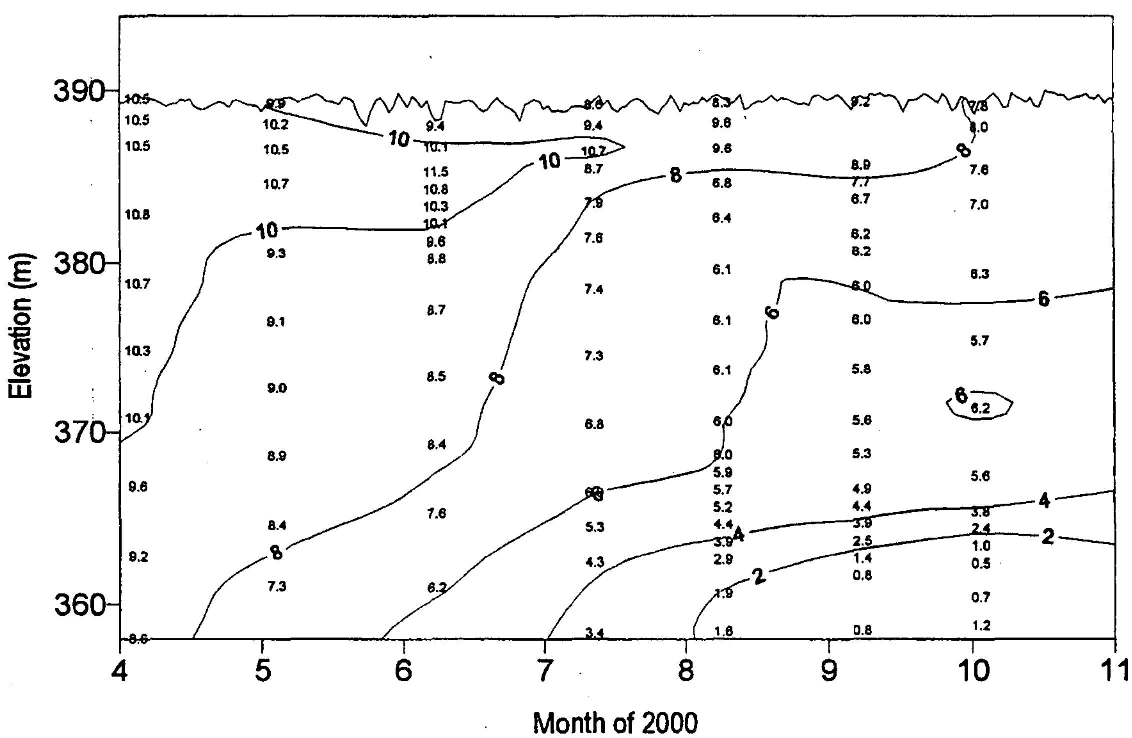
Temperature and DO Isopleths for Locations Monitored as Part of Routine Vital Signs Monitoring in 2000

Apalachia Reservoir - HiRM 67.0

Temperature (deg C)

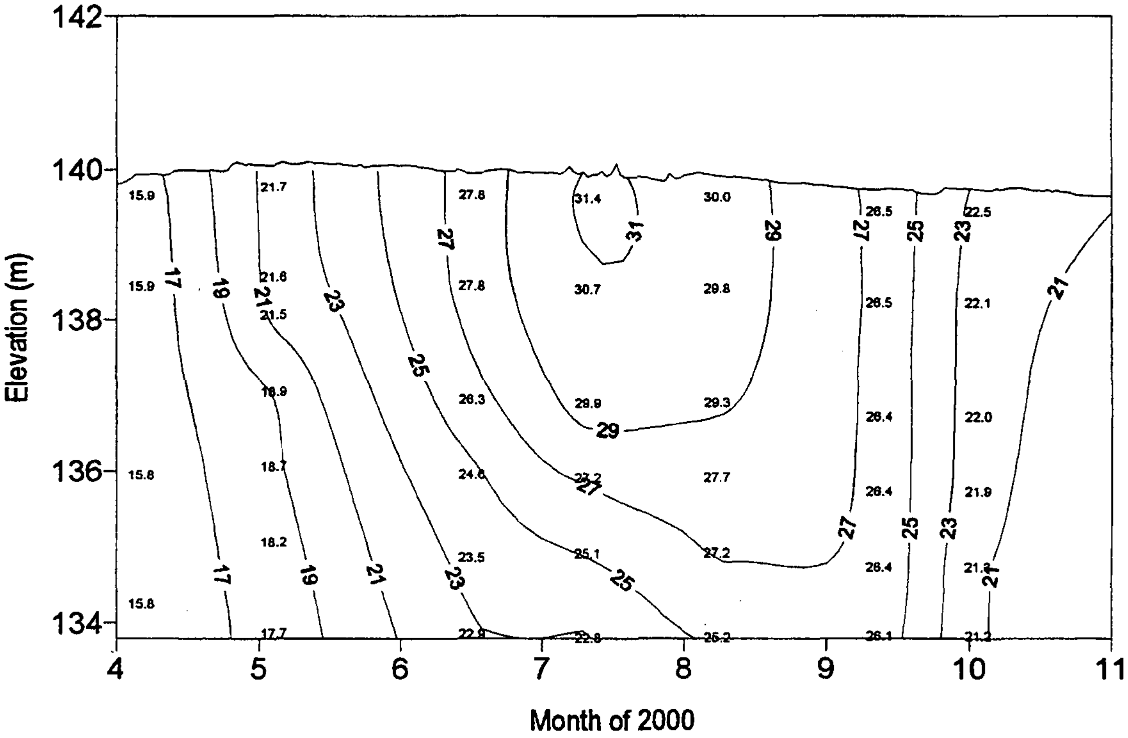


Dissolved Oxygen (mg/L)

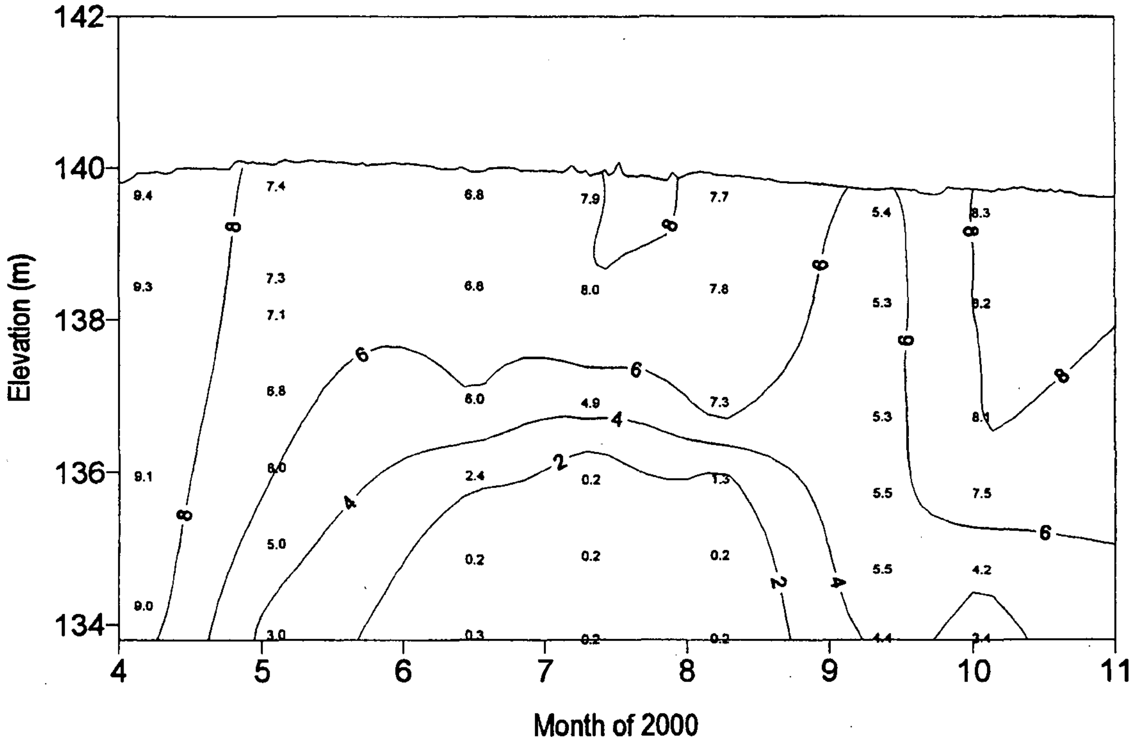


Beech Reservoir - BRM 36.0

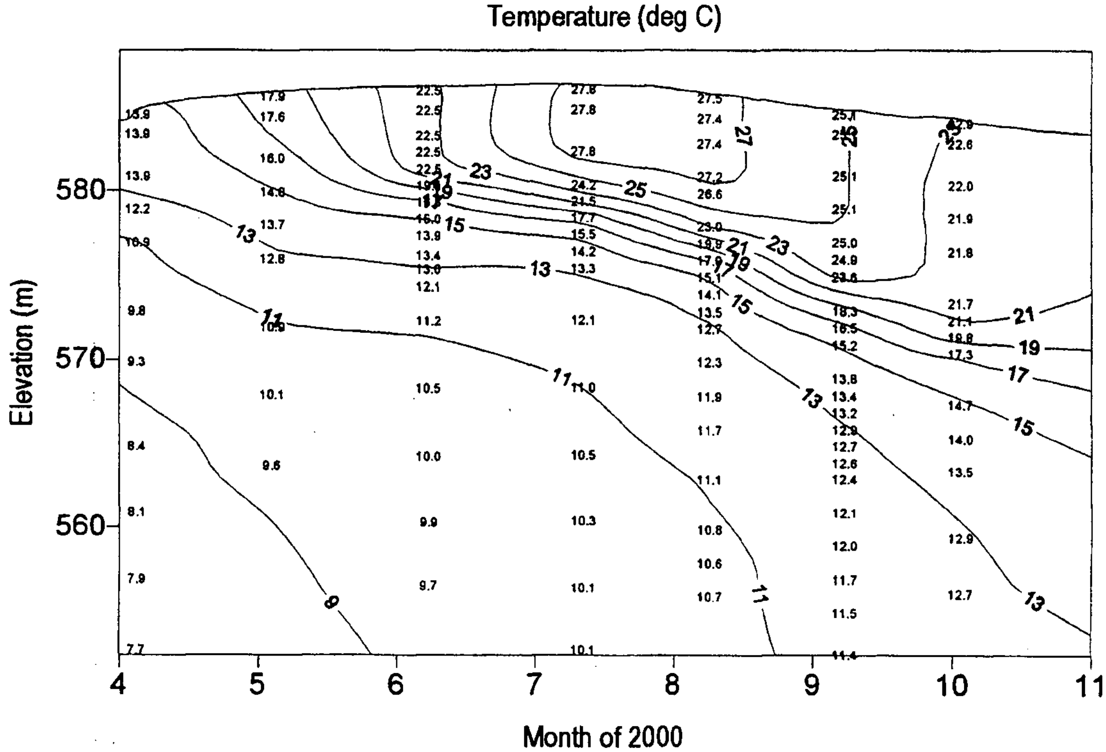
Temperature (deg C)

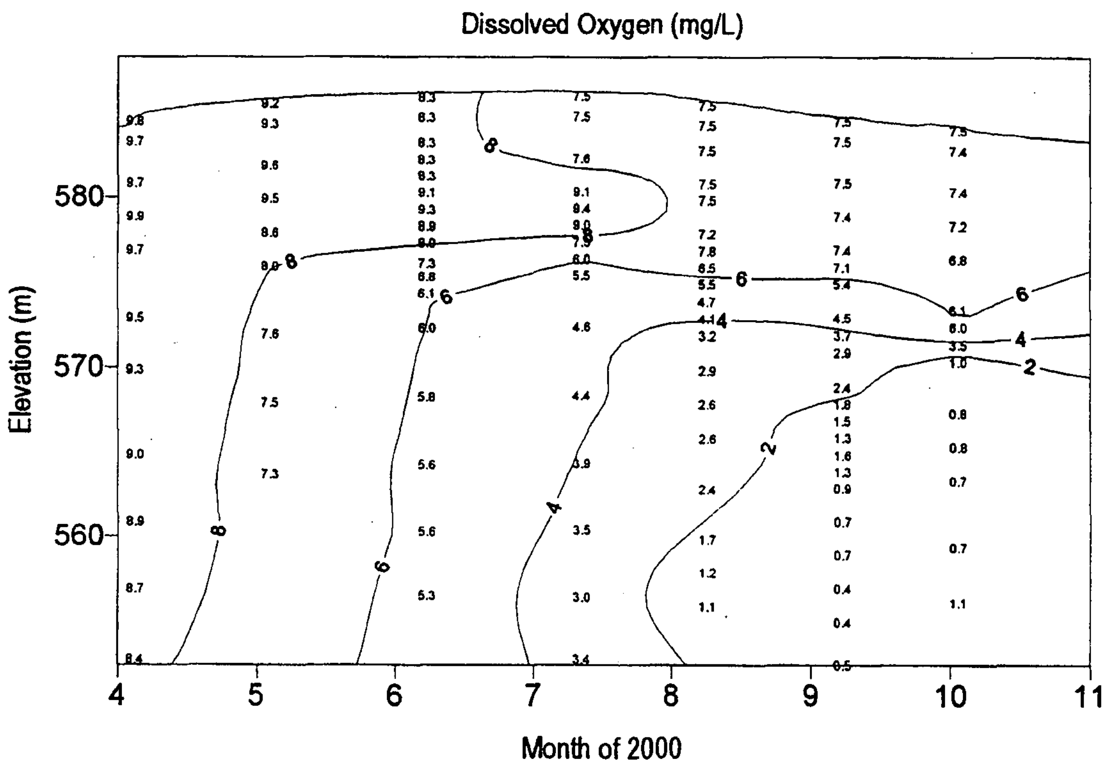


Oxygen (mg/L)



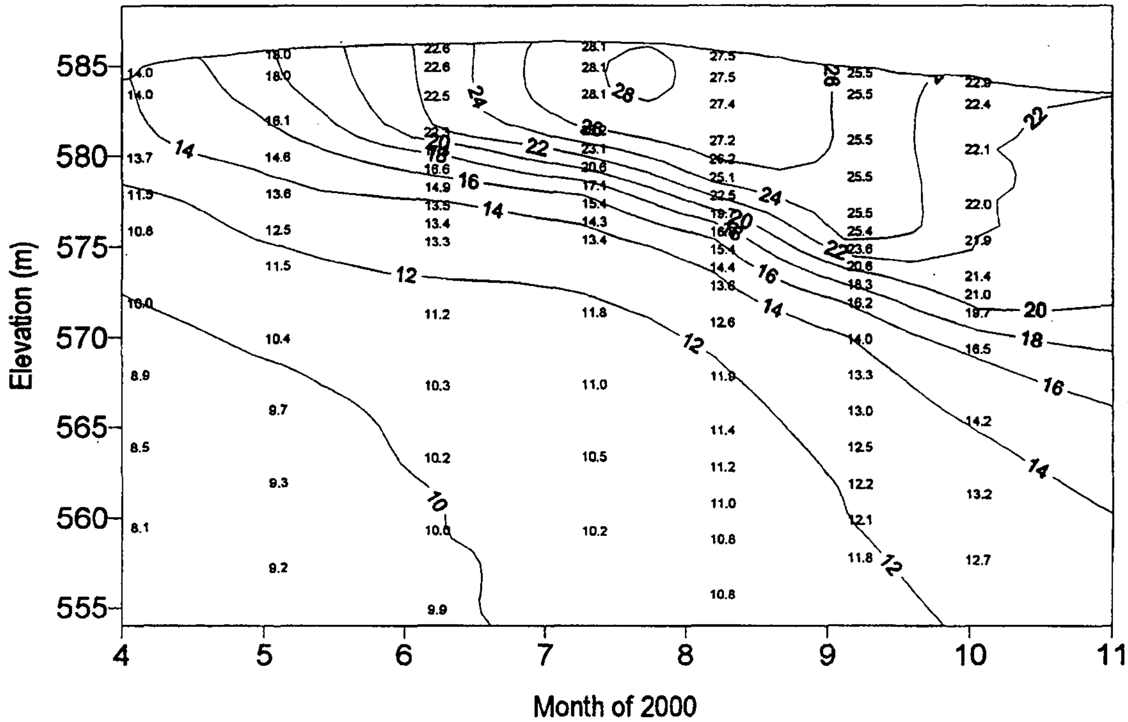
Chatuge Reservoir - HiRM 122.0



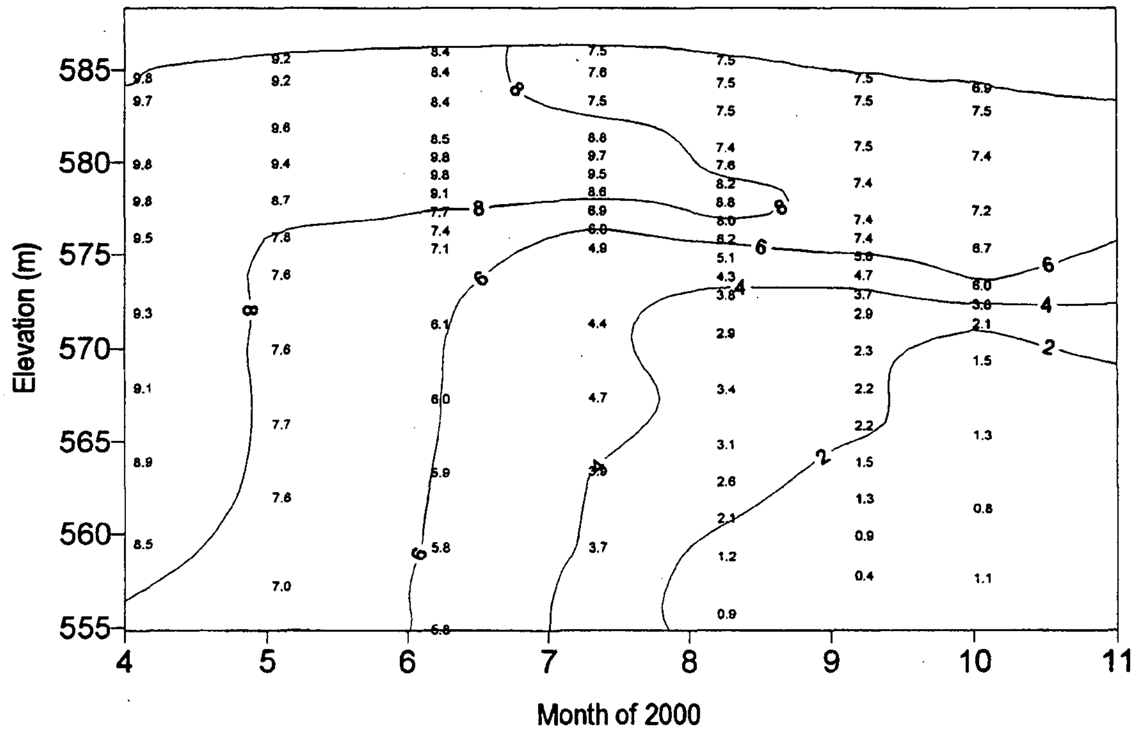


Chatuge Reservoir - Shooting Creek 1.5

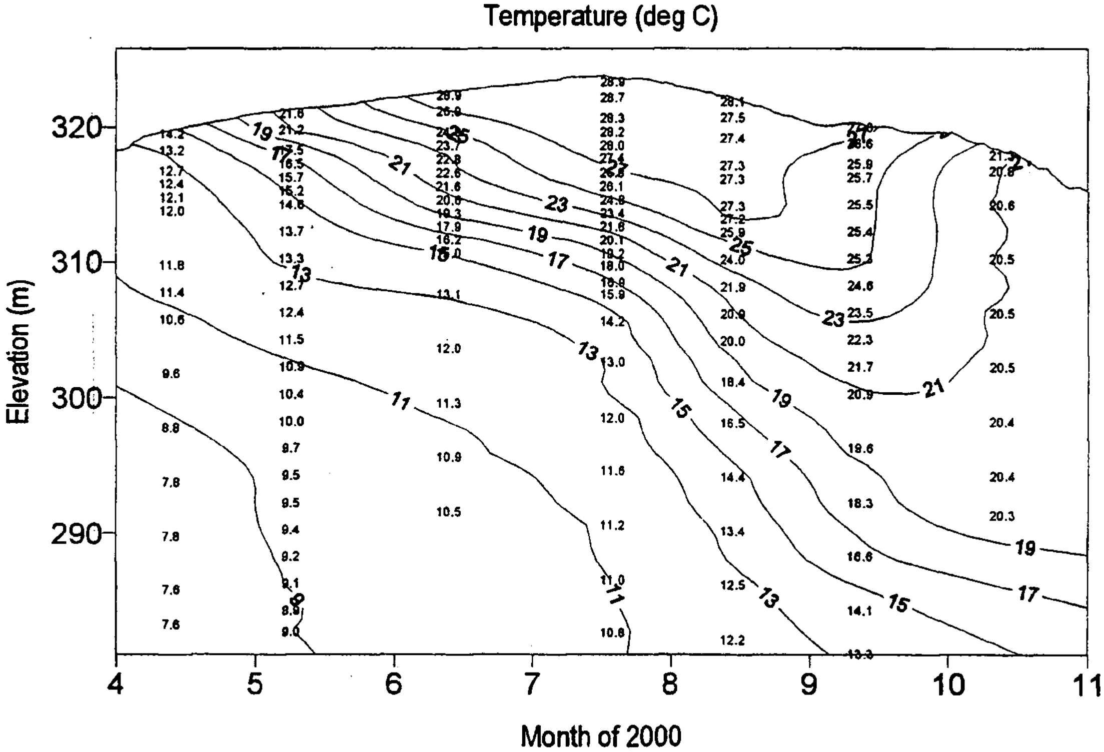
Temperature (deg C)

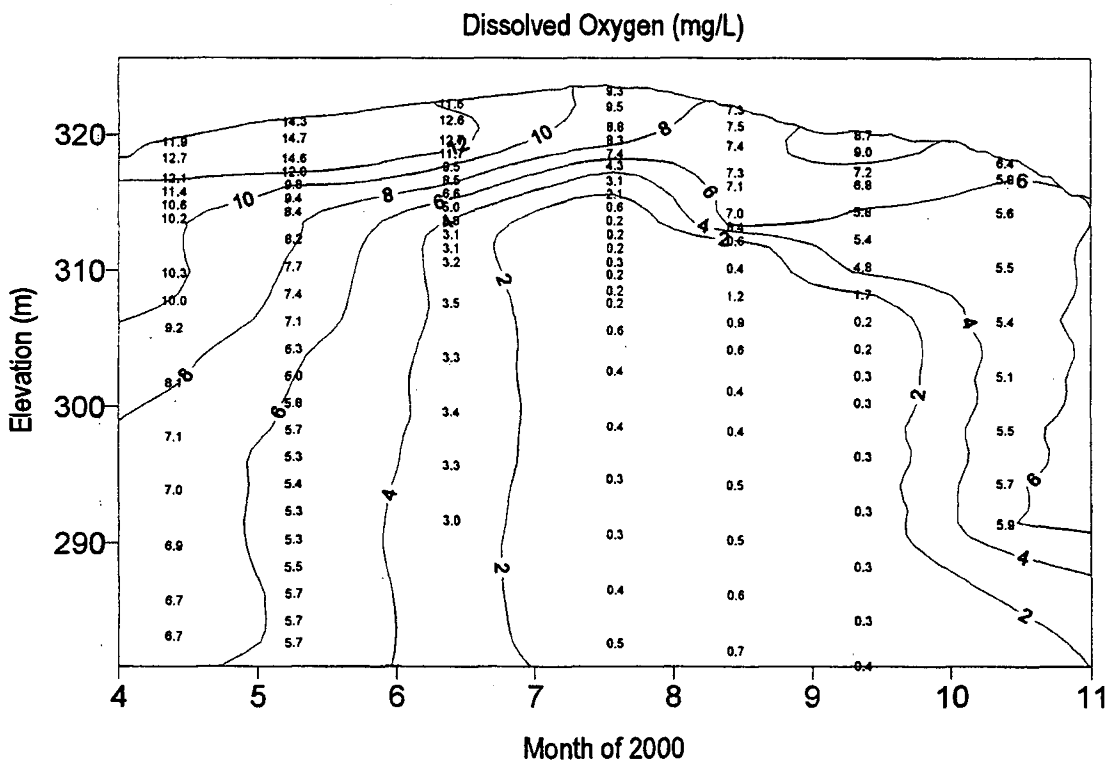


Dissolved Oxygen (mg/L)

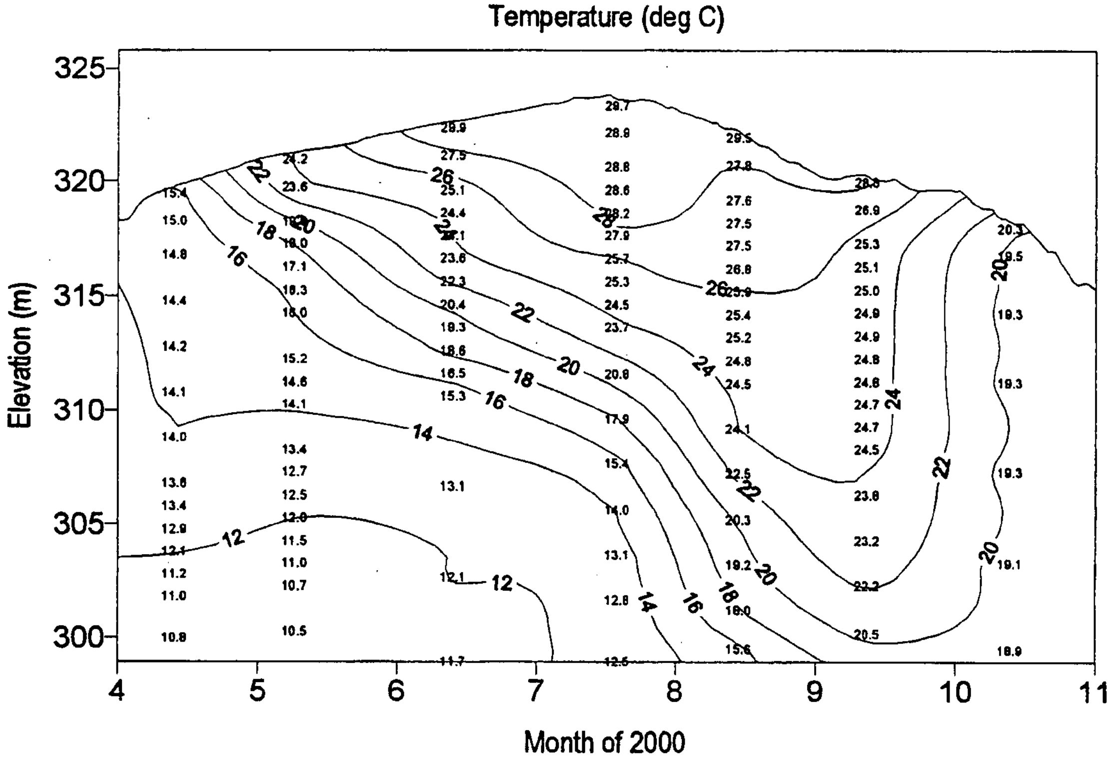


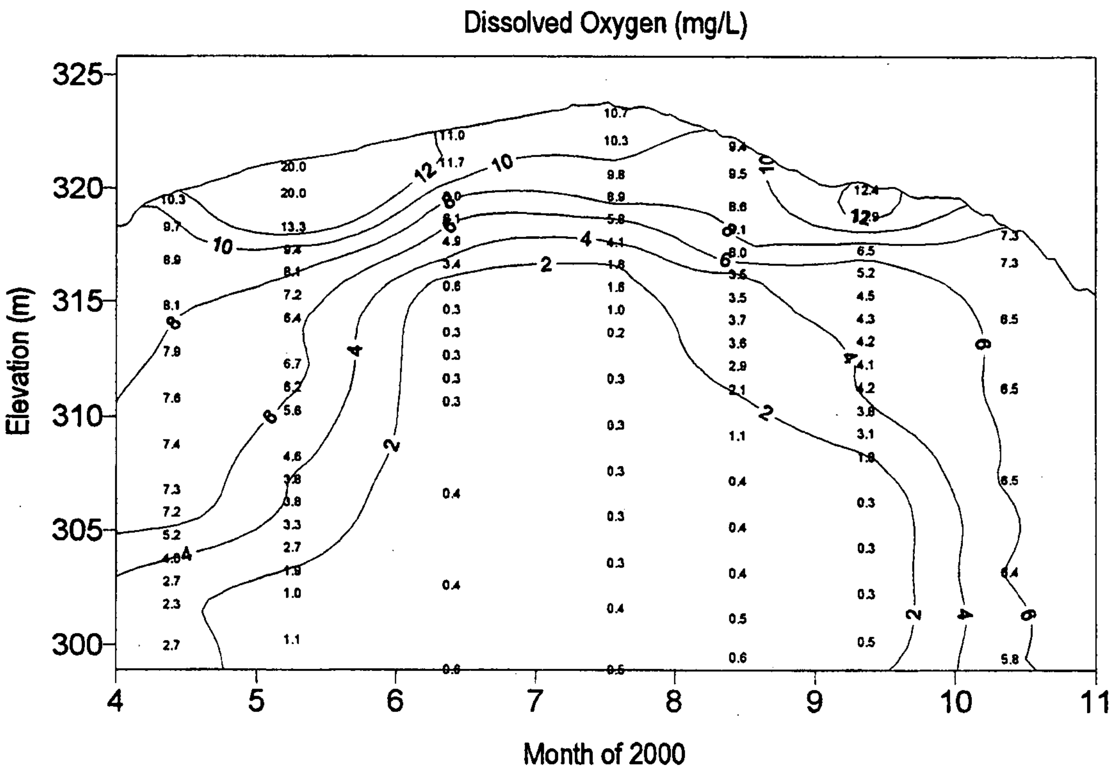
Cherokee Reservoir - HRM 55.0



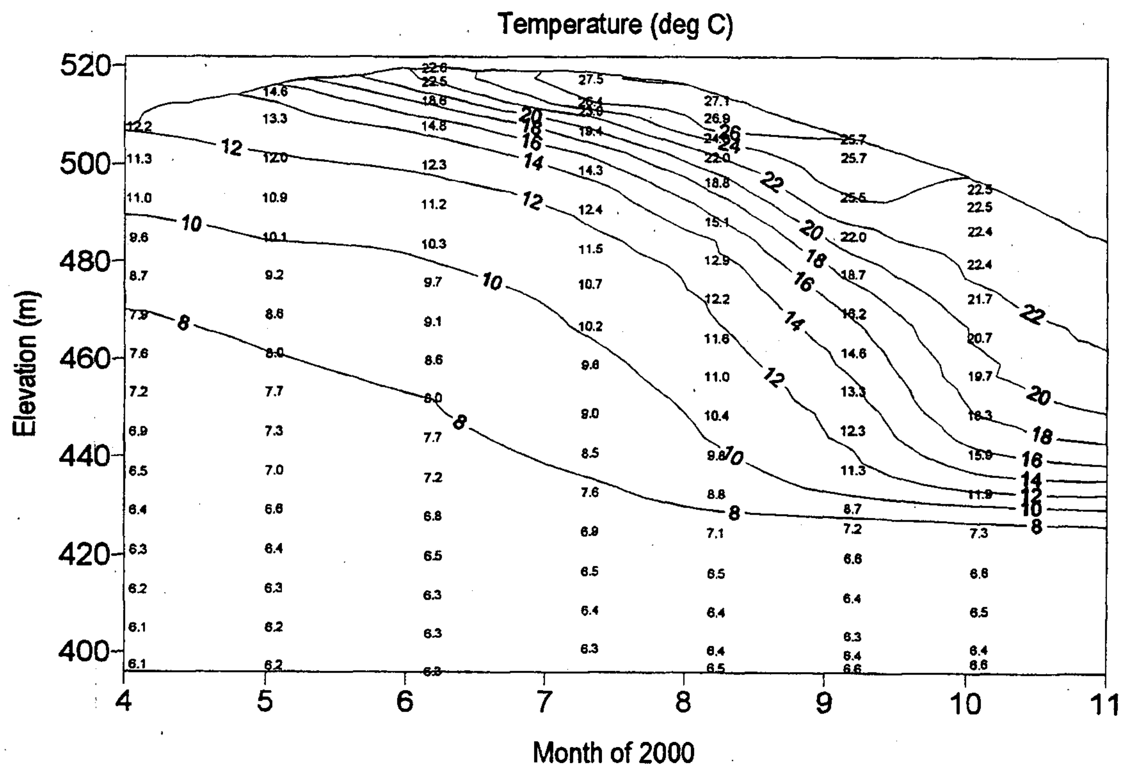


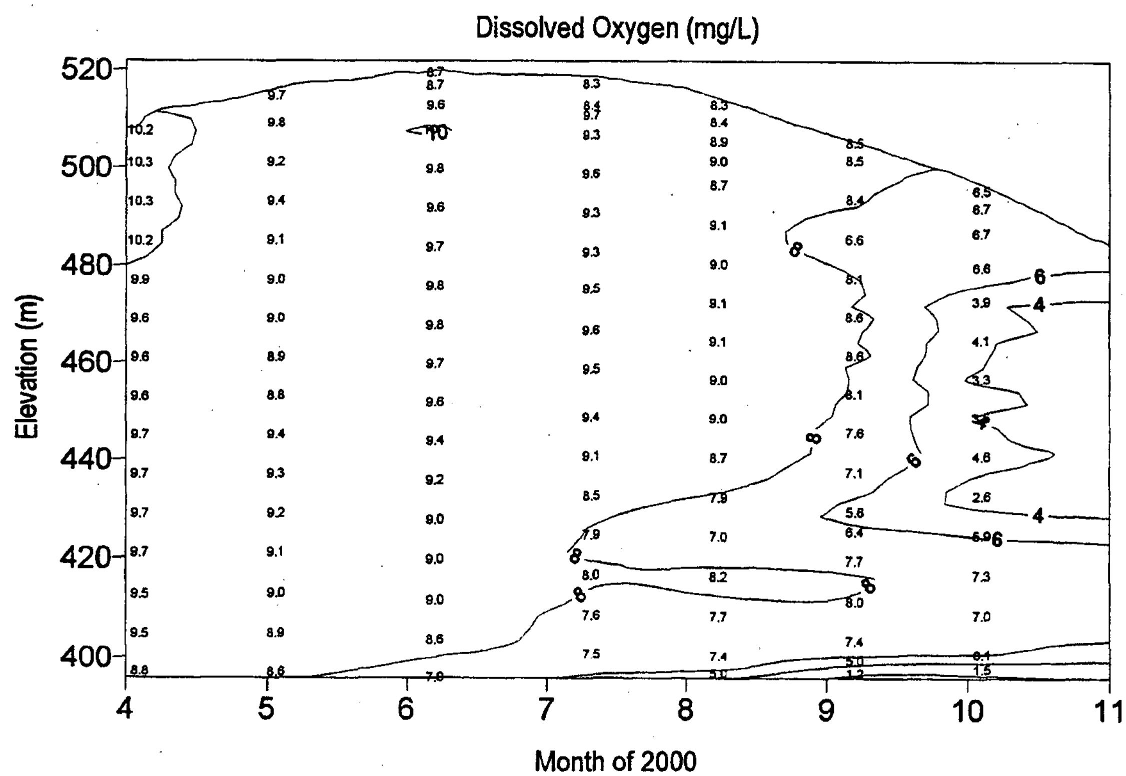
Cherokee Reservoir - HRM 76.0





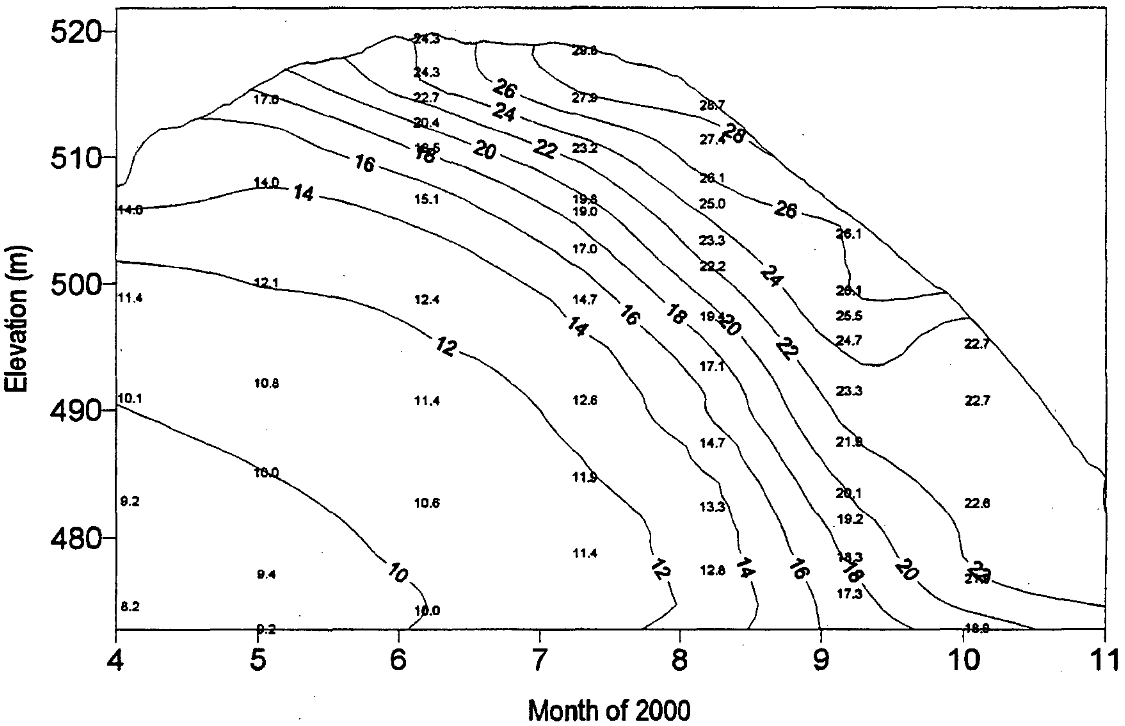
Fontana Reservoir - LTRM 62.0



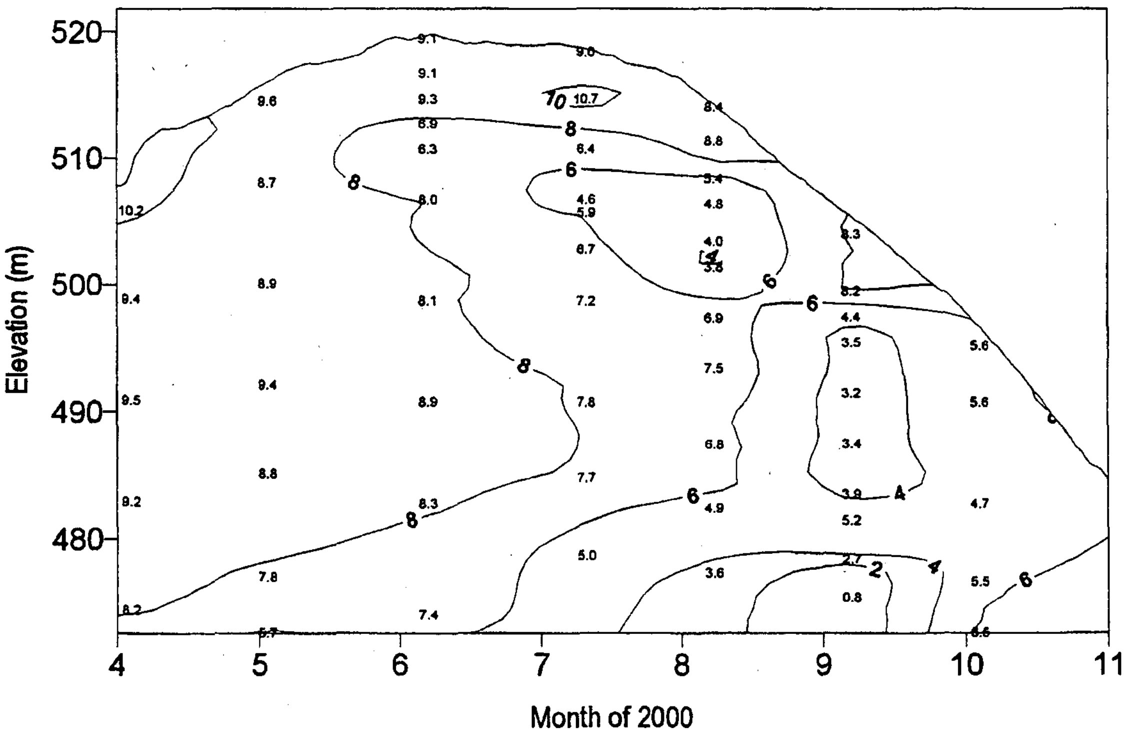


Fontana Reservoir - LTRM 81.5

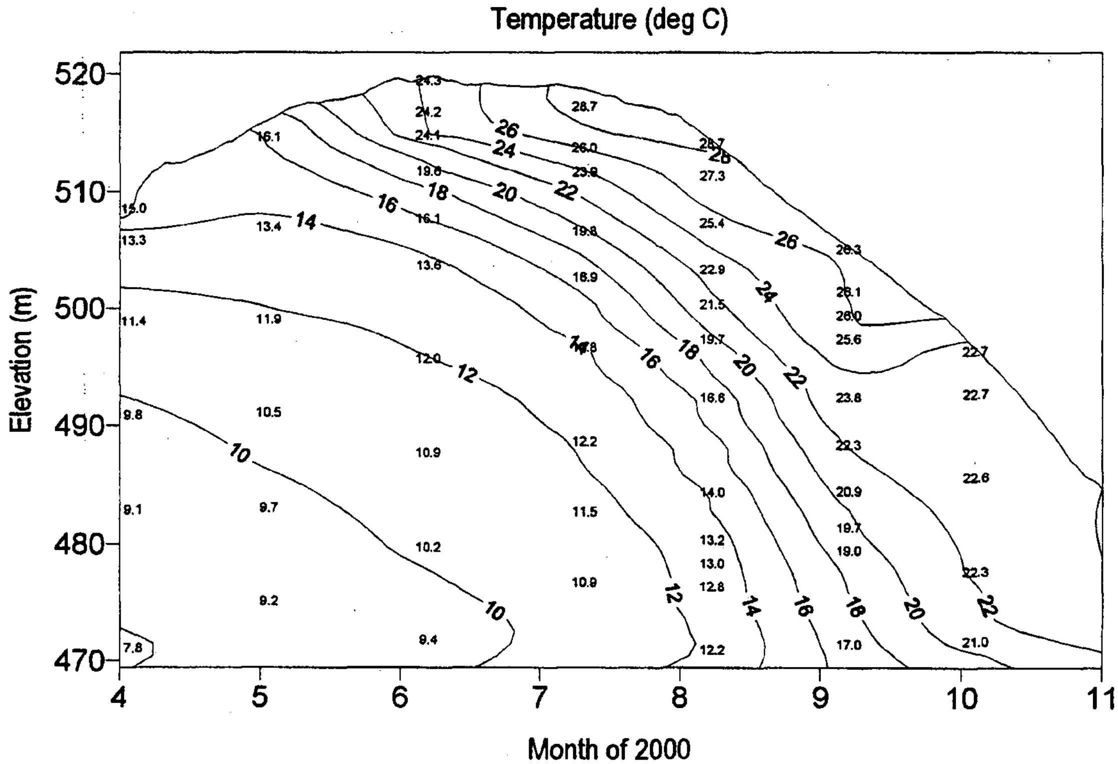
Temperature (deg C)

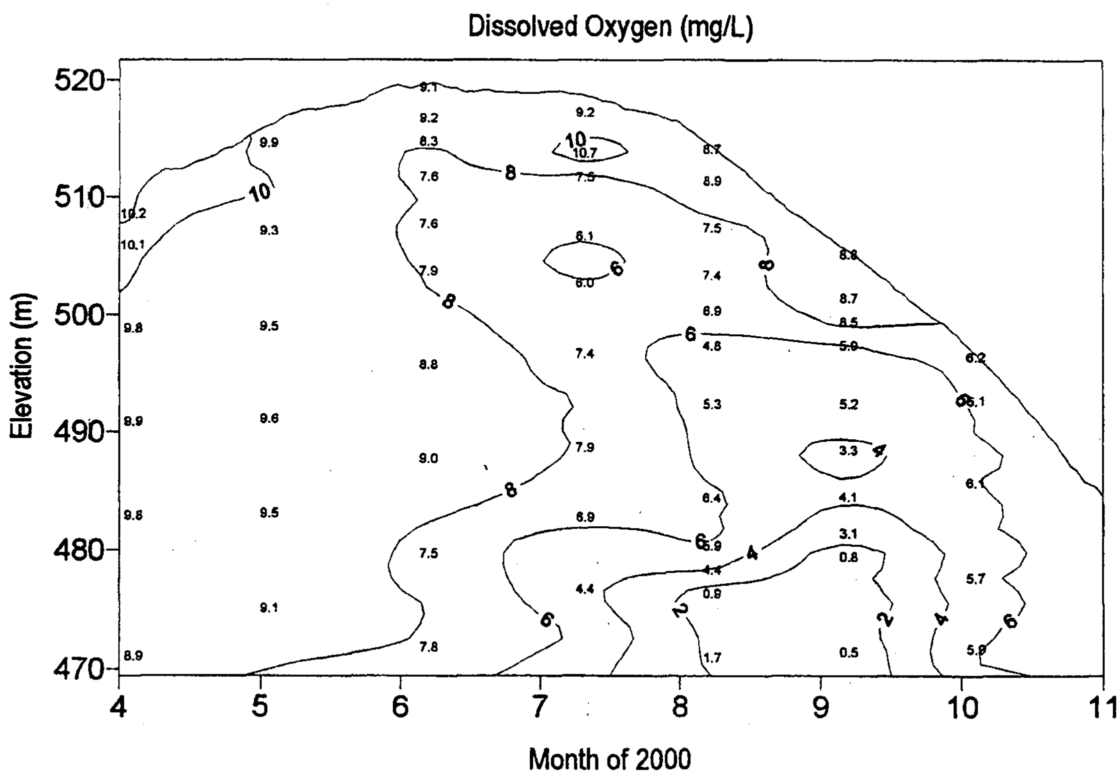


Dissolved Oxygen (mg/L)



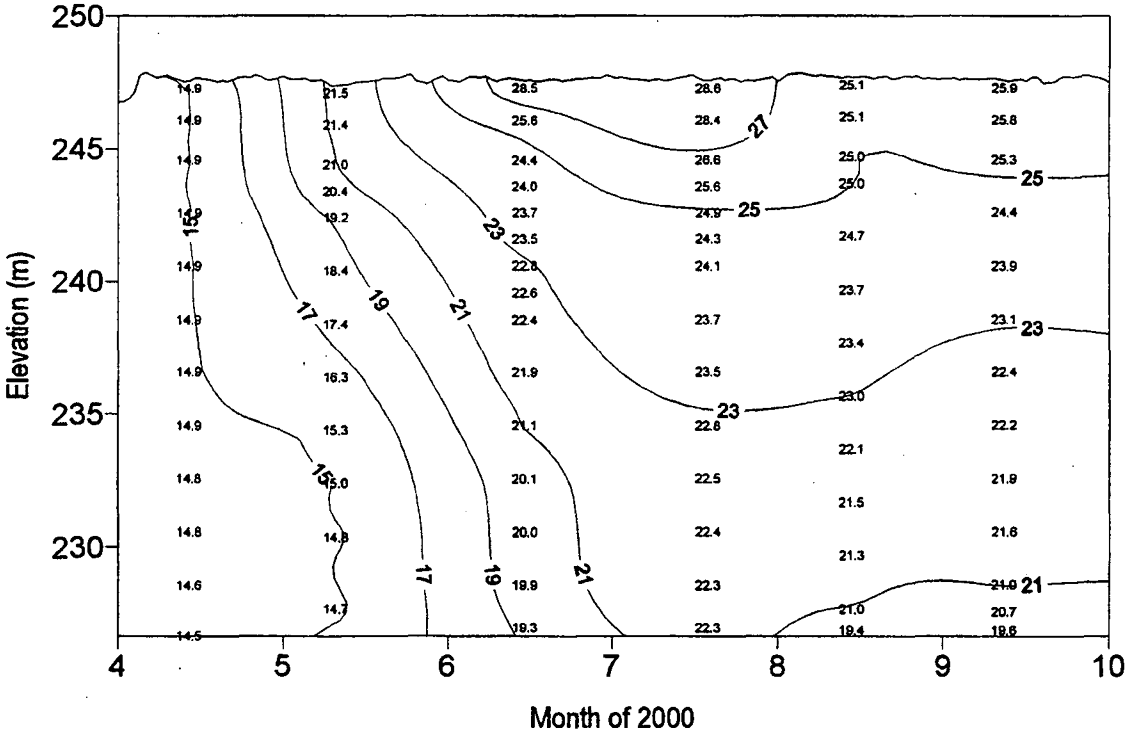
Fontana Reservoir - TkRM 3.0



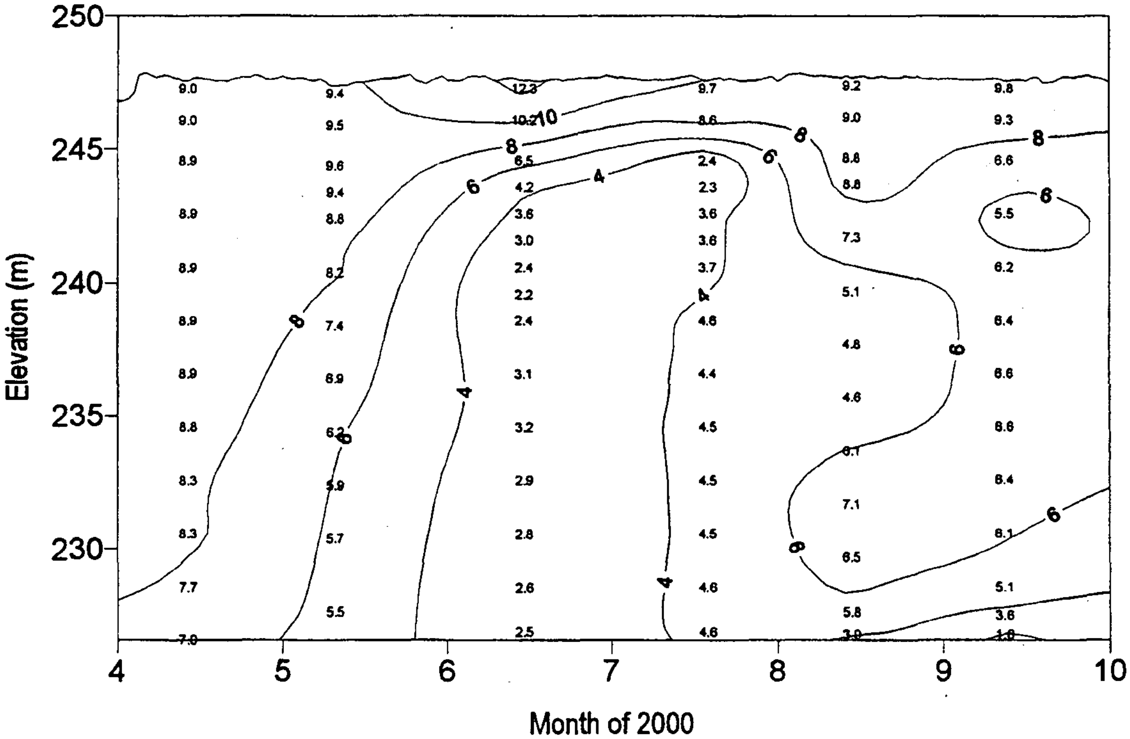


Fort Loudon Reservoir - TRM 605.5

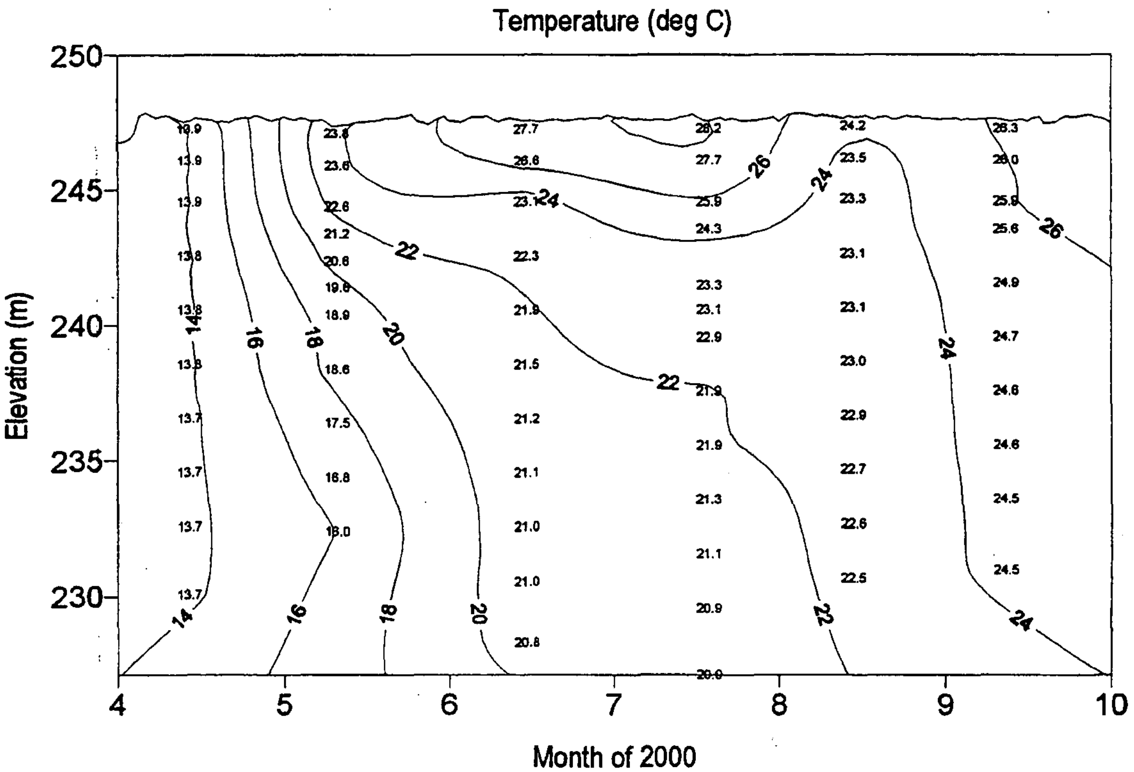
Temperature (deg C)

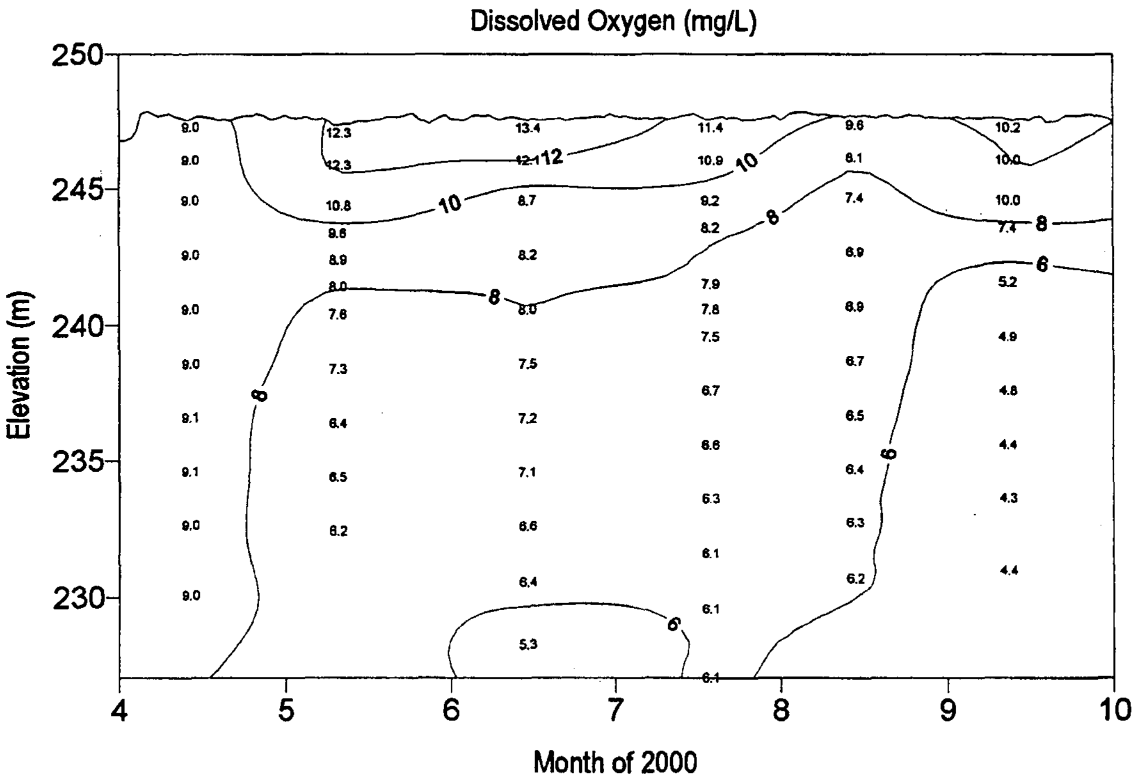


Dissolved Oxygen (mg/L)

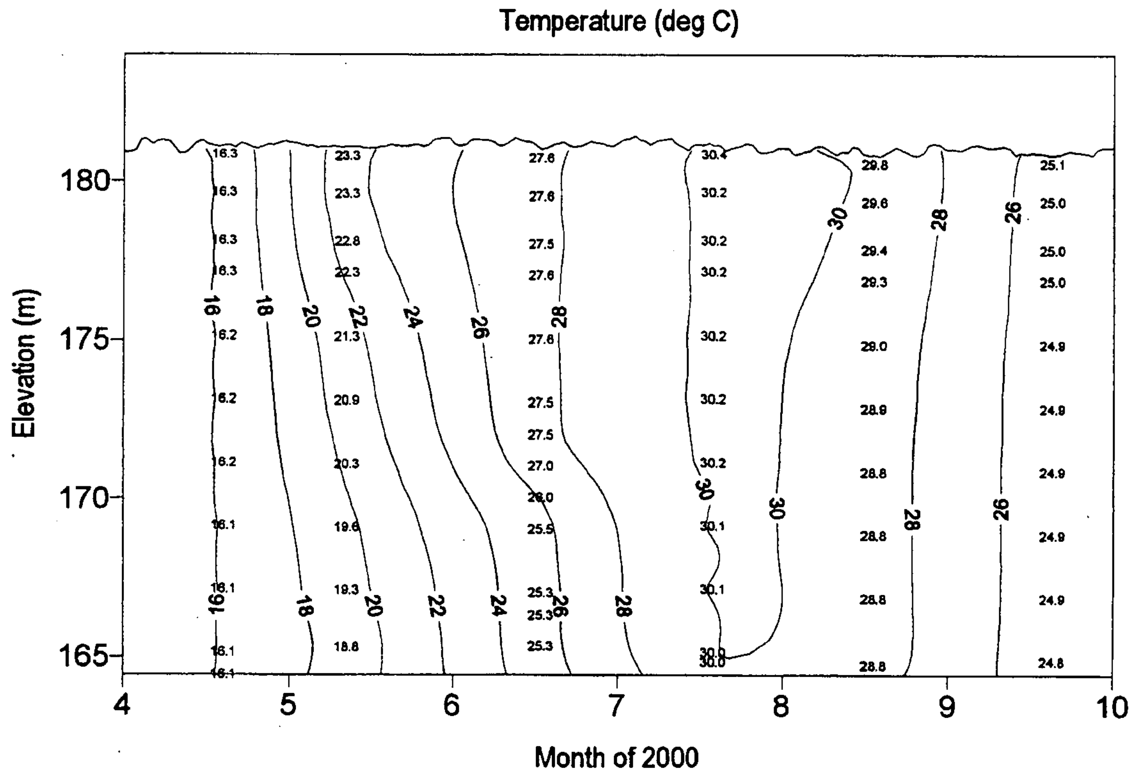


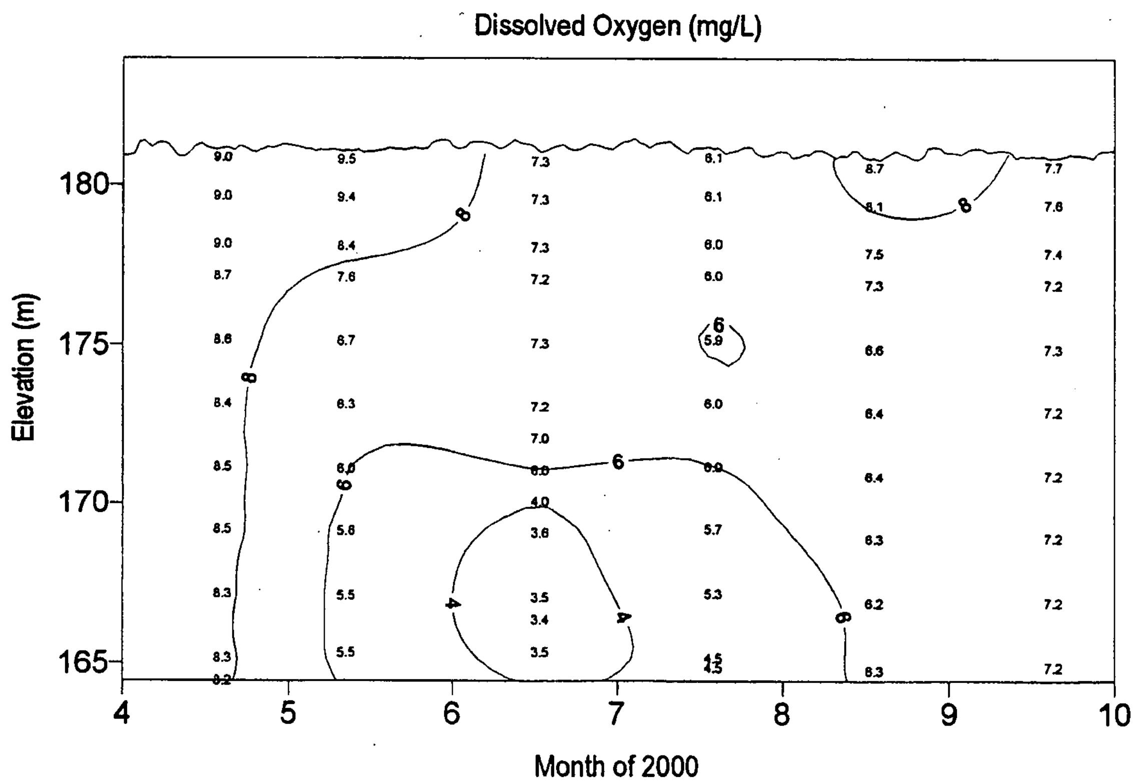
Fort Loudon Reservoir - TRM 624.6





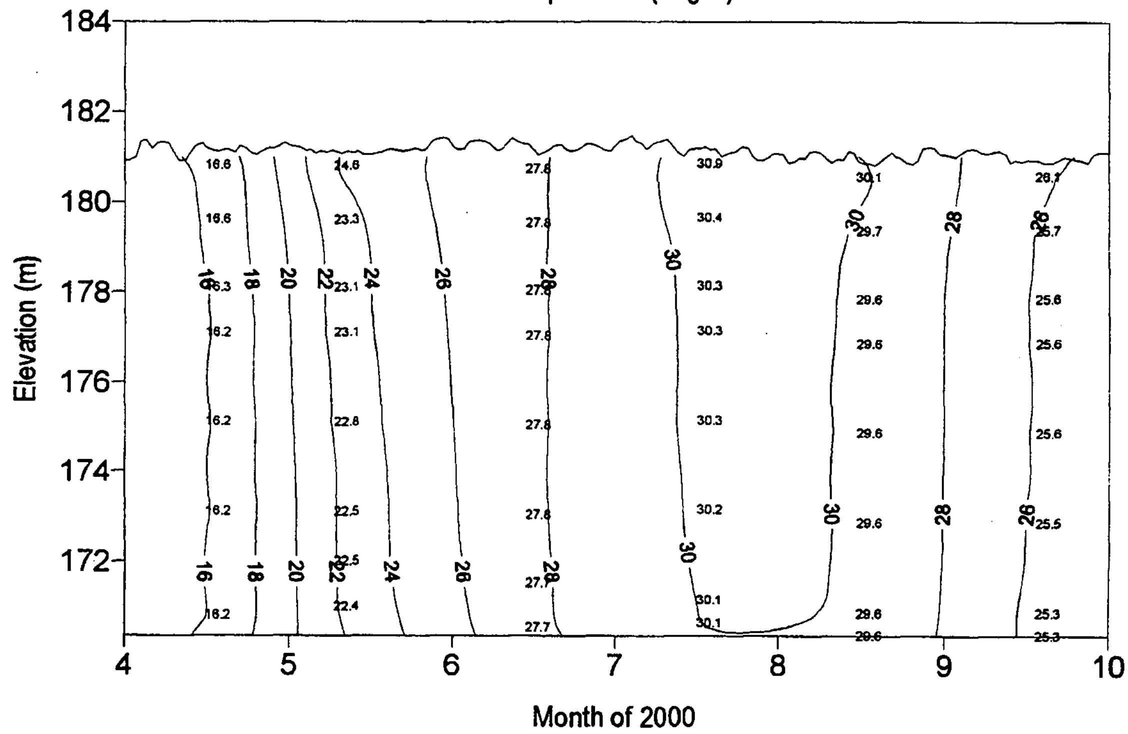
Guntersville Reservoir - TRM 350.0



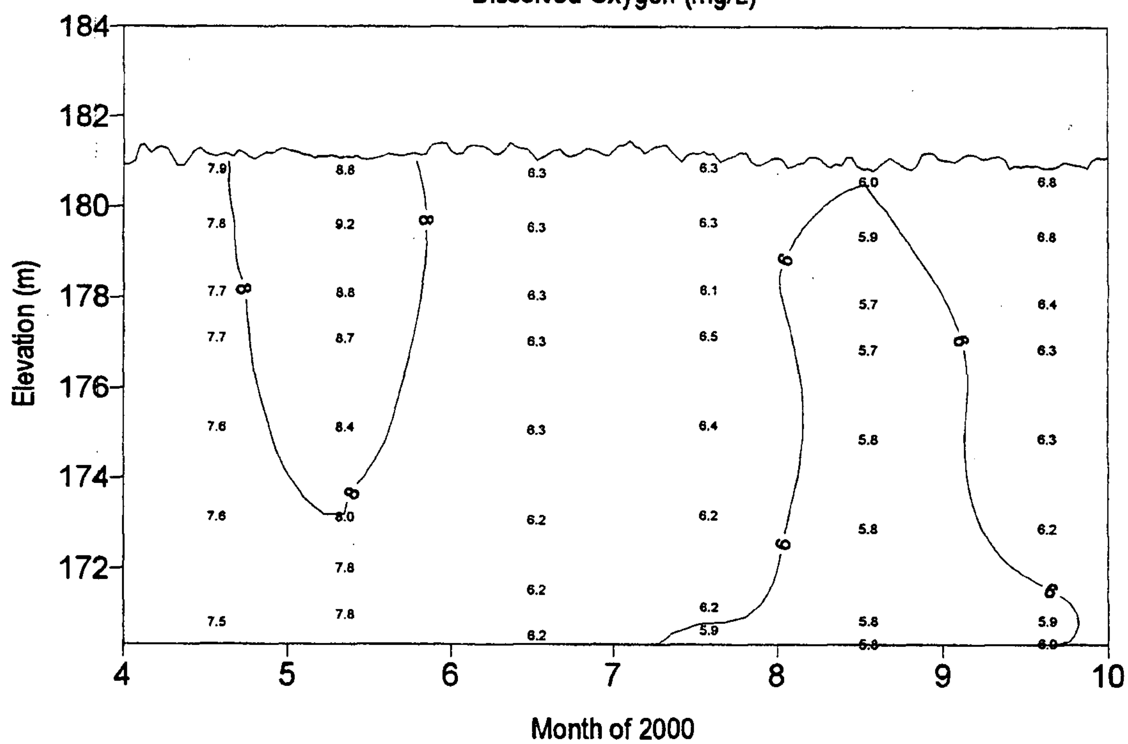


Guntersville Reservoir - TRM 375.2

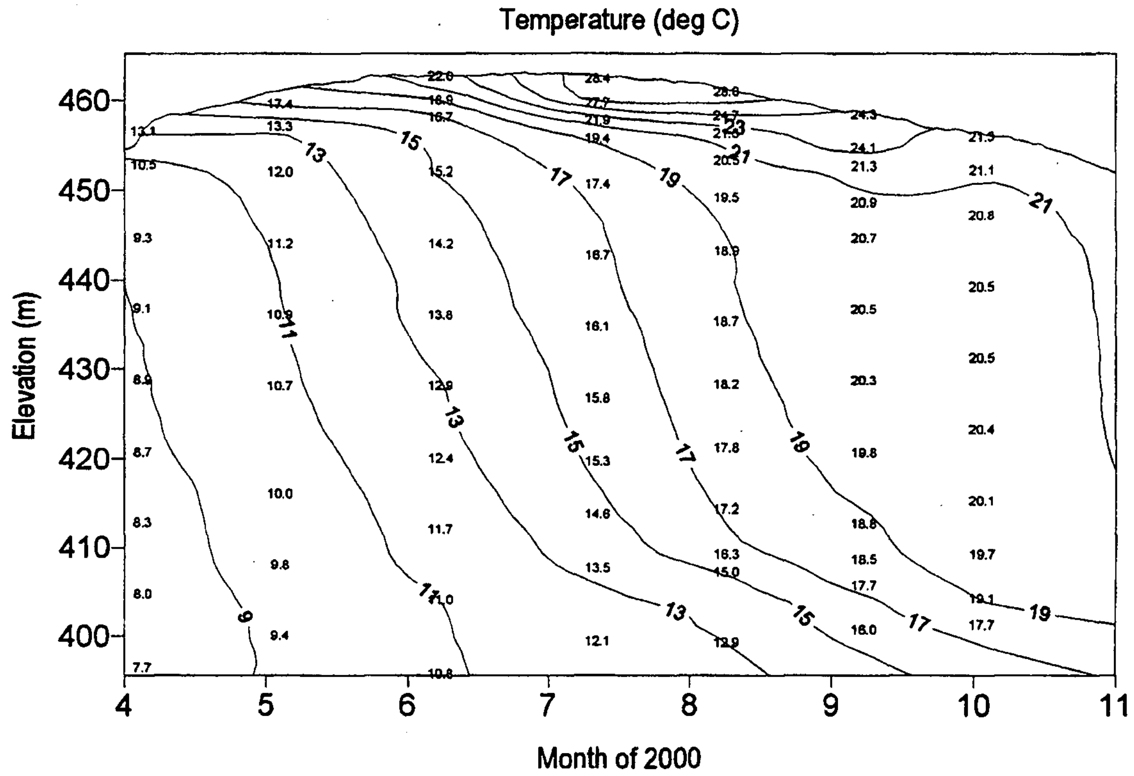
Temperature (deg C)

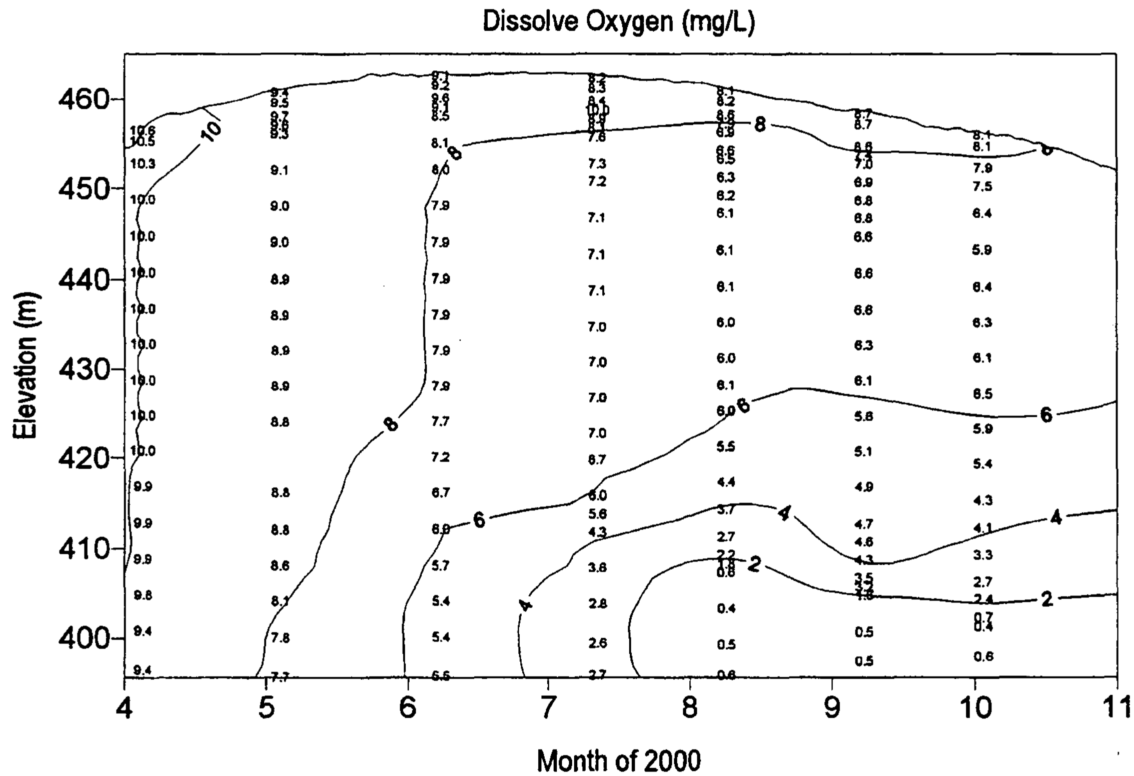


Dissolved Oxygen (mg/L)



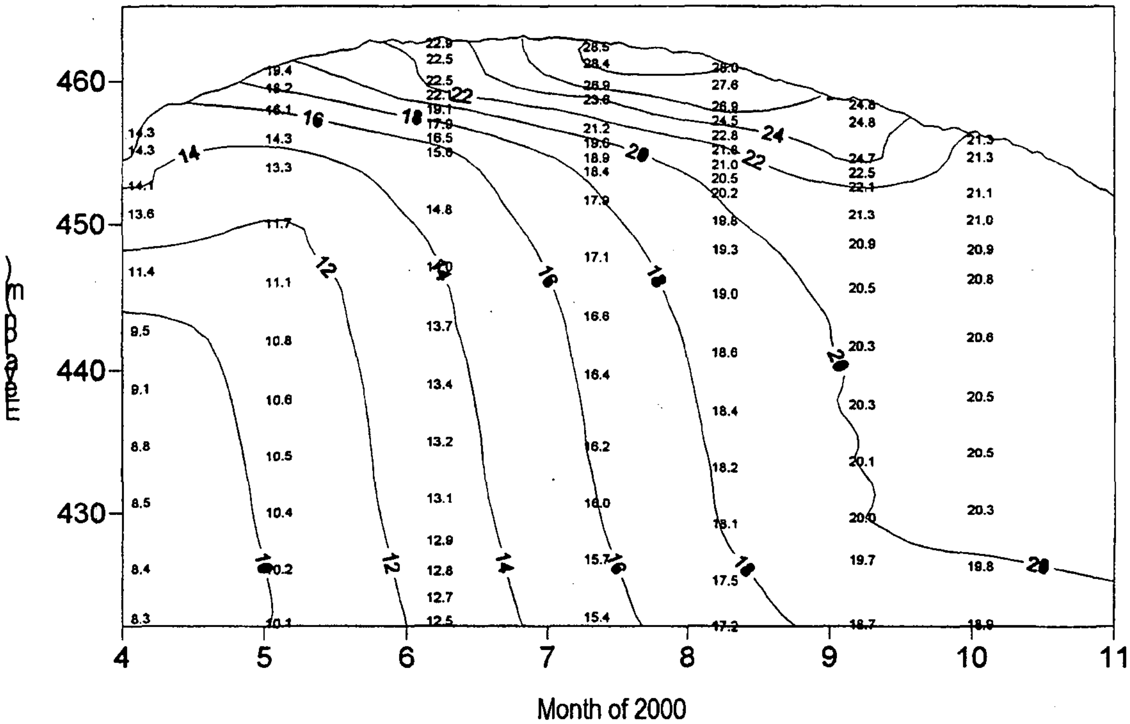
Hiwassee Reservoir - HiRM 77.5



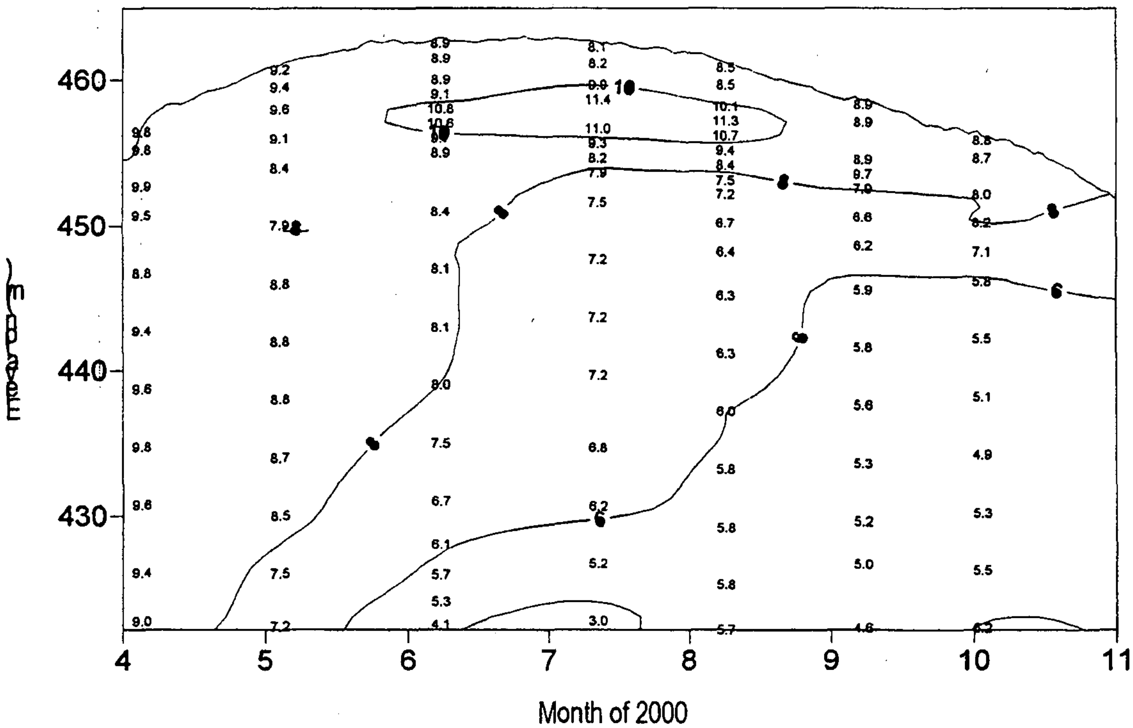


Hiwassee Reservoir - HiRM 85.0

Temperature (deg C)

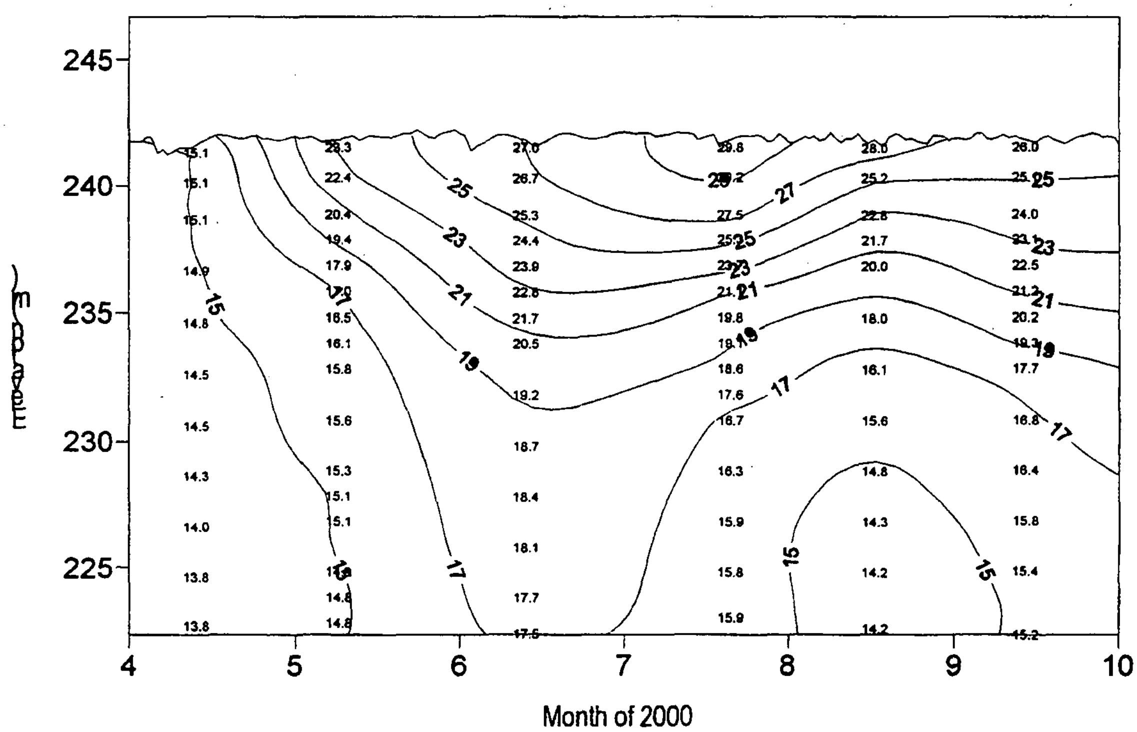


Dissolved Oxygen (mg/L)

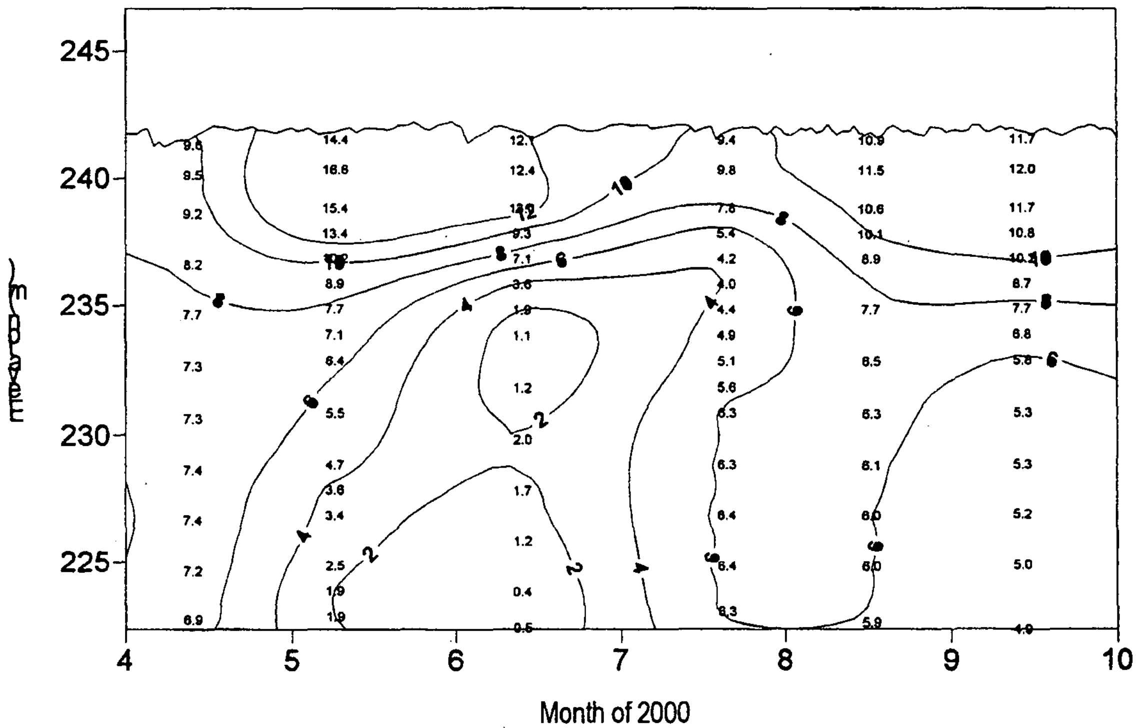


Melton Hill Reservoir - CRM 24.0

Temperature (deg C)

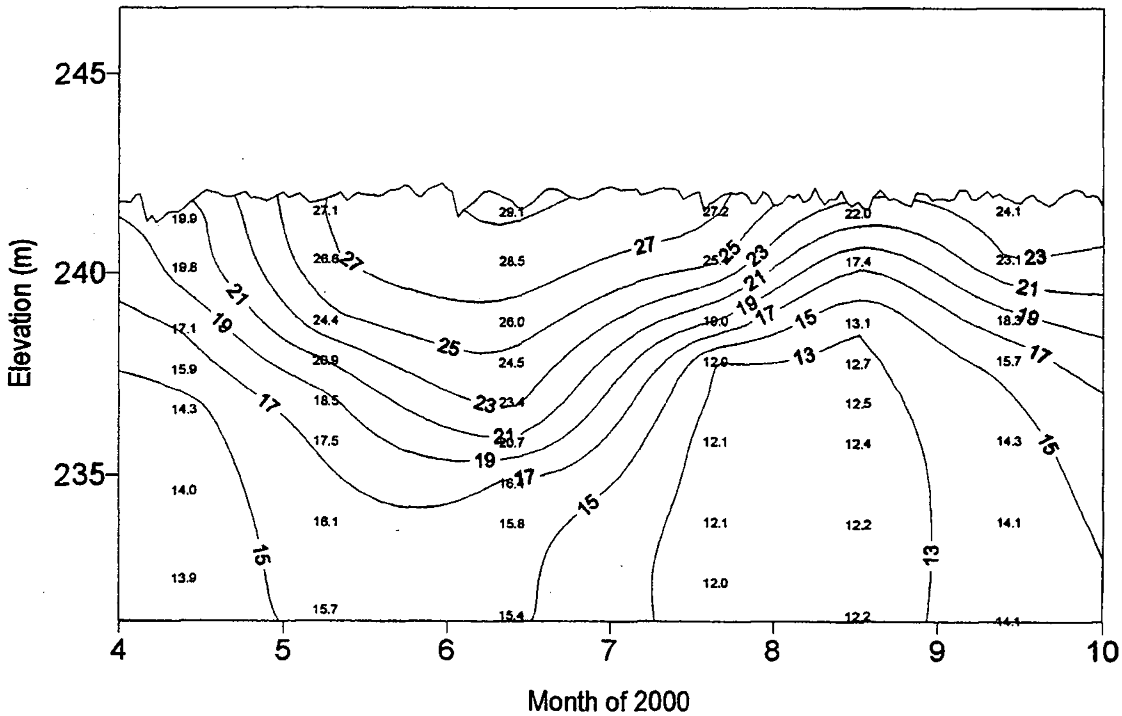


Dissolved Oxygen

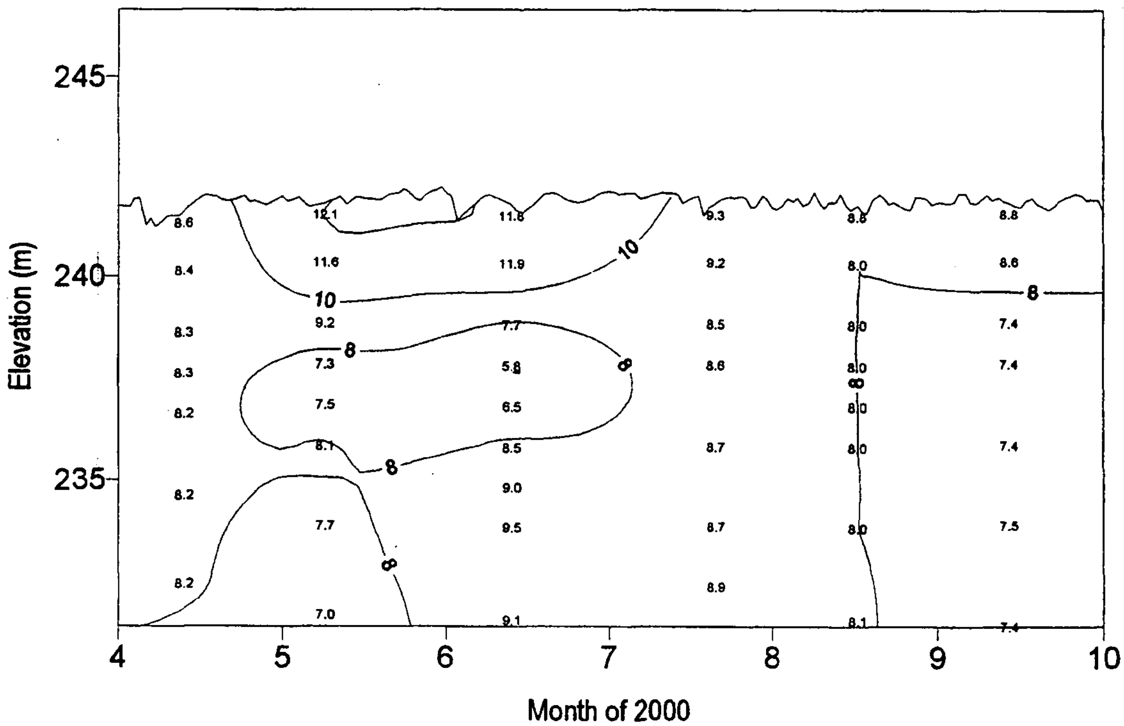


Melton Hill Reservoir - CRM 45.0

Temperature (deg C)

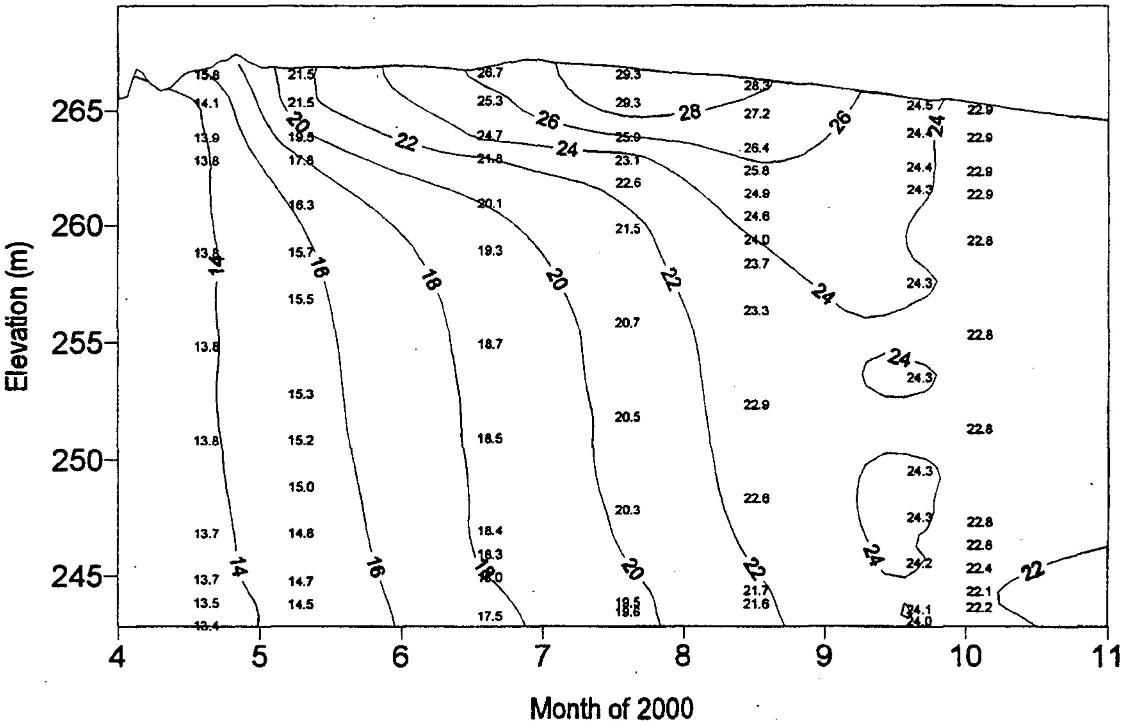


Dissolved Oxygen (mg/L)

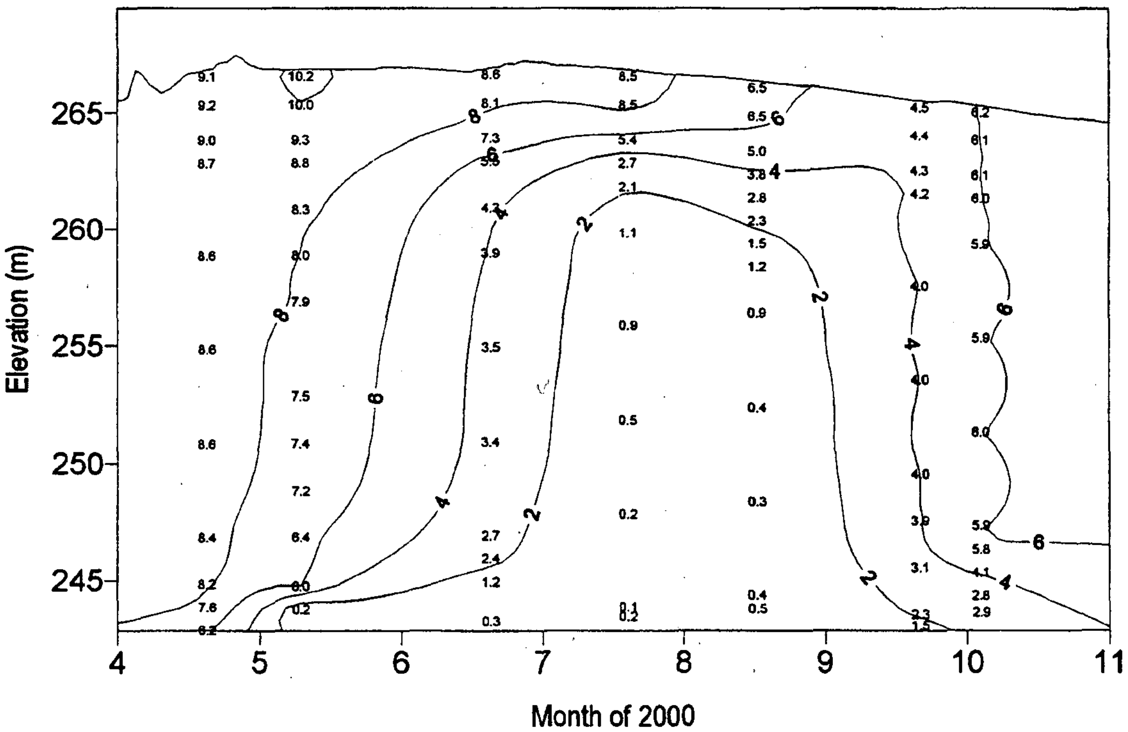


Normandy Forebay - DRM 249.5

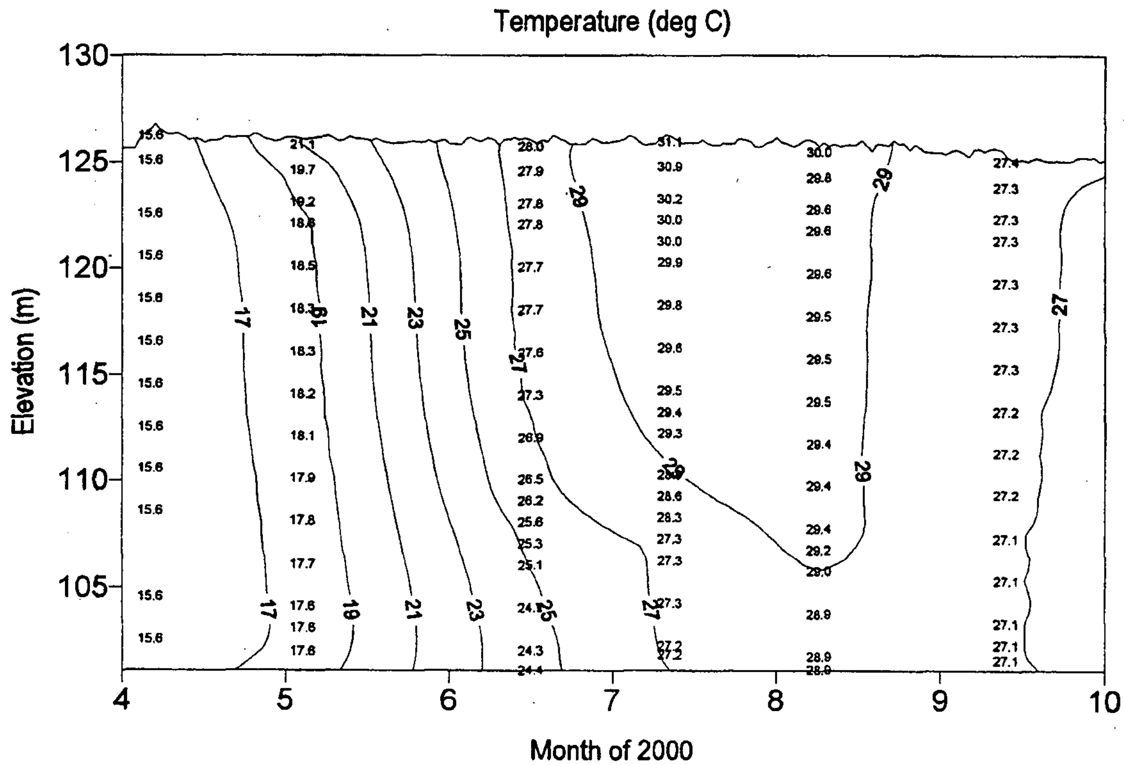
Temperature (deg C)

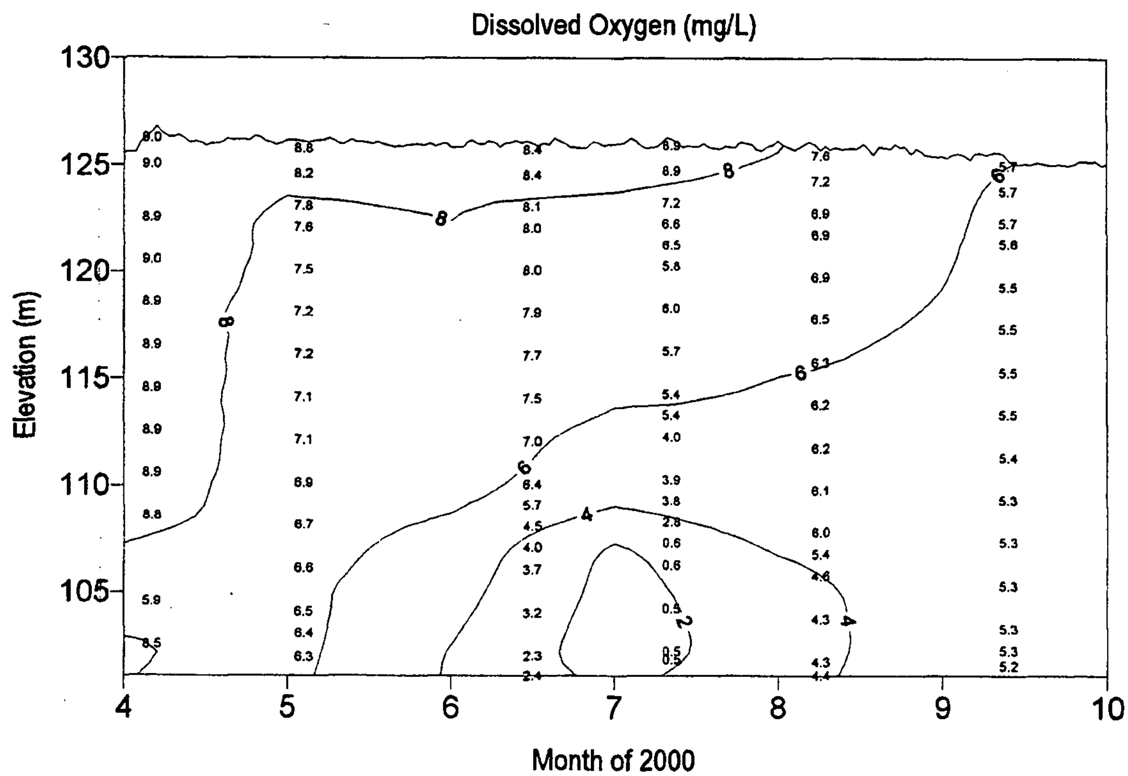


Dissolved Oxygen (mg/L)

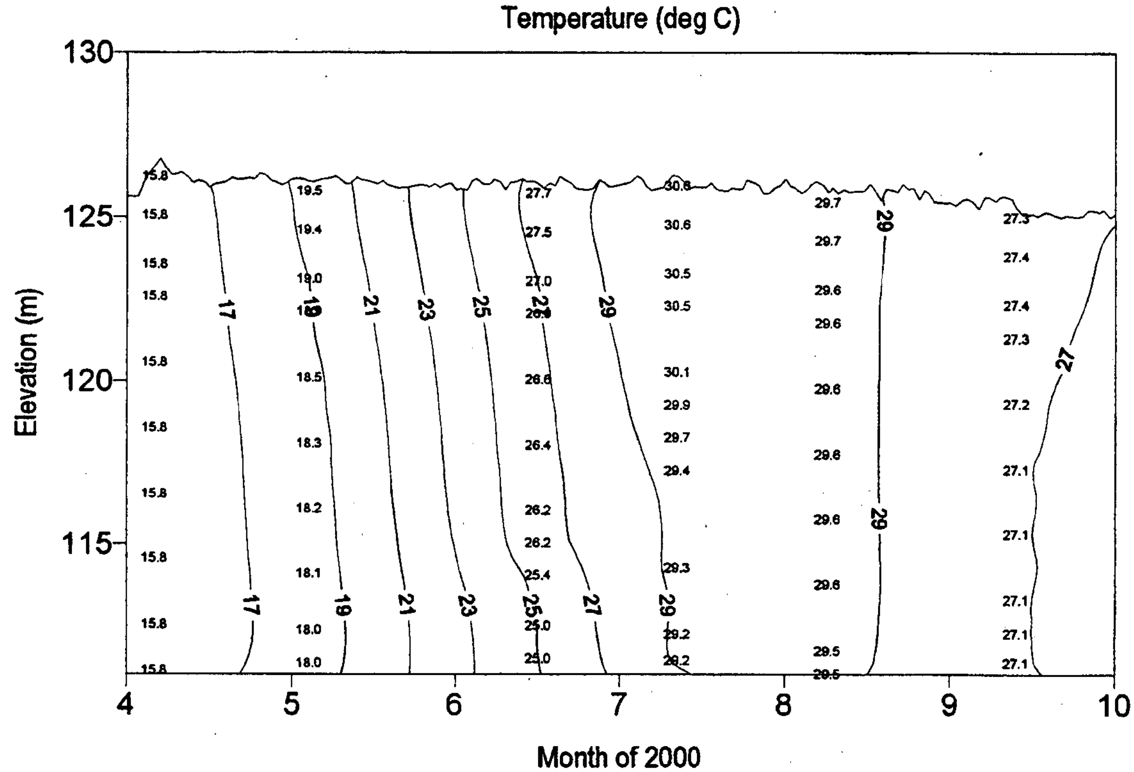


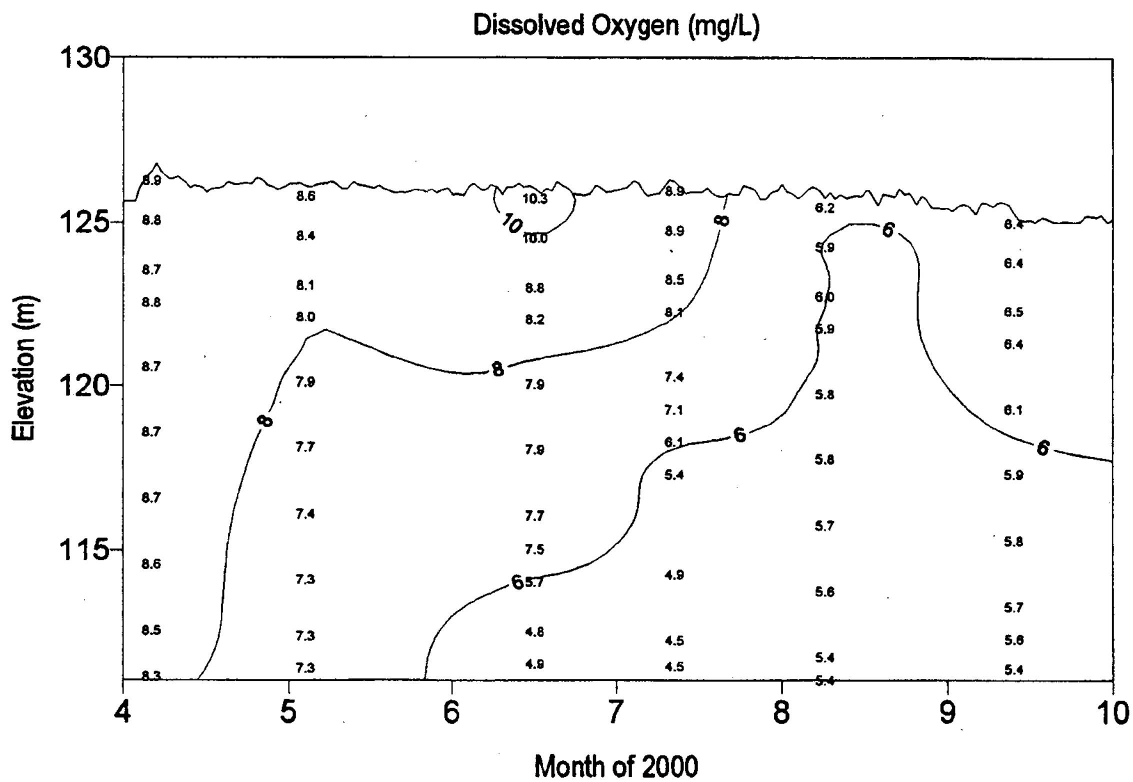
Pickwick Reservoir - TRM 207.3





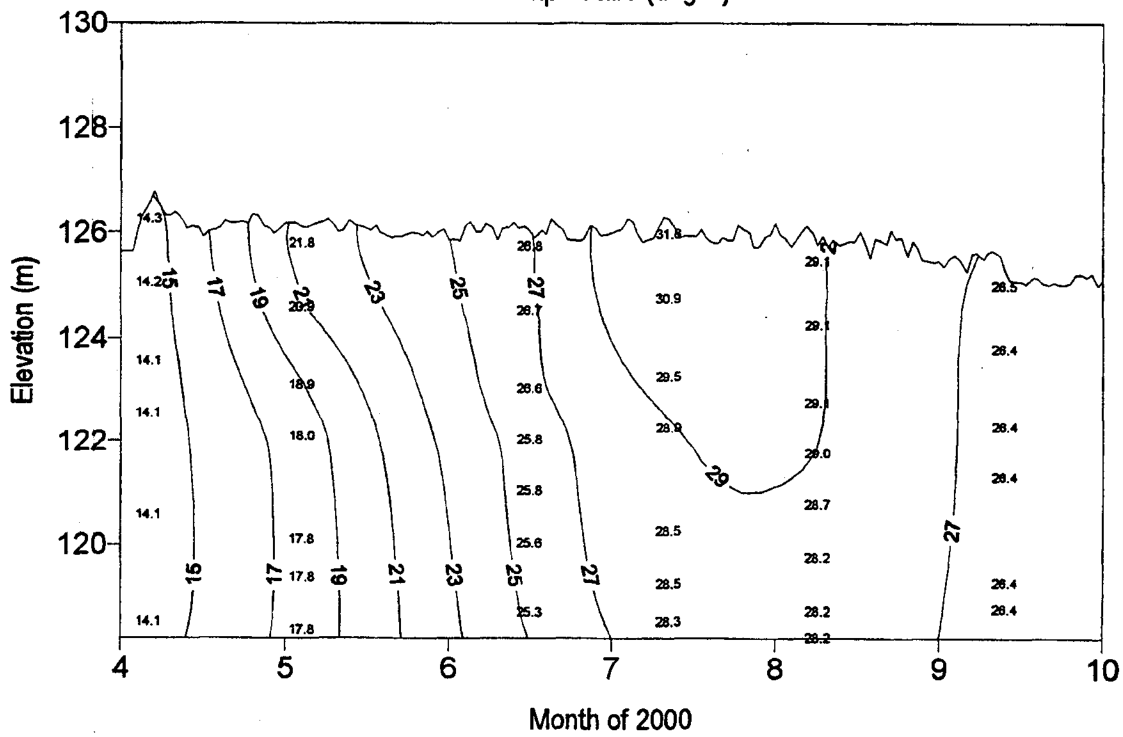
Pickwick Reservoir - TRM 230.0



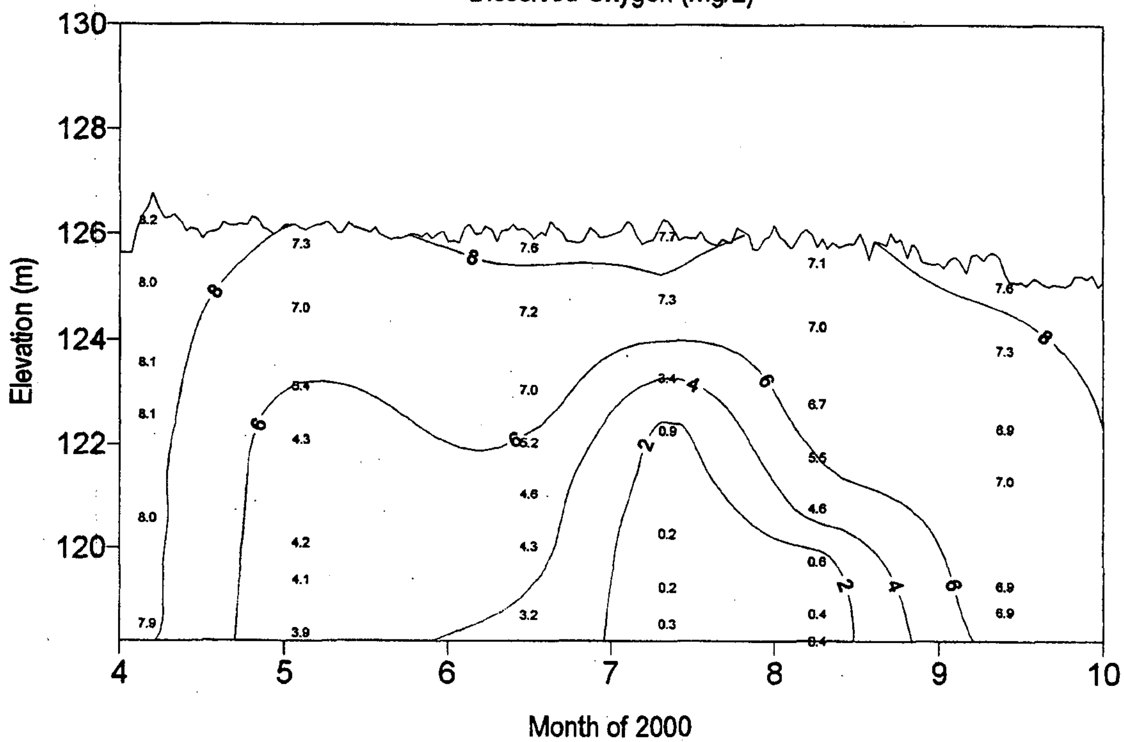


Pickwick Reservoir - BCM 8.4

Temperature (deg C)

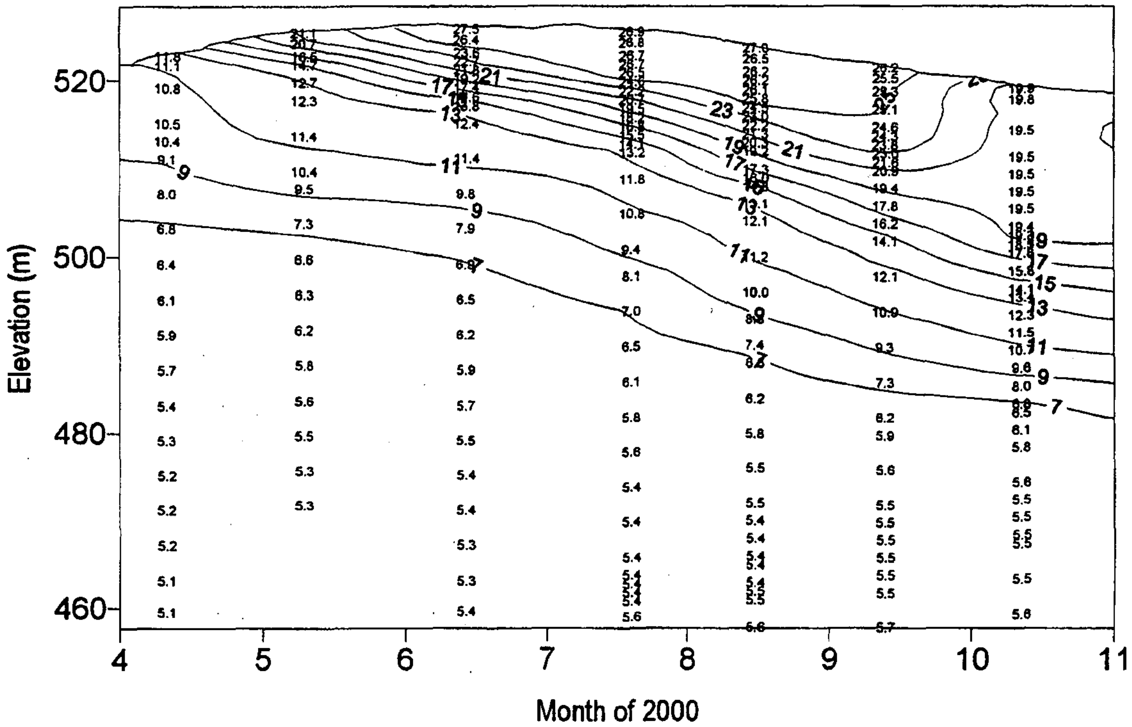


Dissolved Oxygen (mg/L)

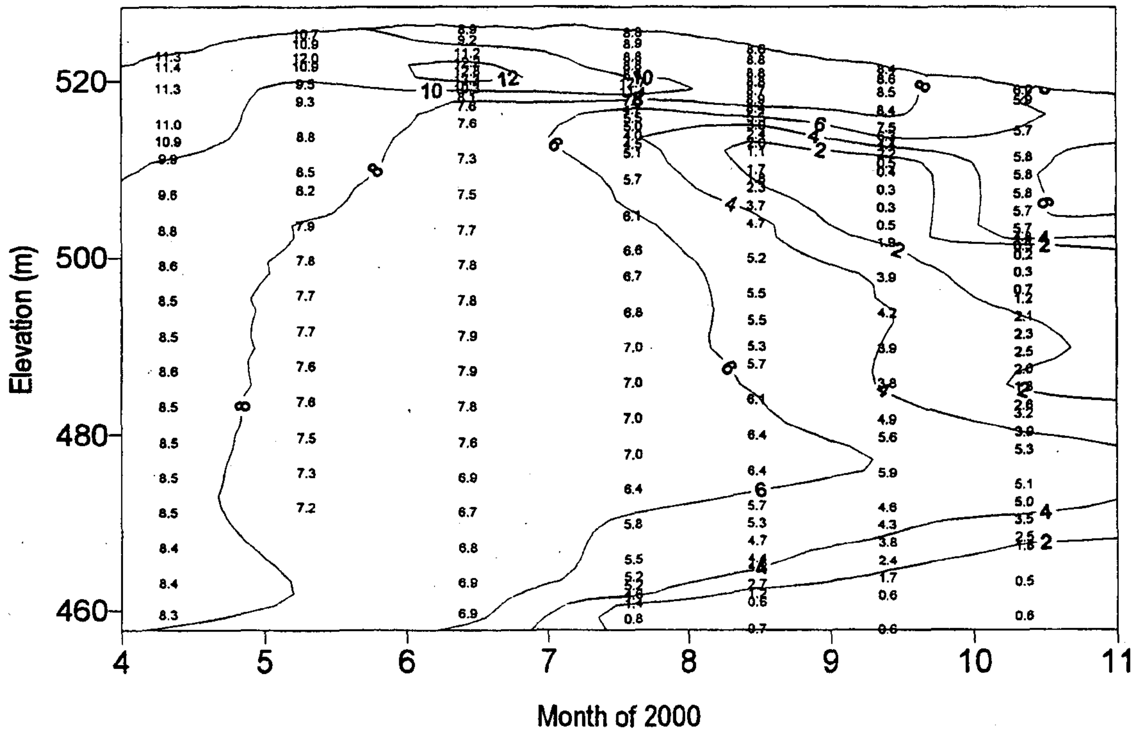


South Holston Reservoir - SFHRM 51.0

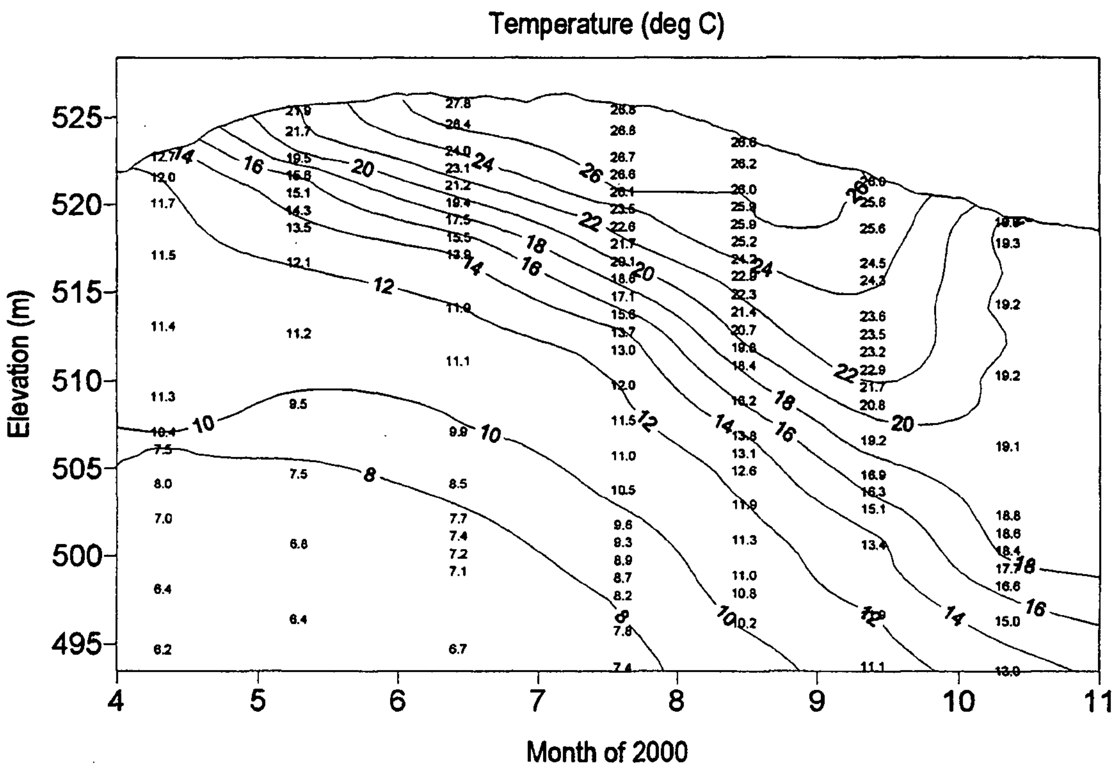
Temperature (deg C)

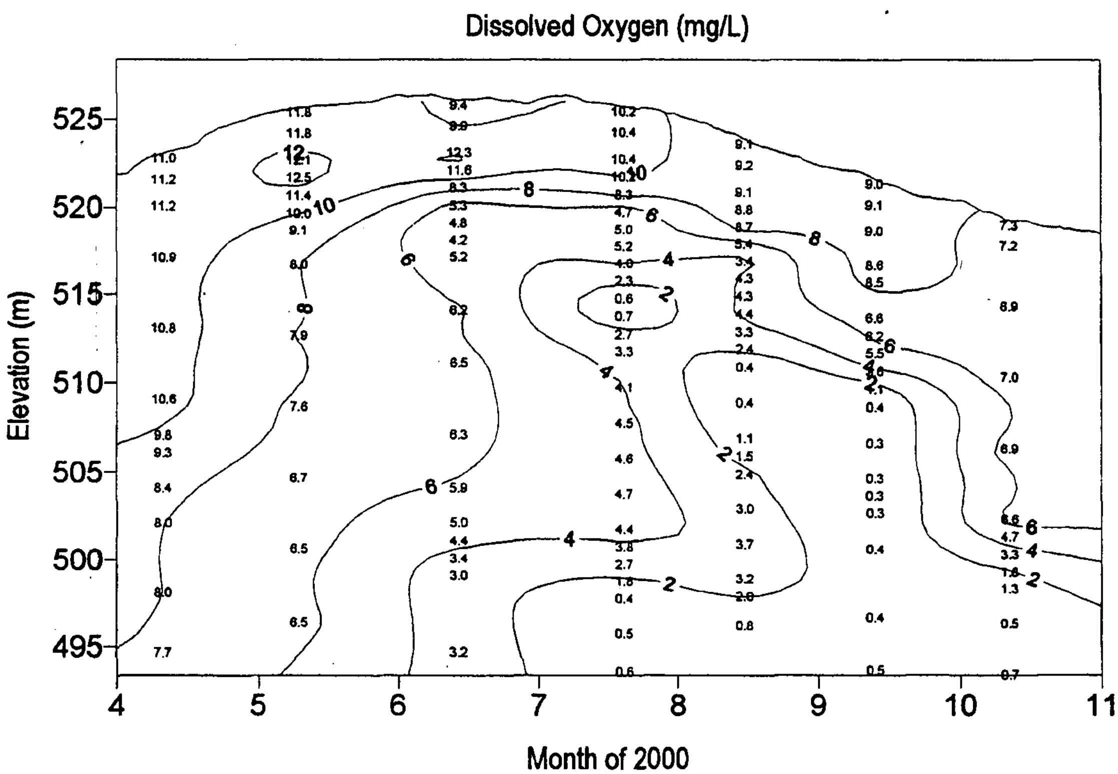


Dissolved Oxygen (mg/L)

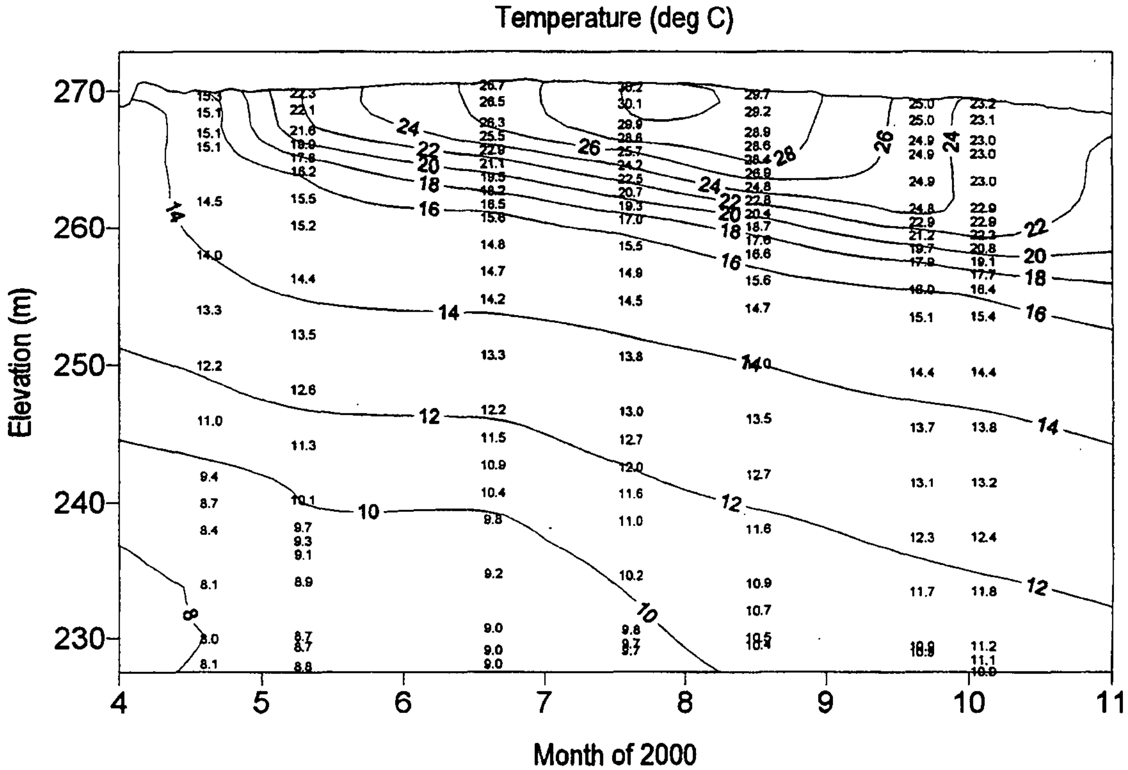


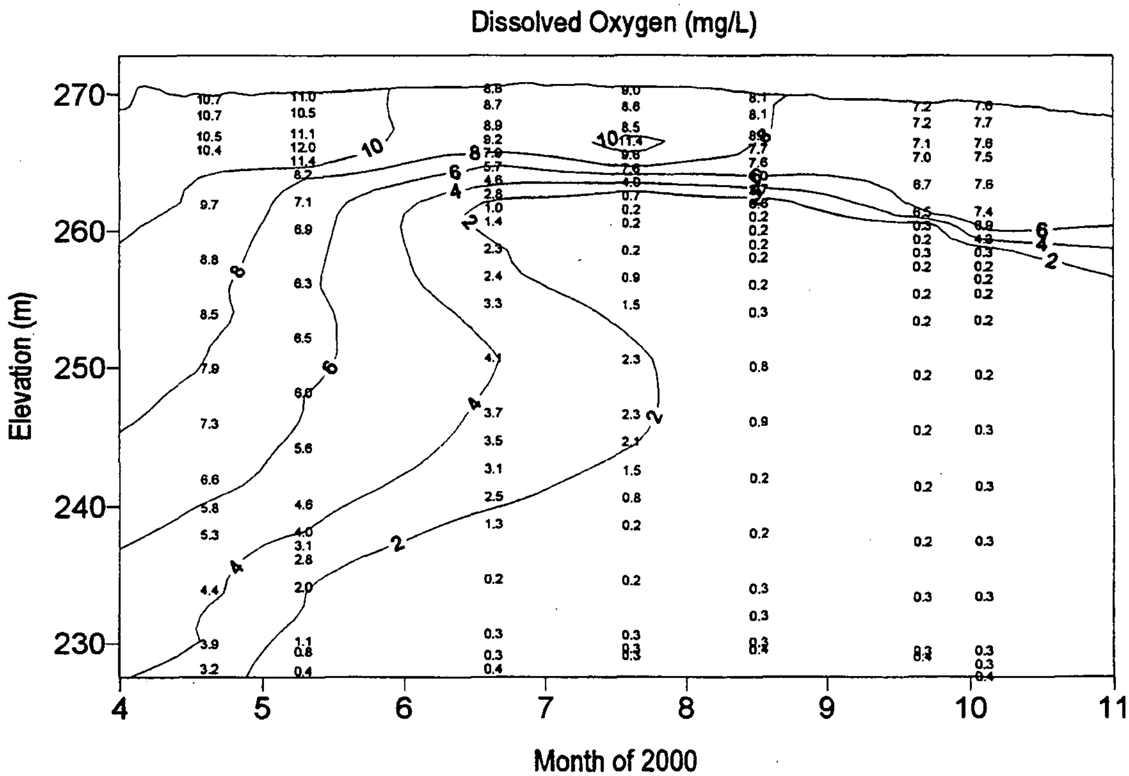
South Holston Reservoir - SFHRM 62.5





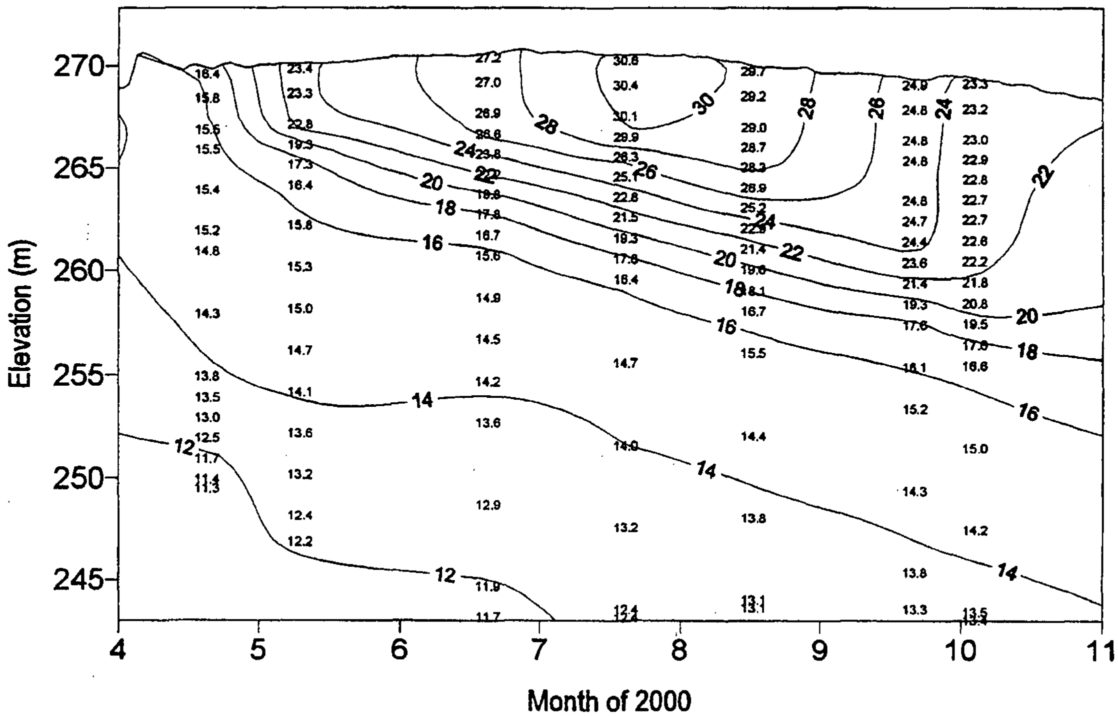
Tims Ford Reservoir - ERM 135.0



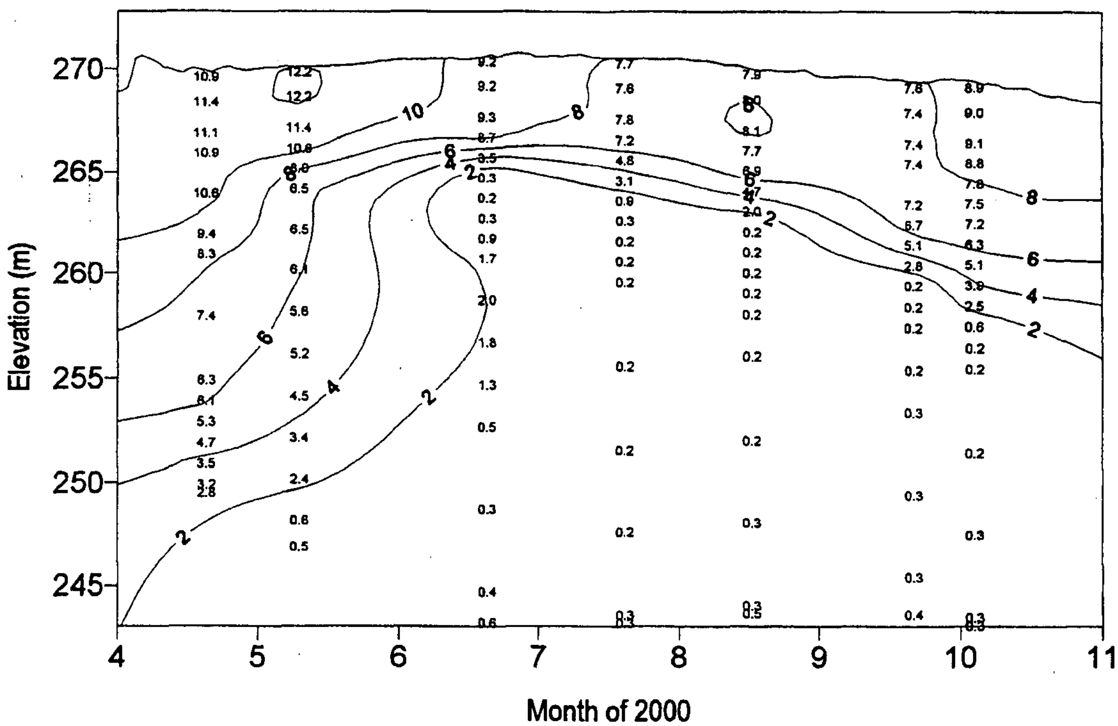


Tims Ford Reservoir - ERM 150.0

Temperature (deg C)

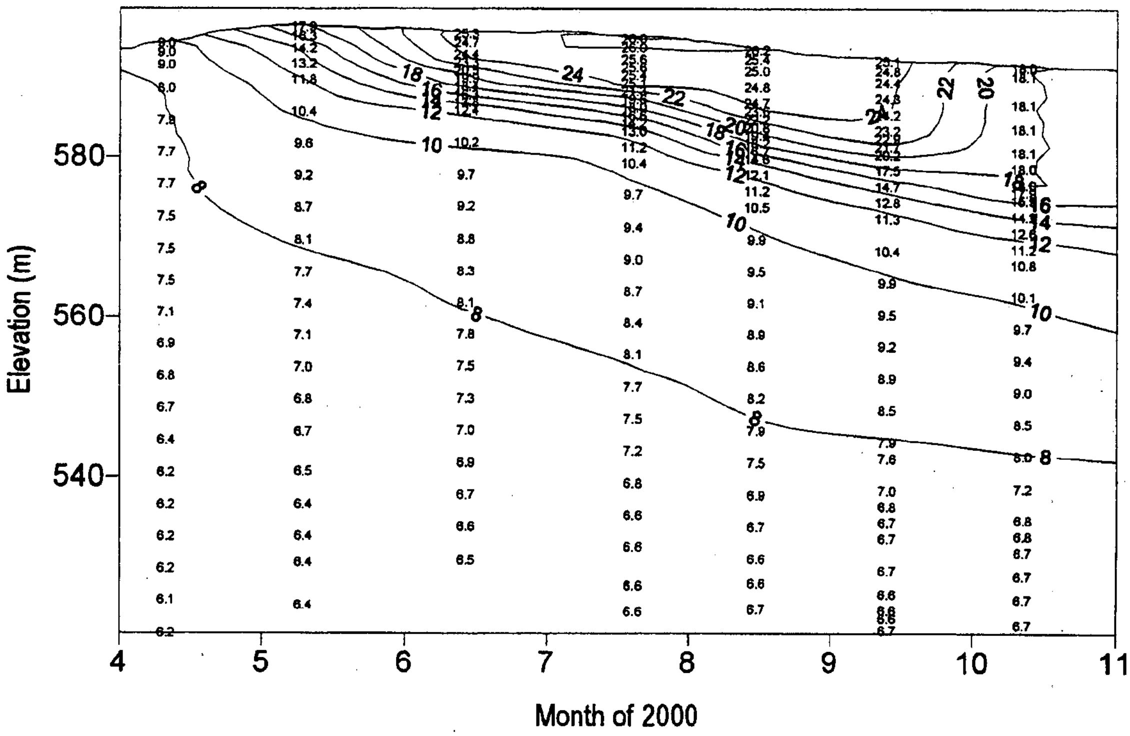


Dissolved Oxygen (mg/L)

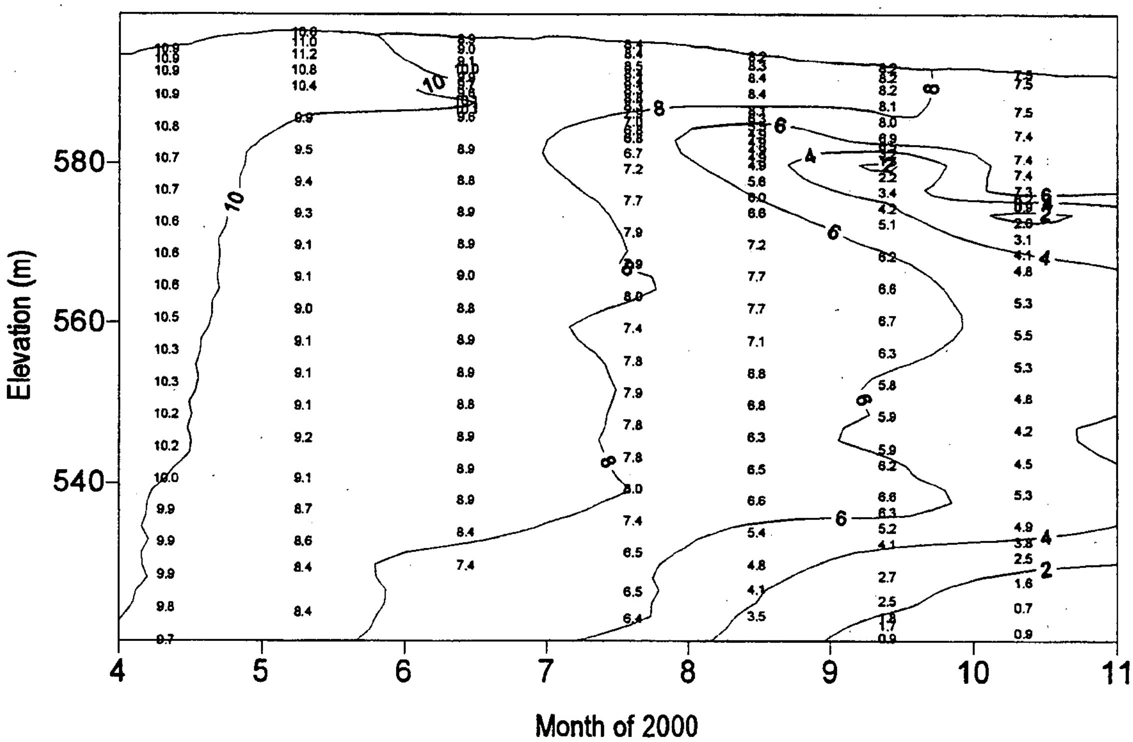


Watauga Reservoir - WRM 37.4

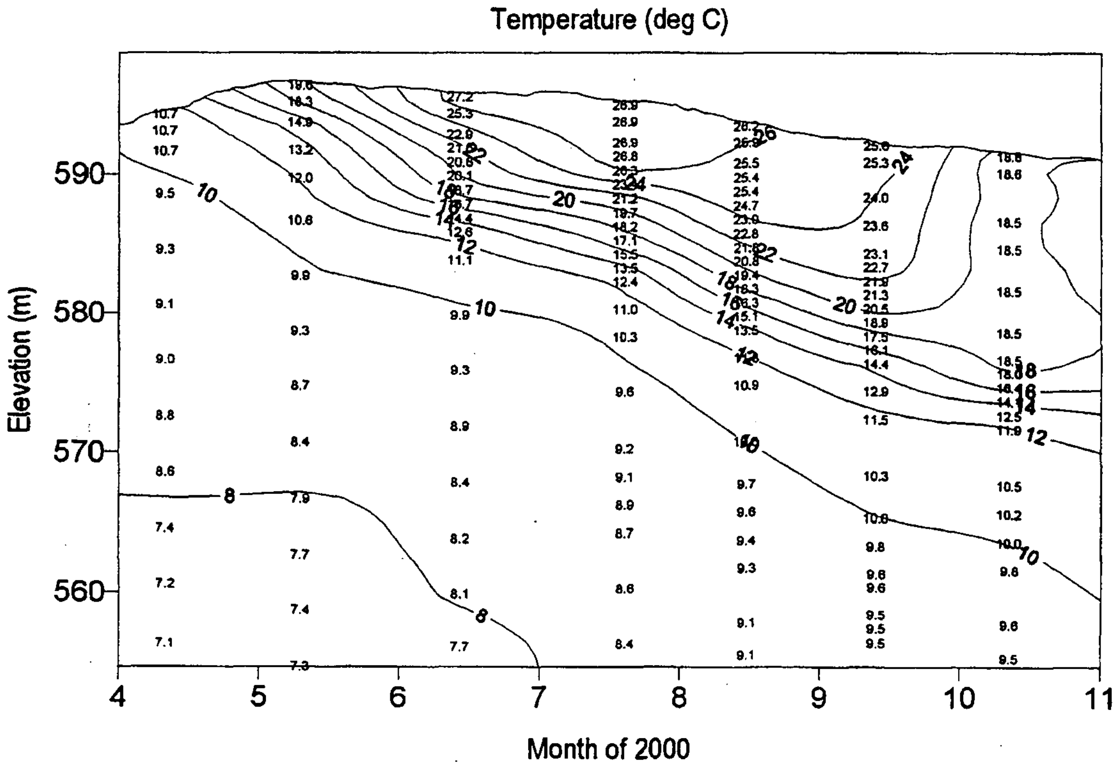
Temperature (deg C)

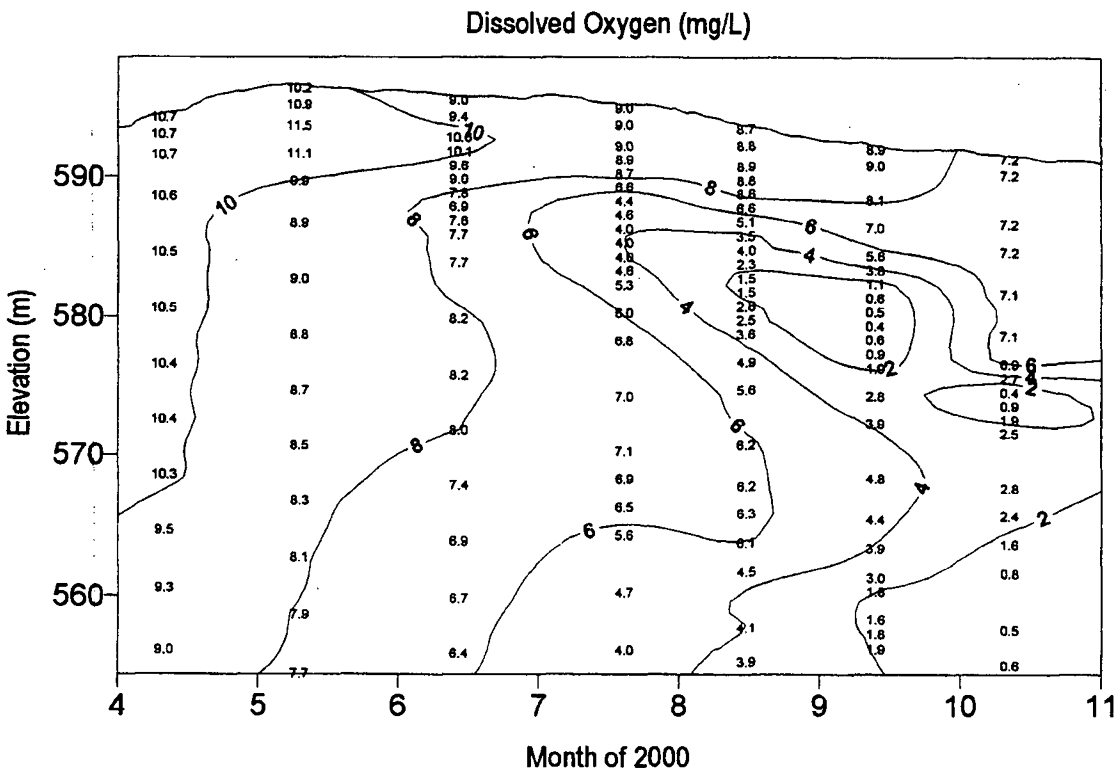


Dissolved Oxygen (mg/L)

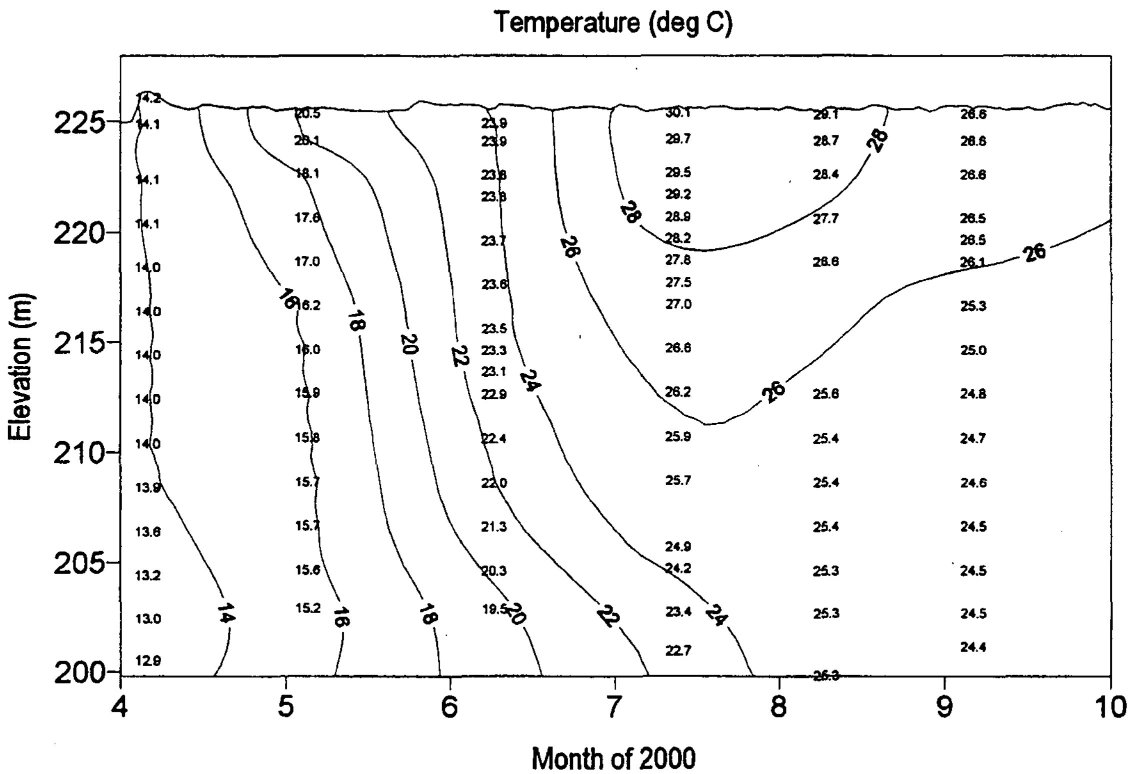


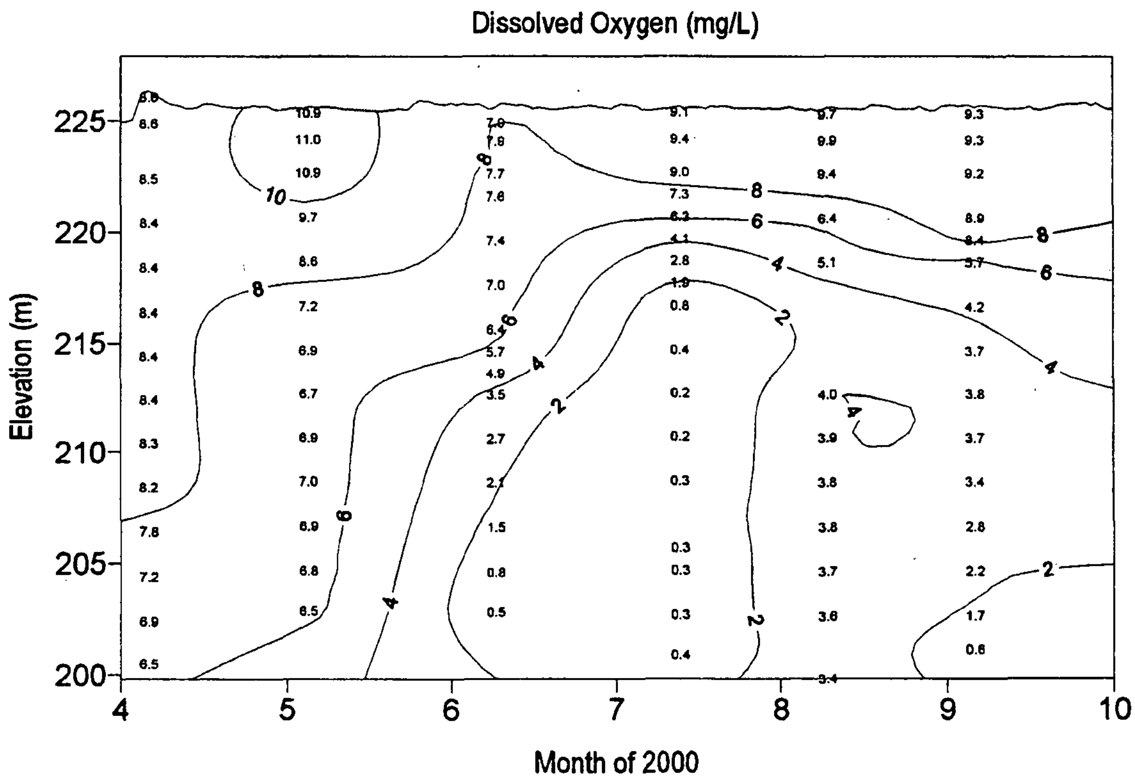
Watauga Reservoir - WRM 45.5





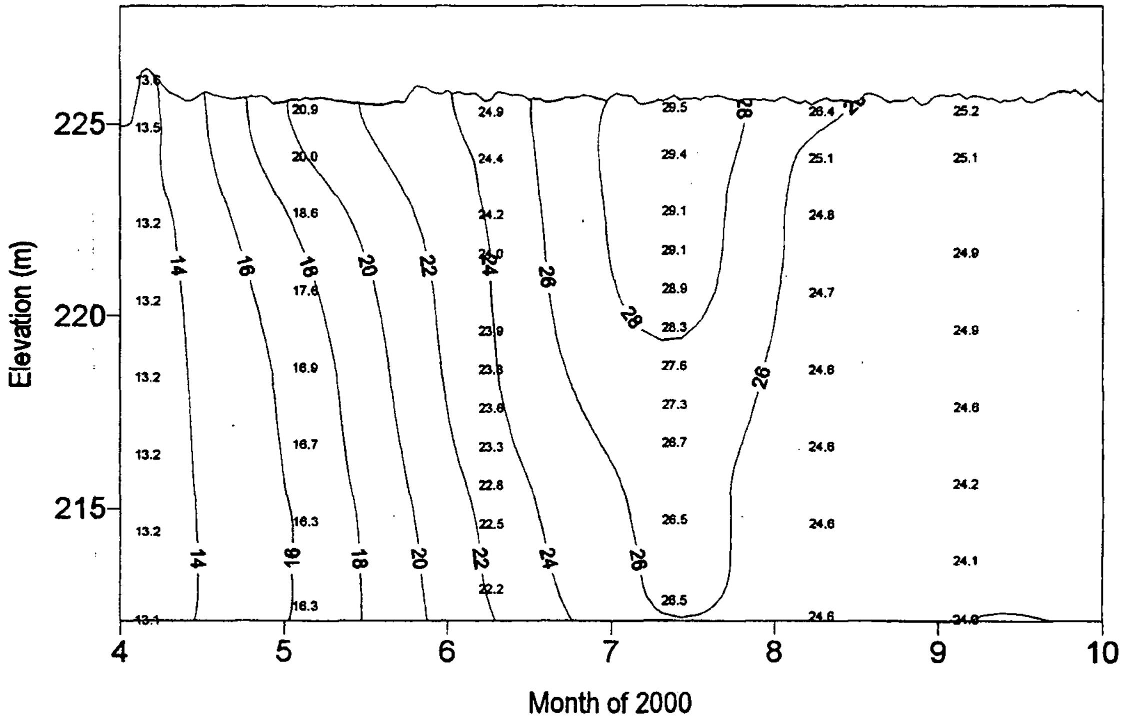
Watts Bar Reservoir - TRM 532.5



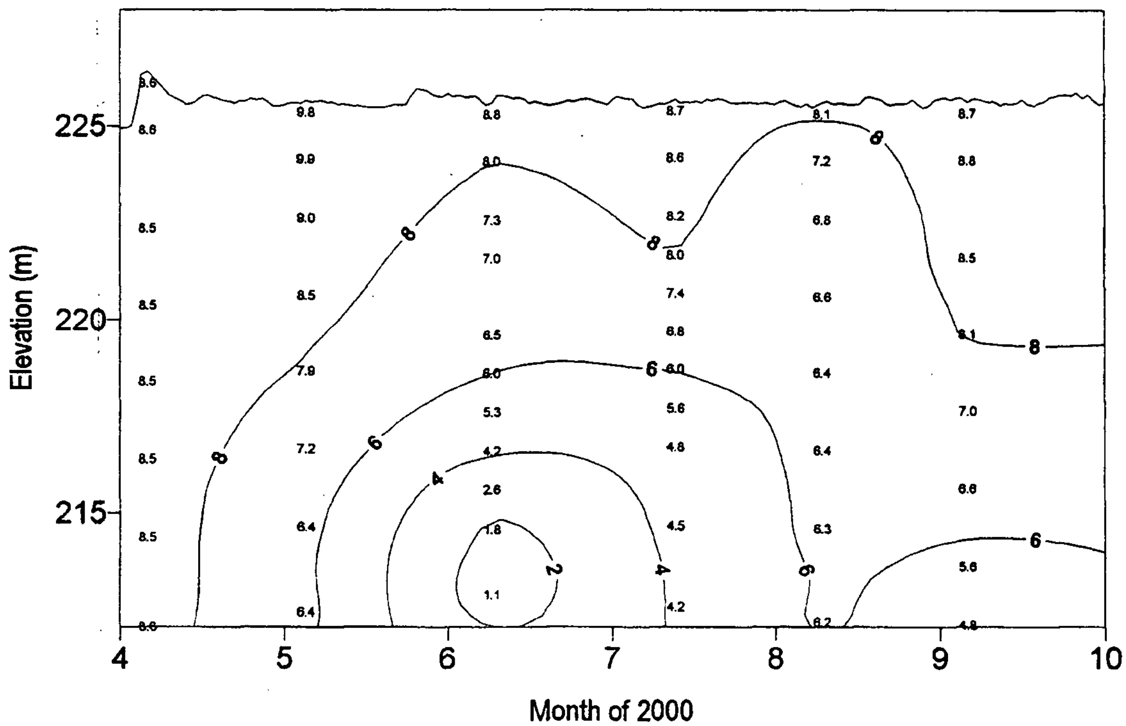


Watts Bar Reservoir - TRM 560.8

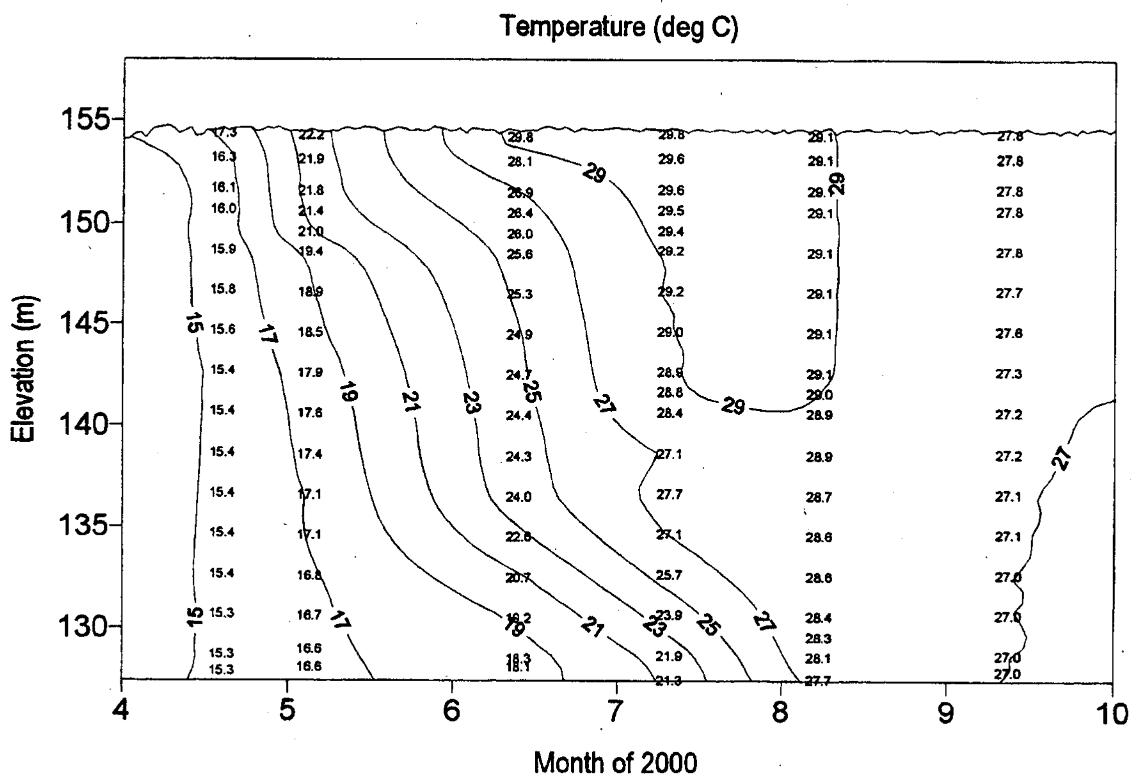
Temperature (deg C)

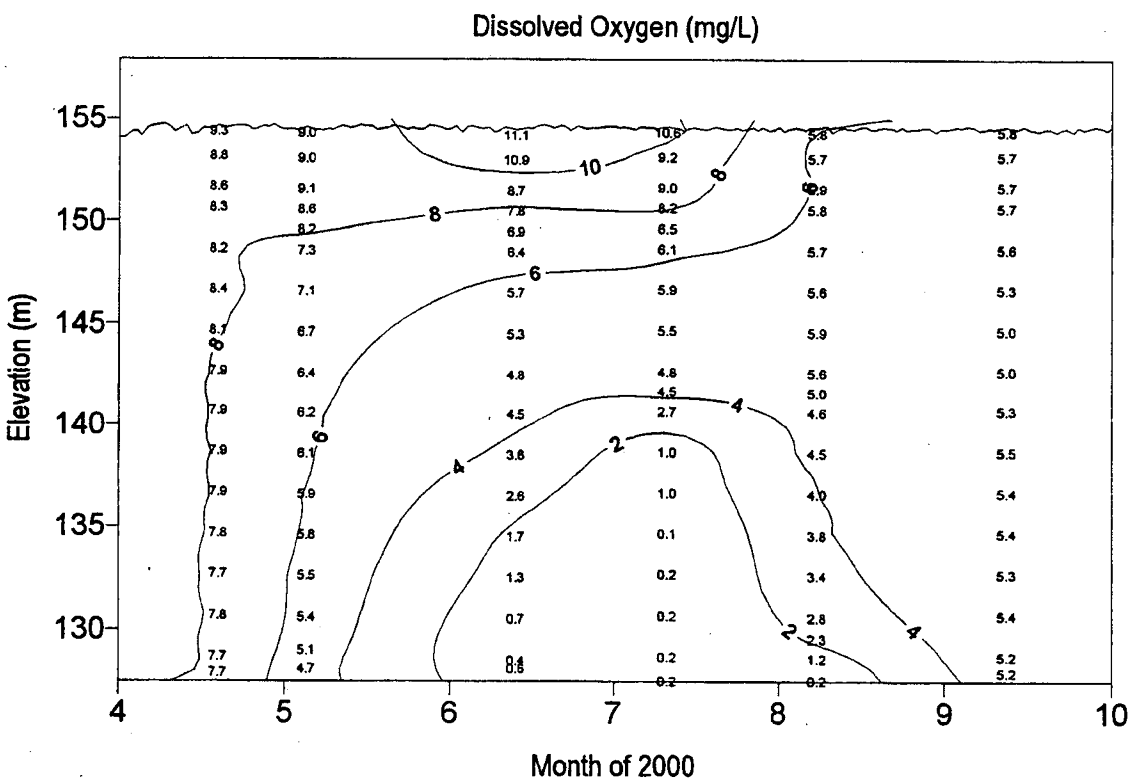


Temperature (deg C)



Wilson Reservoir - TRM 260.8



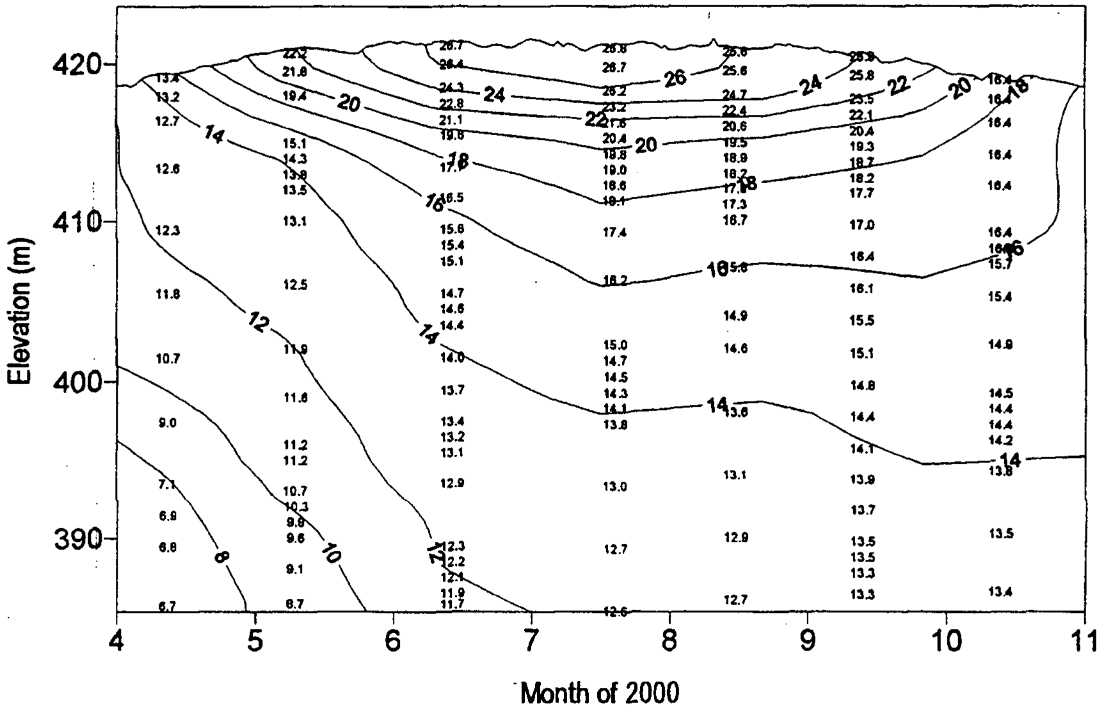


Appendix B

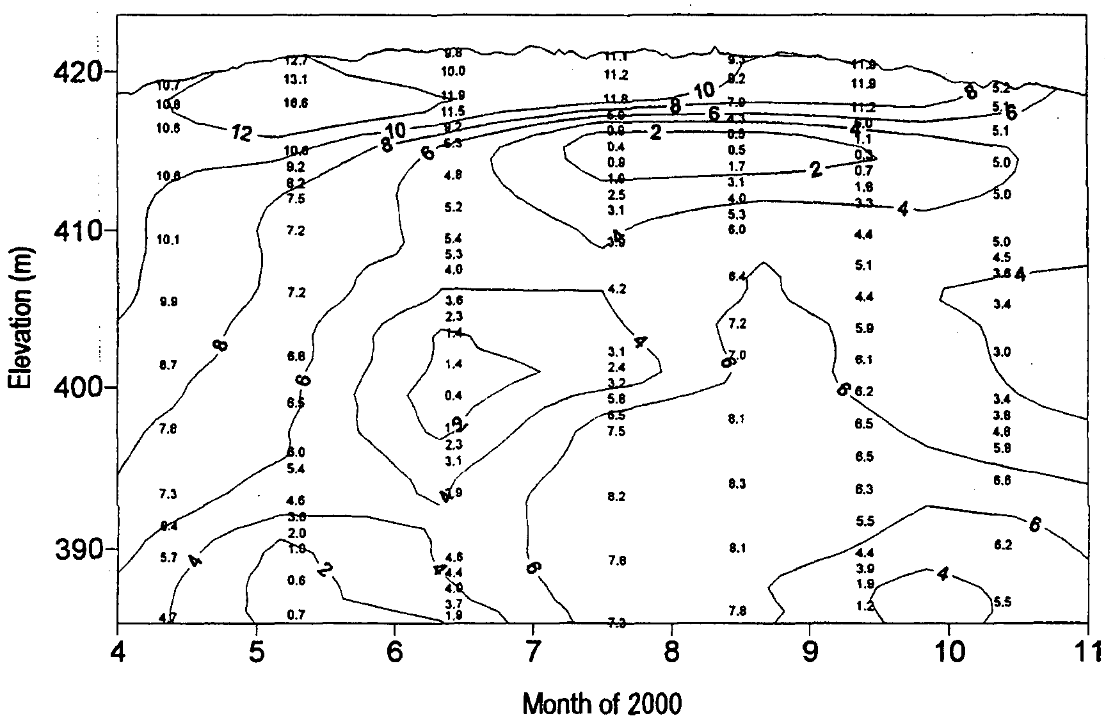
Temperature and DO Isopleths for "Extra" Locations Monitored in 2000 To Meet Specific Needs, Primarily Due to Drought Conditions

Boone Reservoir - SFHRM 19.0

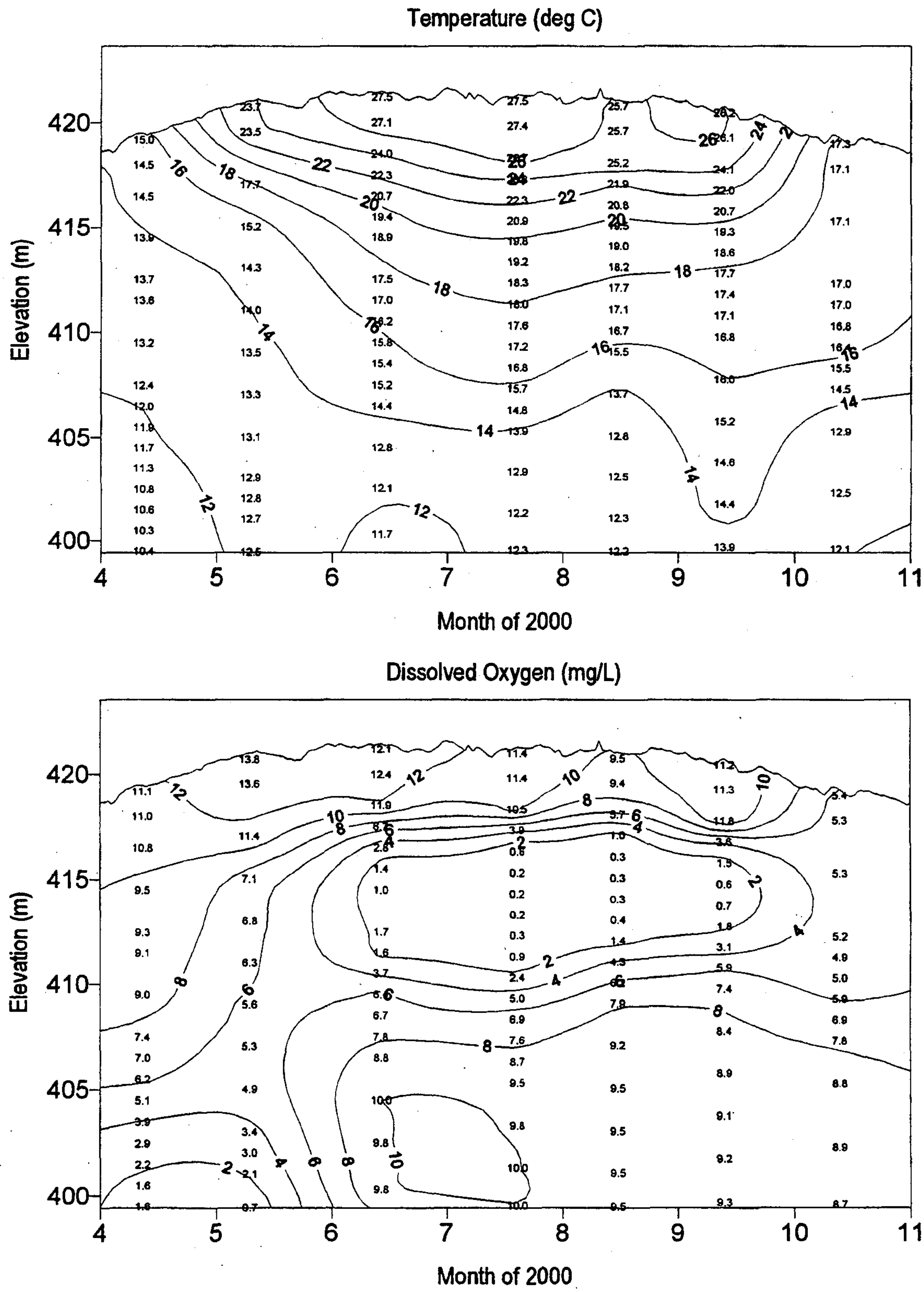
Temperature (deg C)



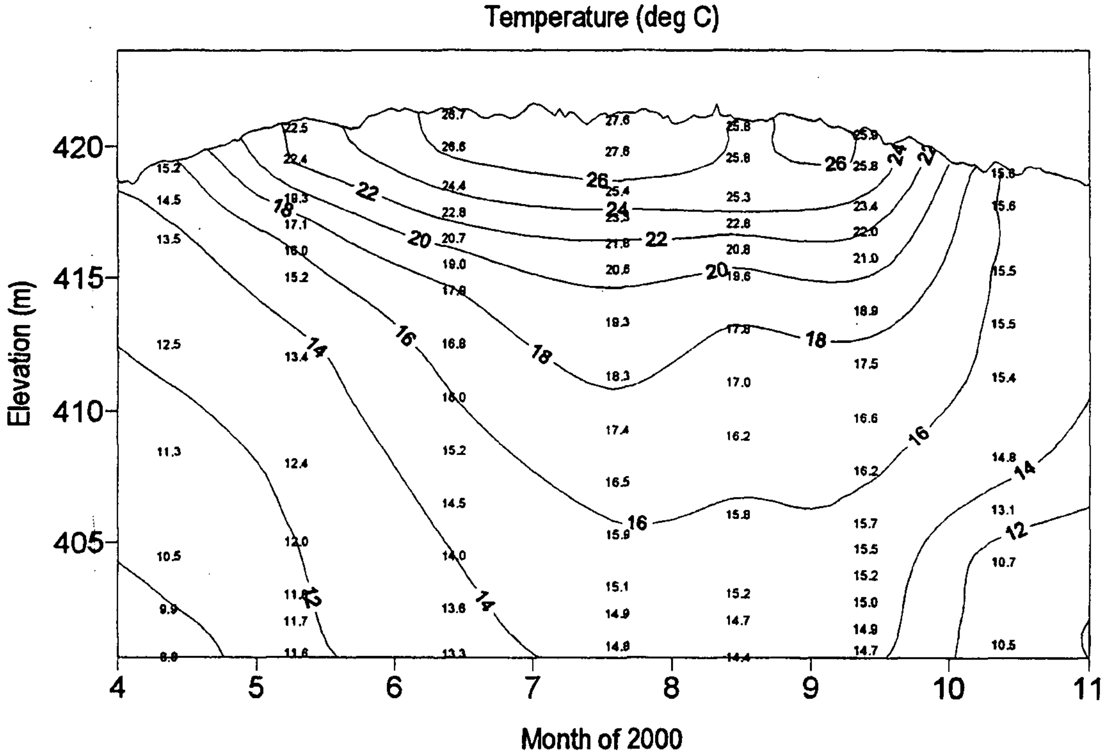
Dissolved Oxygen (mg/L)

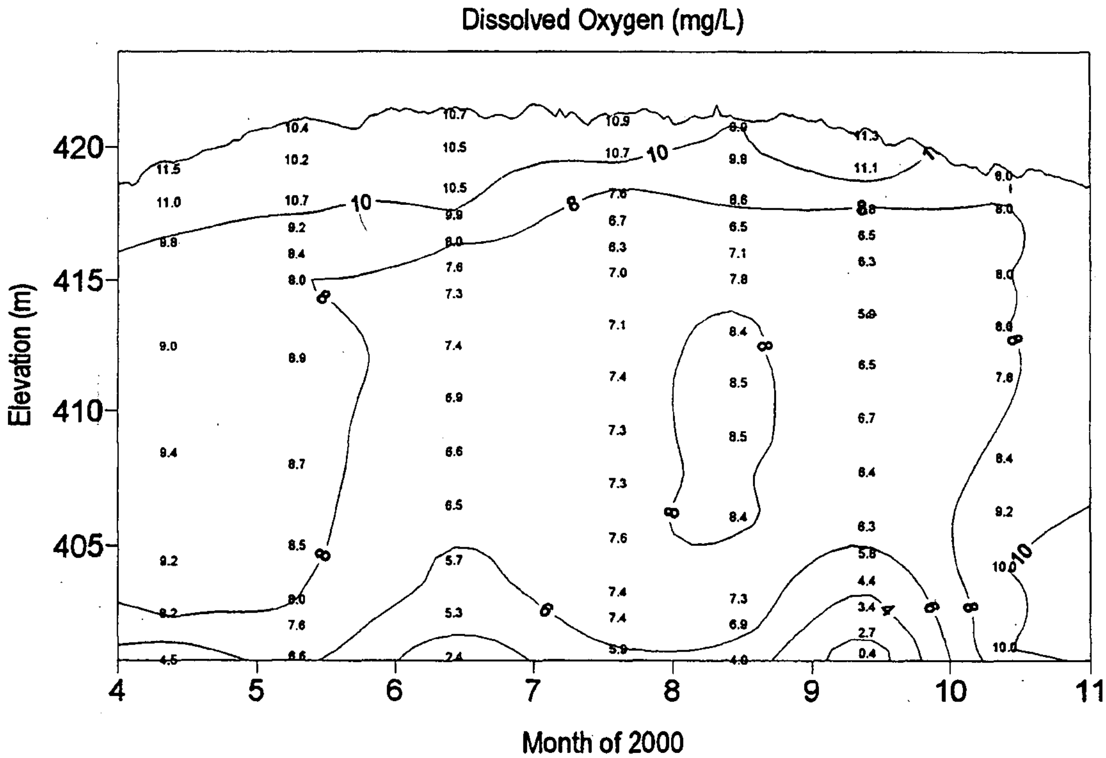


Boone Reservoir - SFHRM 27.0



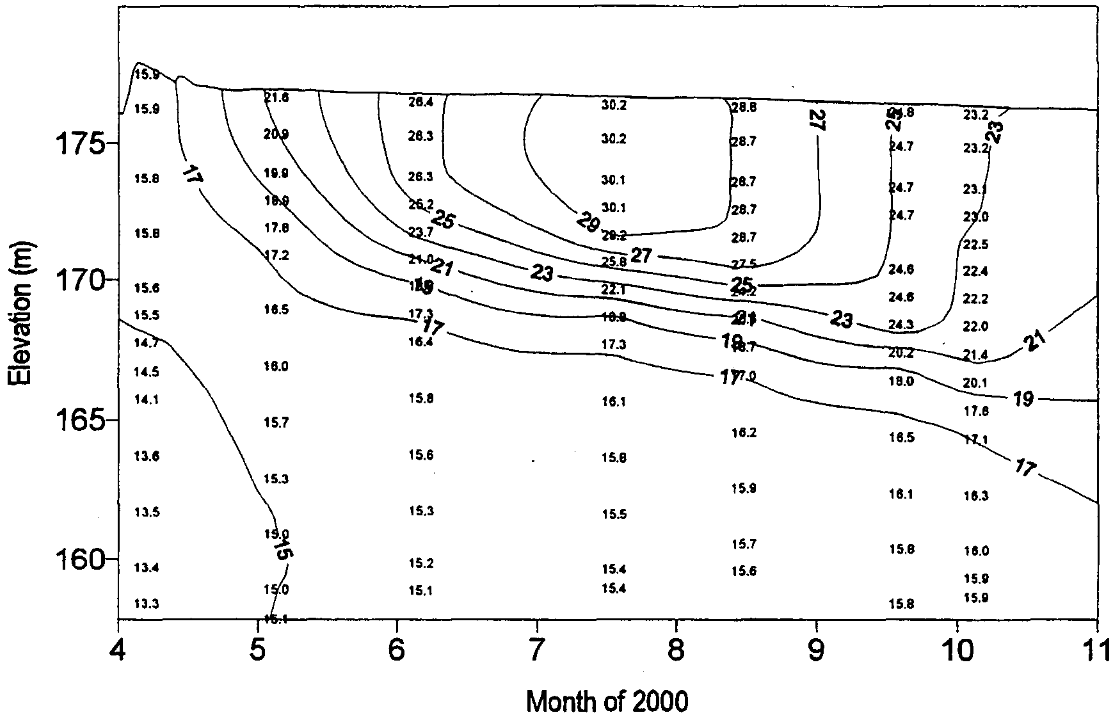
Boone Reservoir - WRM 6.5



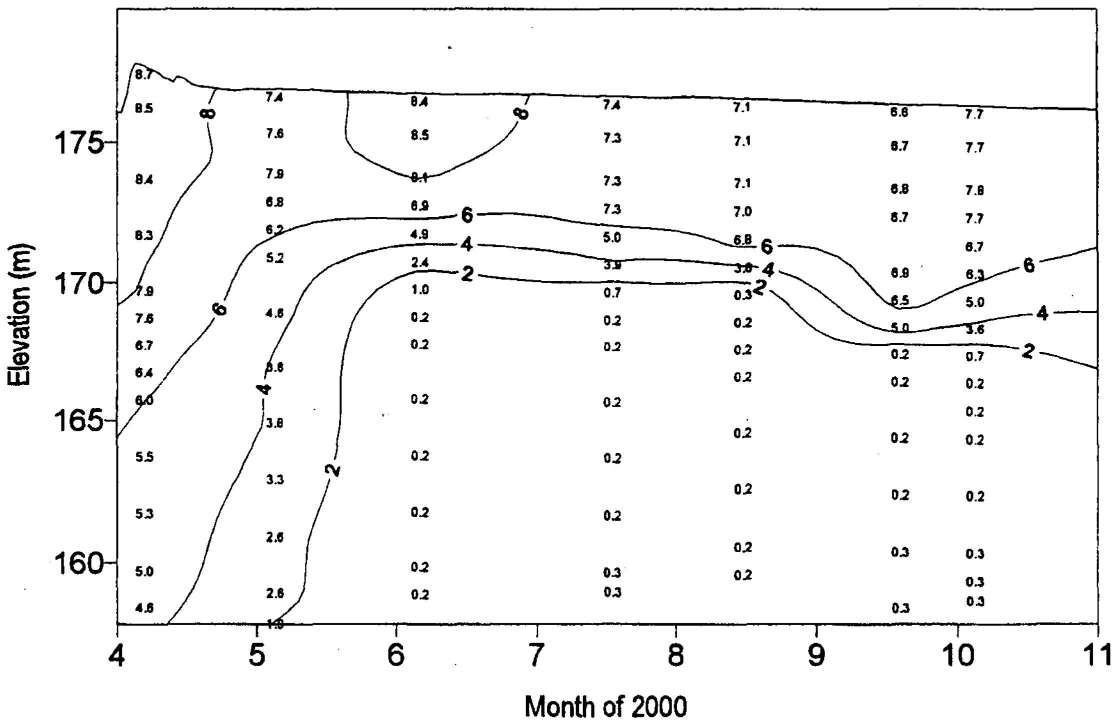


Cedar Creek Reservoir - CCM 25.2

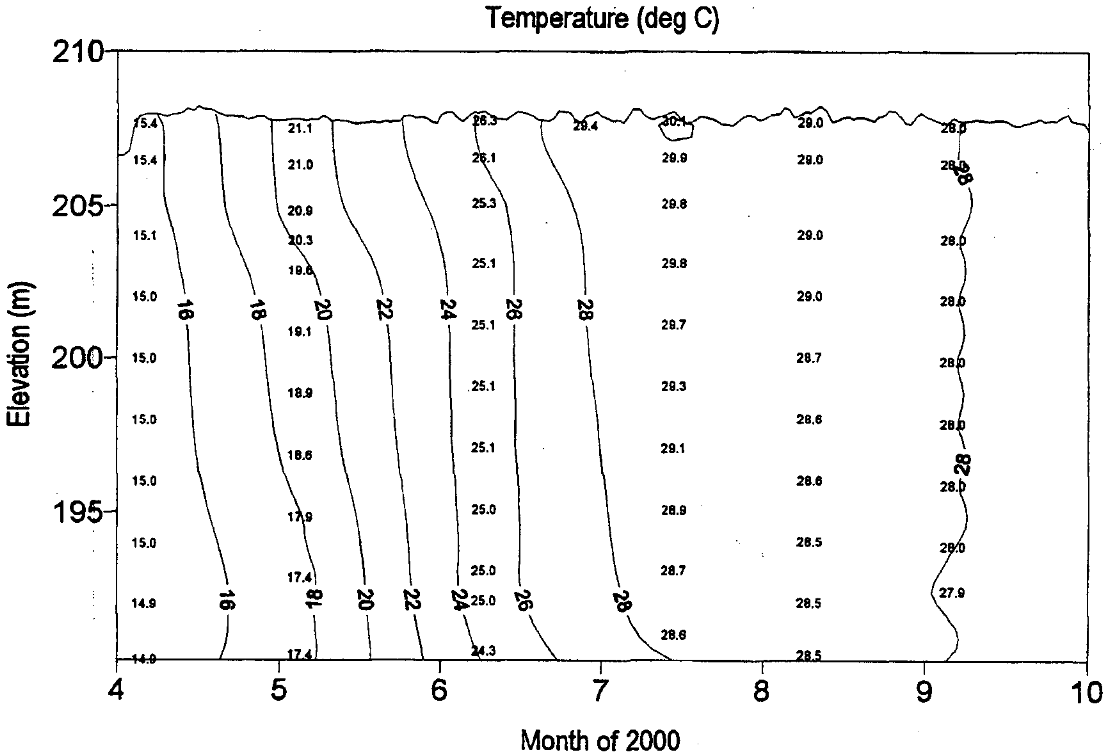
Temperature (deg C)

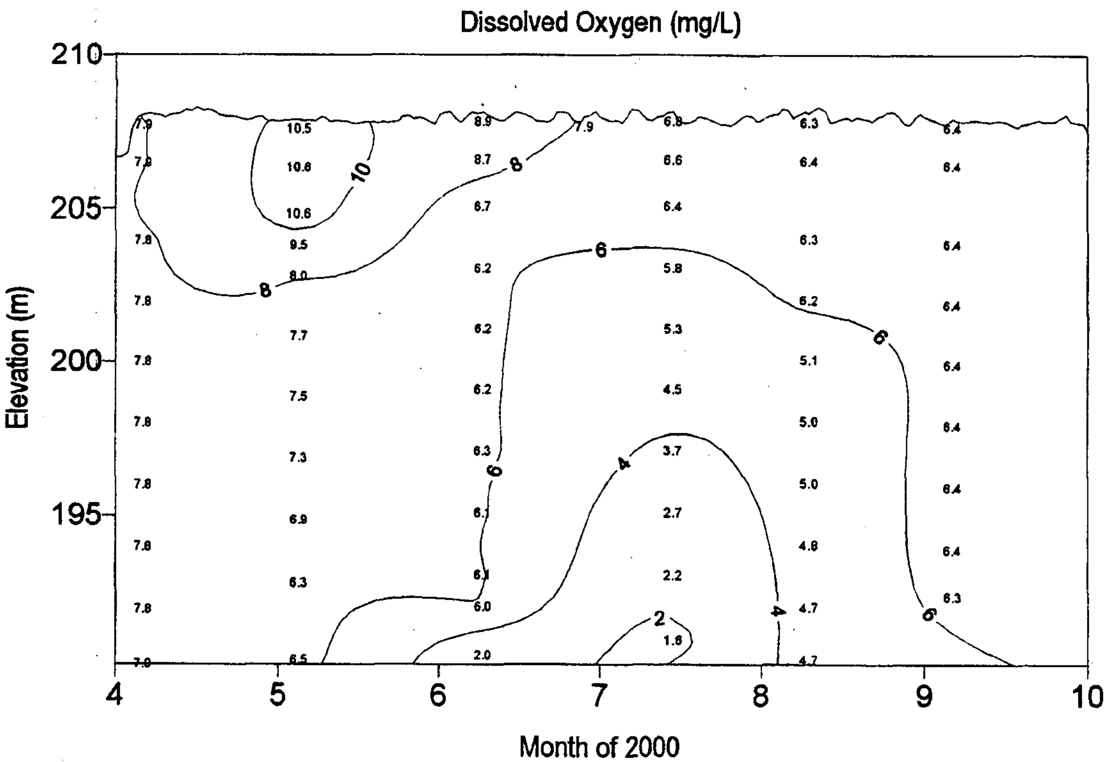


Dissolved Oxygen (mg/L)

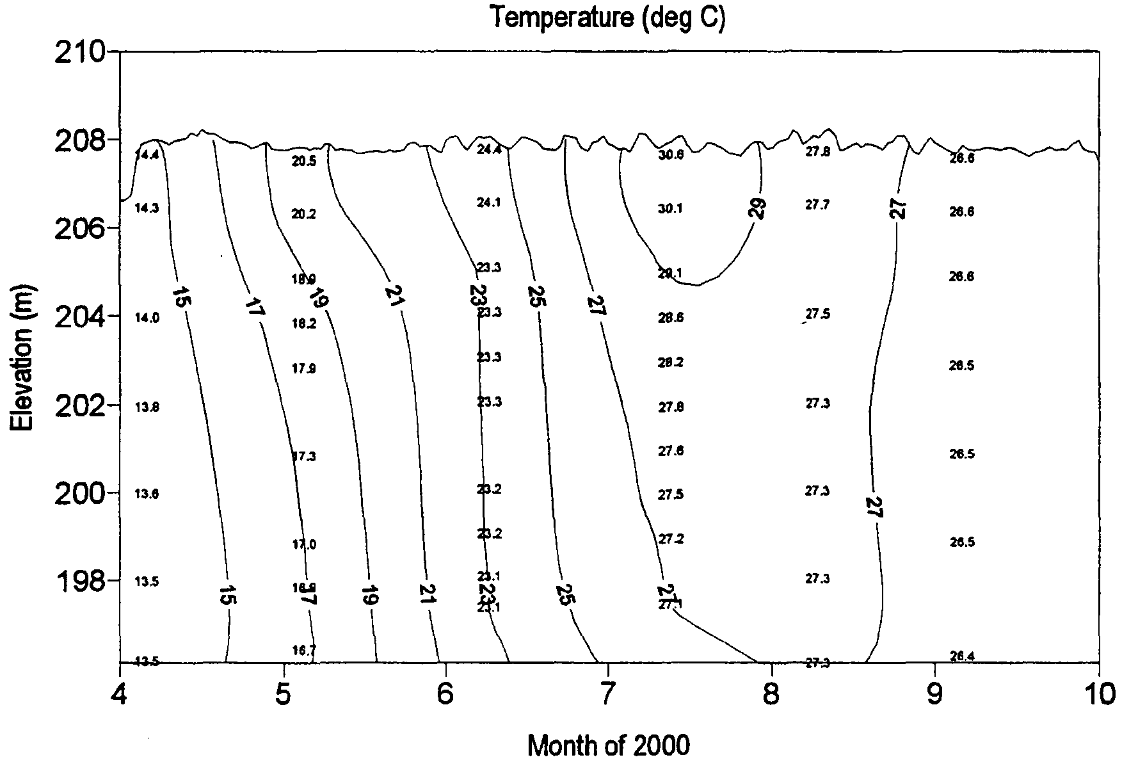


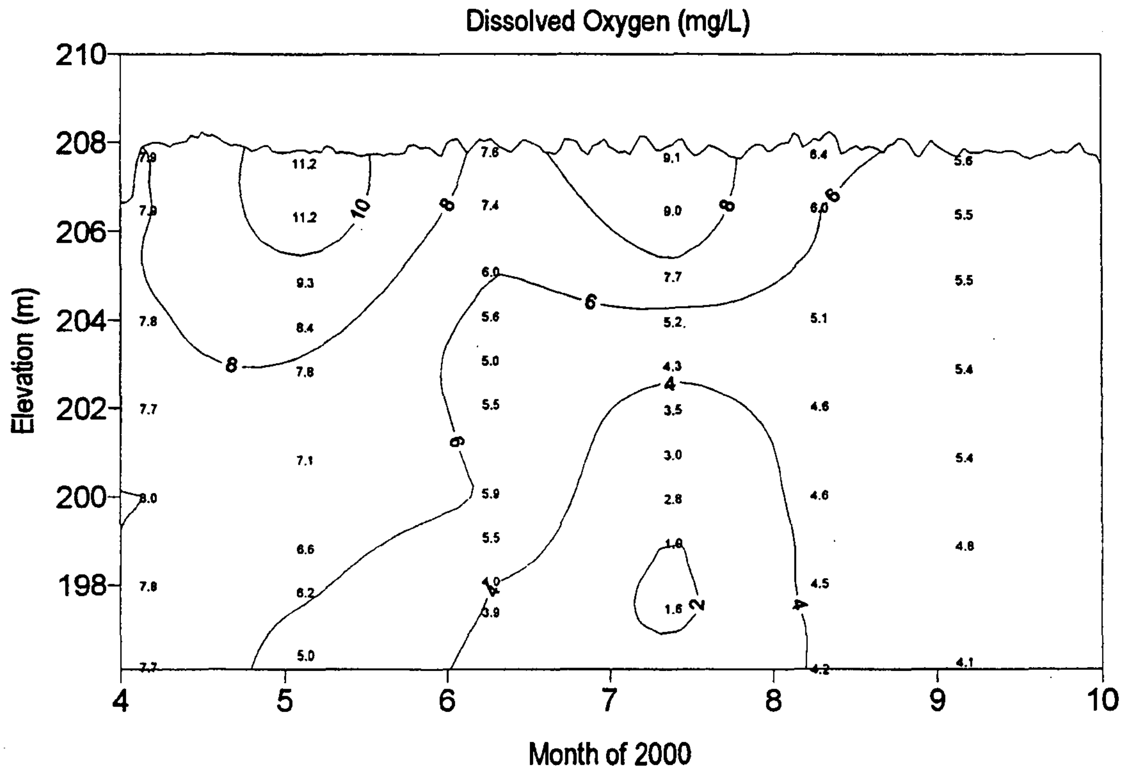
Chickamauga Reservoir - TRM 472.3



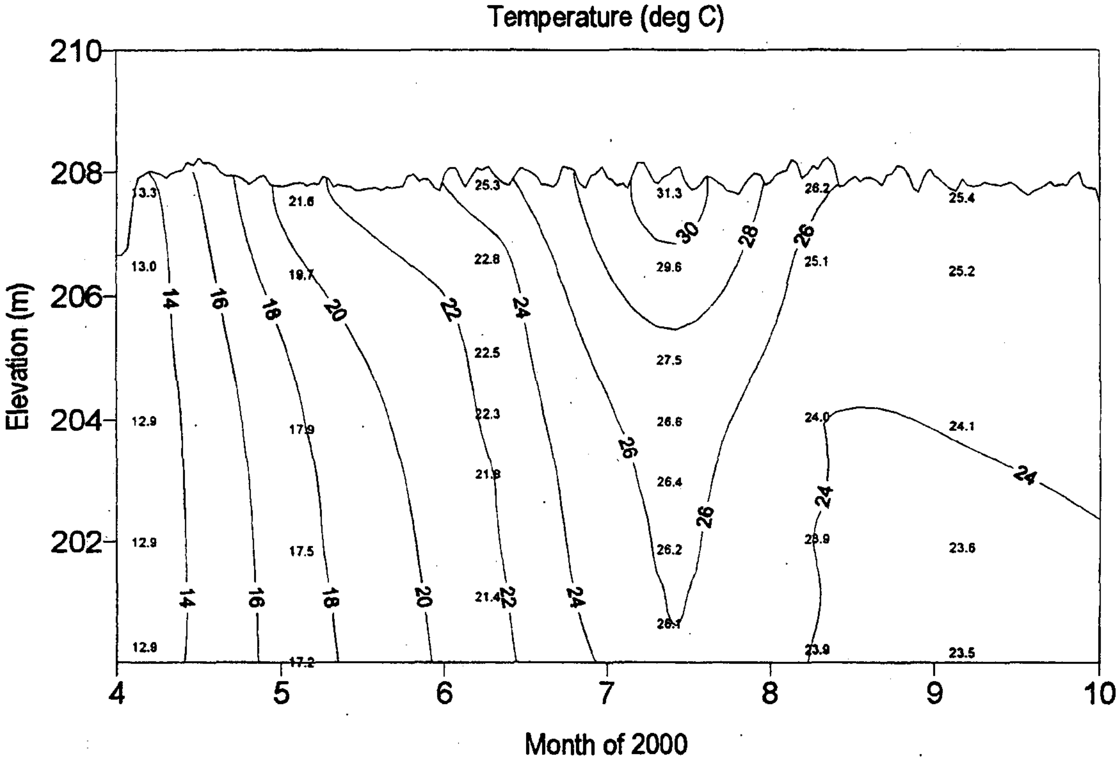


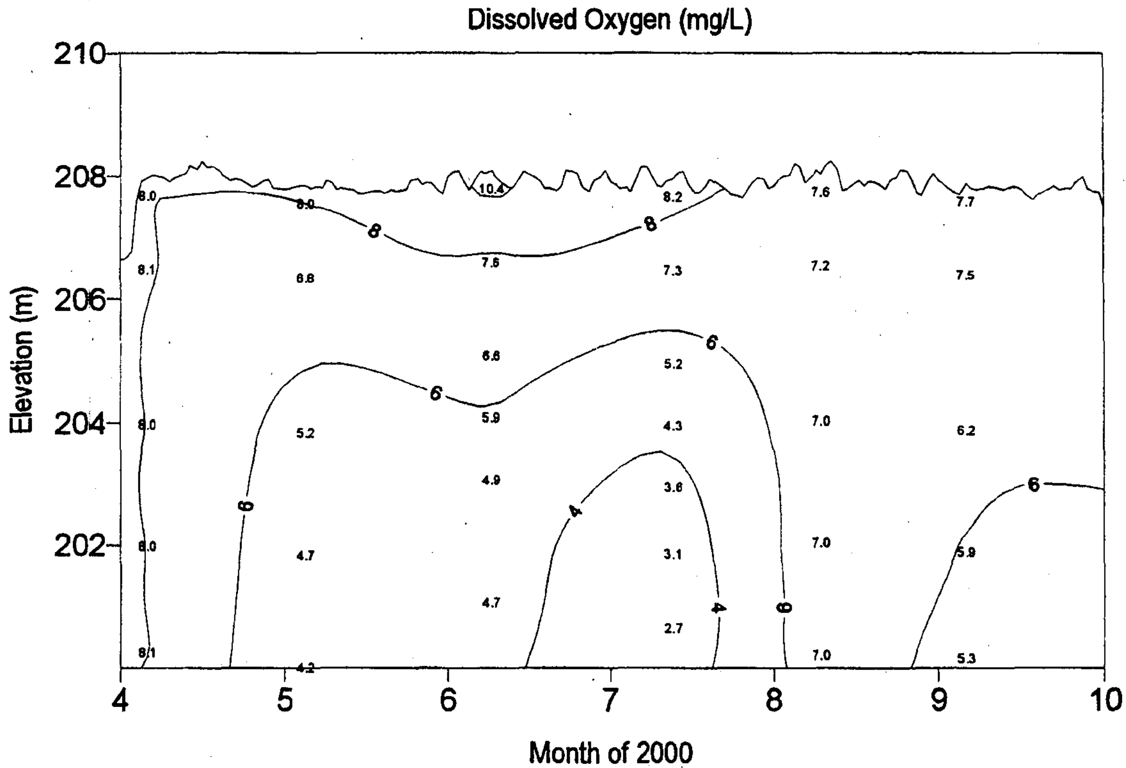
Chickamauga Reservoir - TRM 490.5





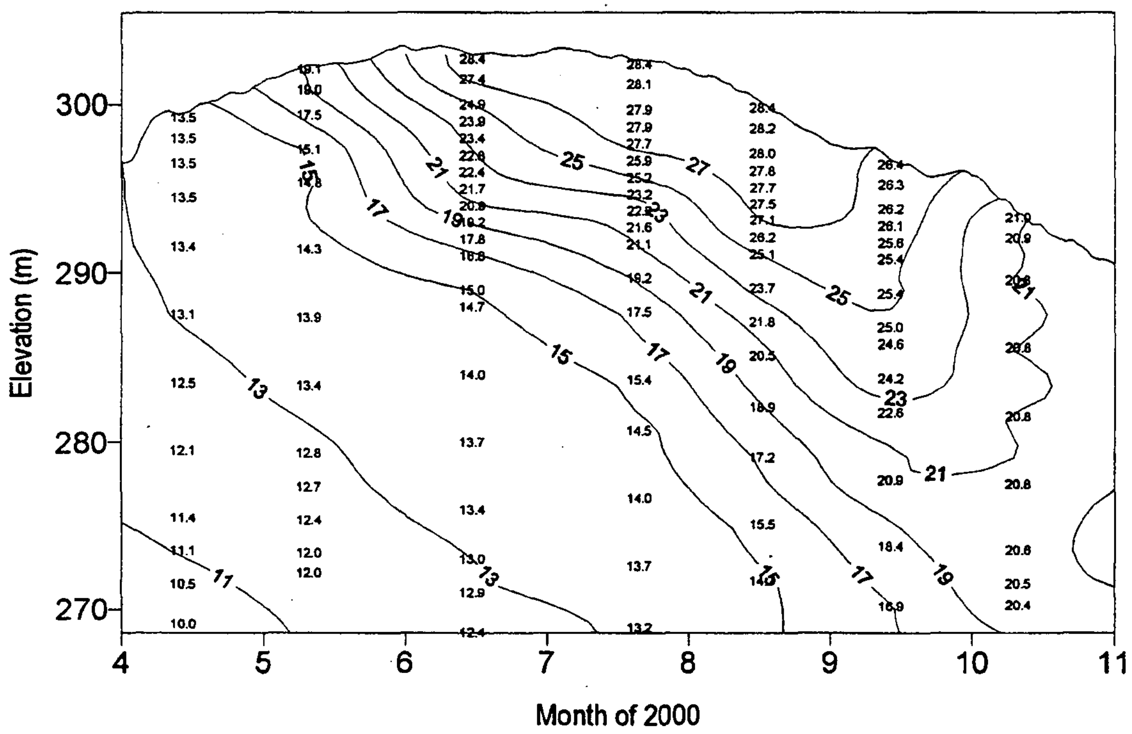
Chickamauga Reservoir - HiRM 8.5



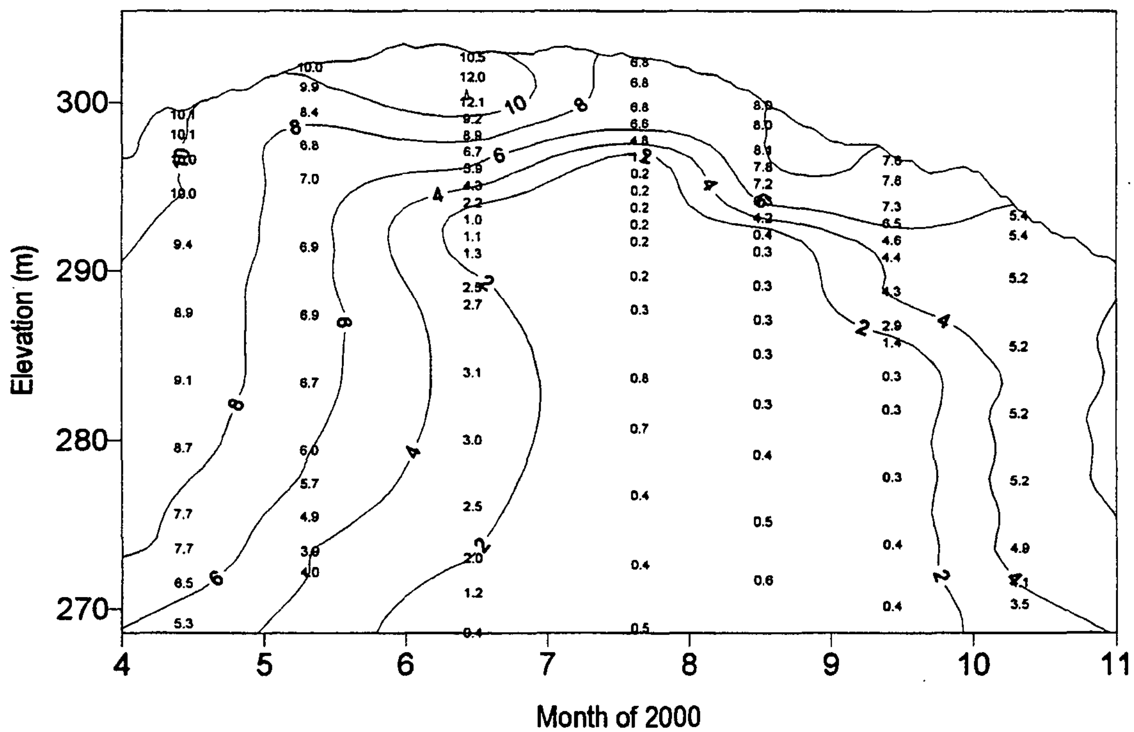


Douglas Reservoir - FBRM 34.5

Temperature (deg C)

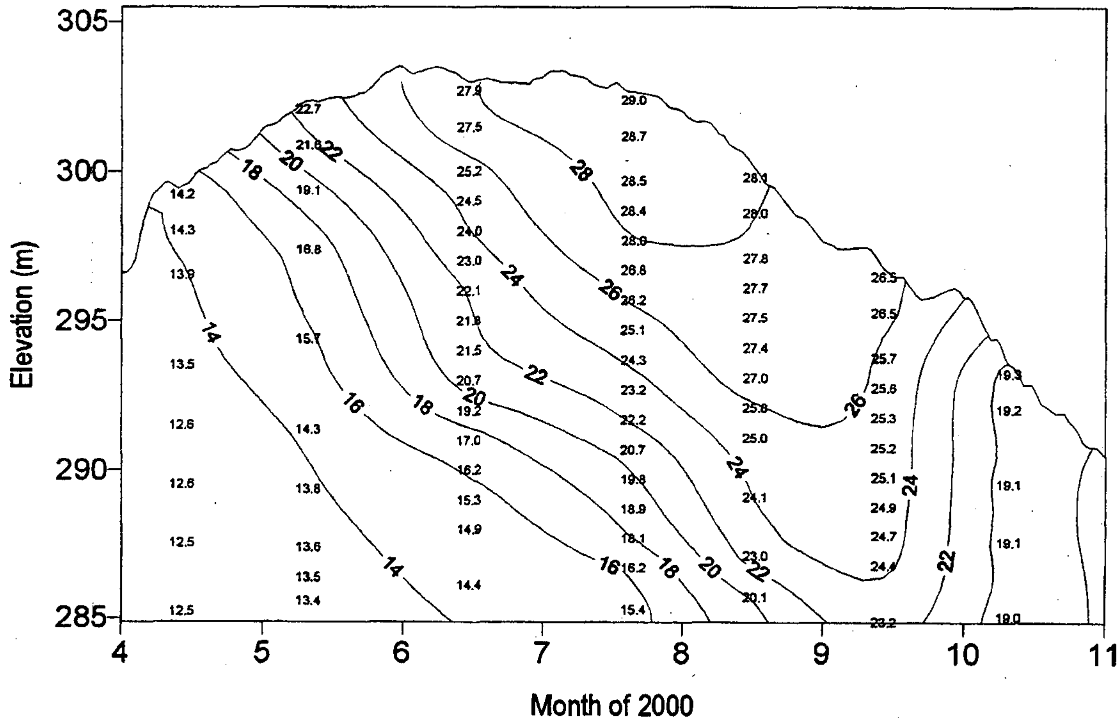


Dissolved Oxygen (mg/L)

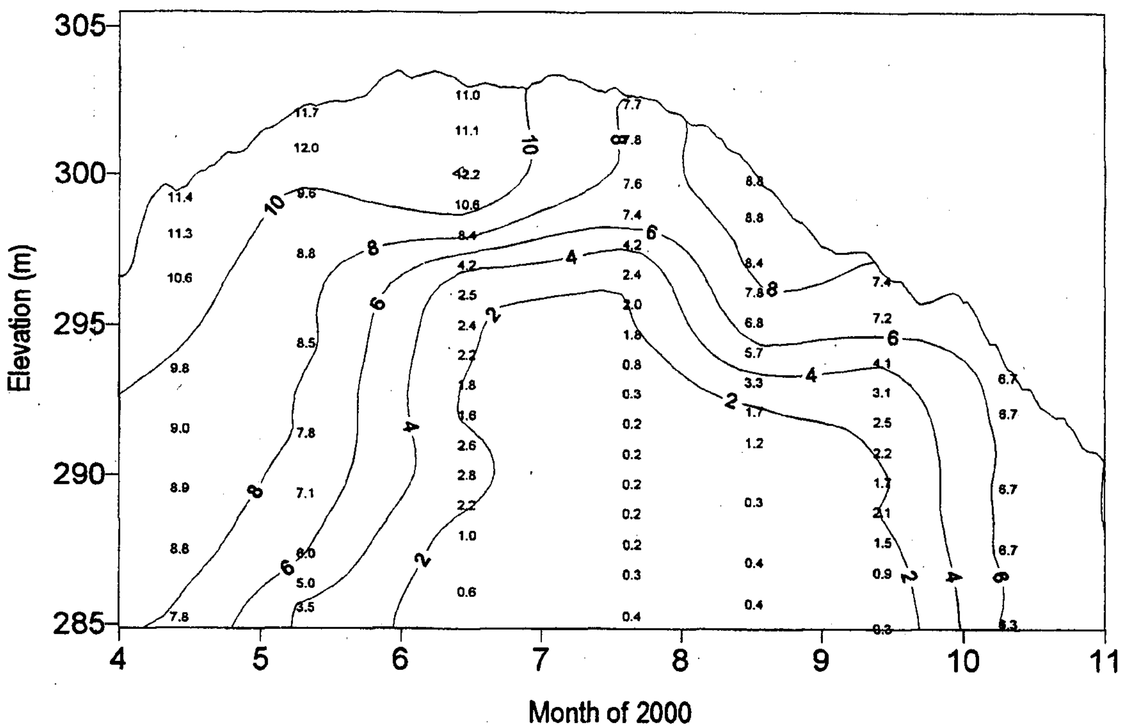


Douglas Reservoir - FBRM 51.0

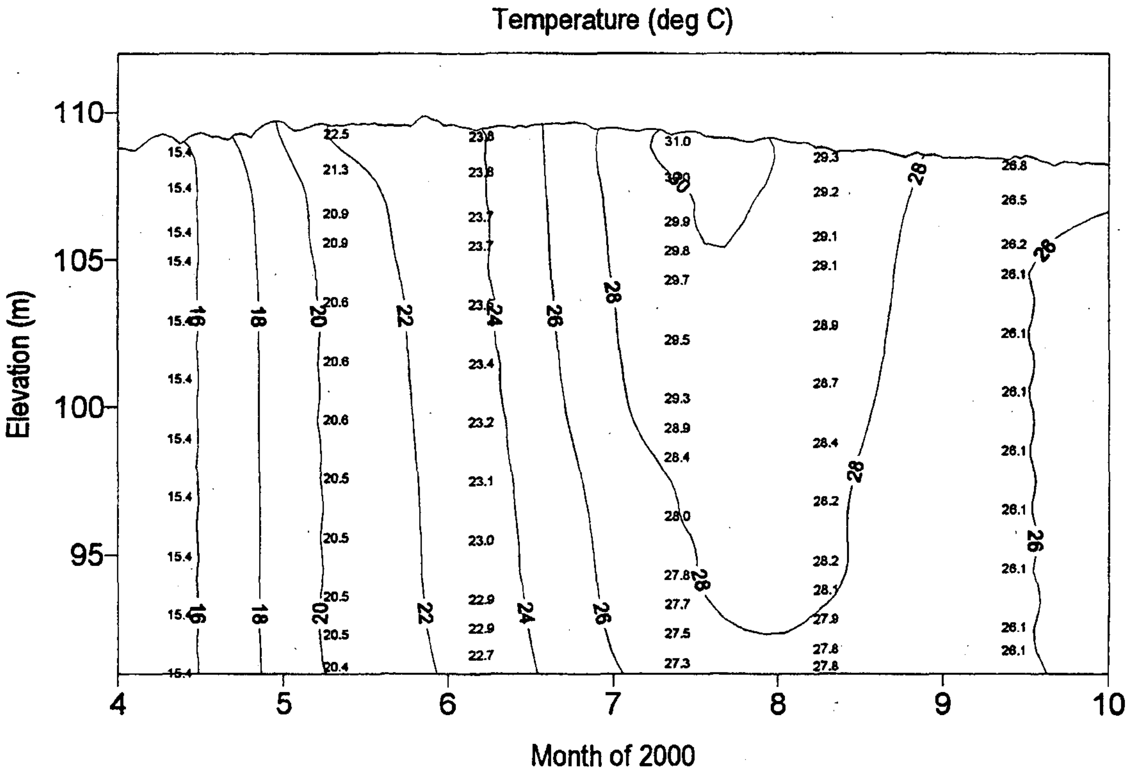
Temperature (deg C)

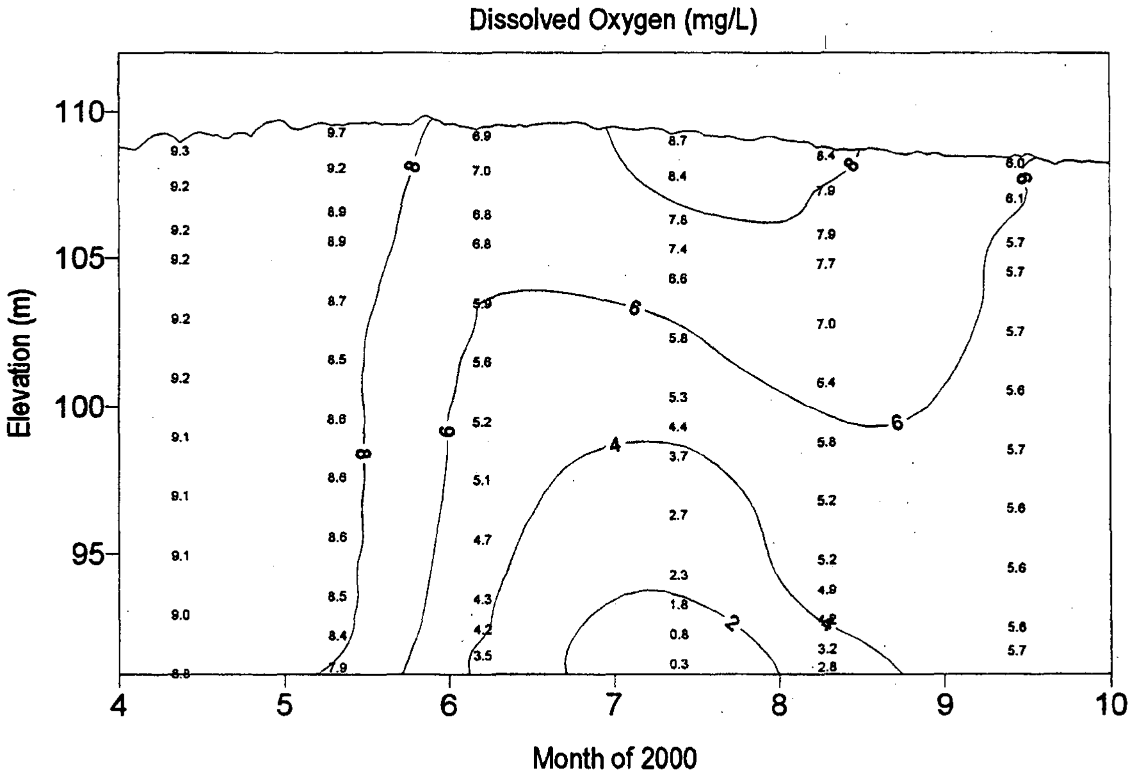


Dissolved Oxygen (mg/L)



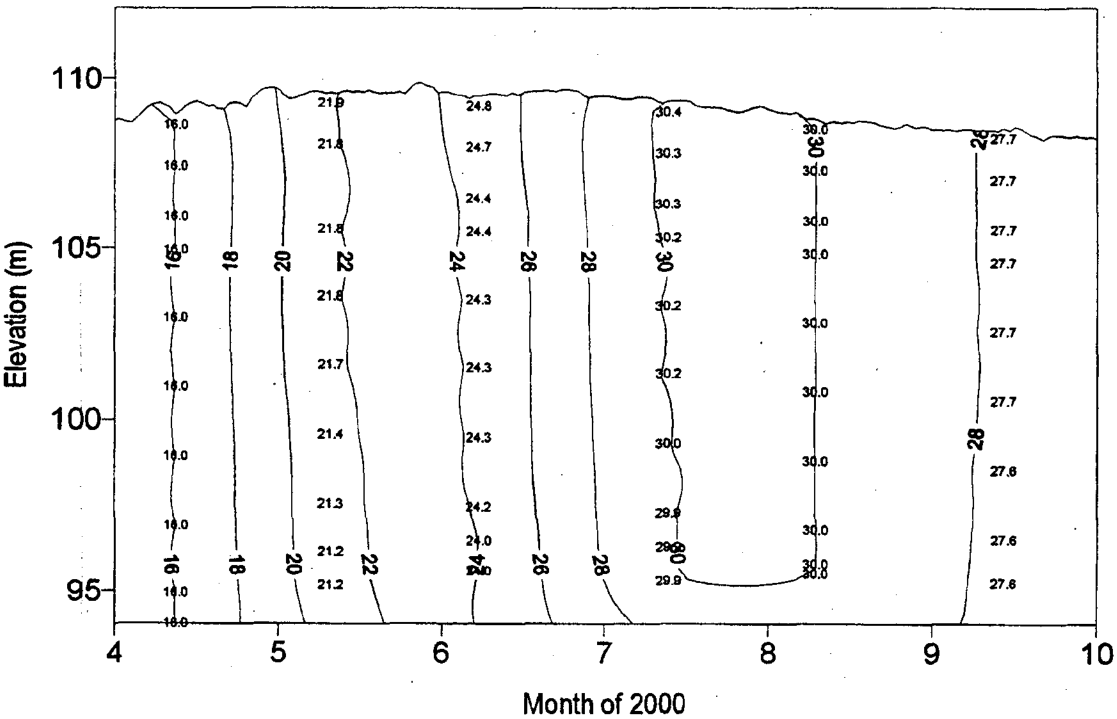
Kentucky Reservoir - TRM 23.0



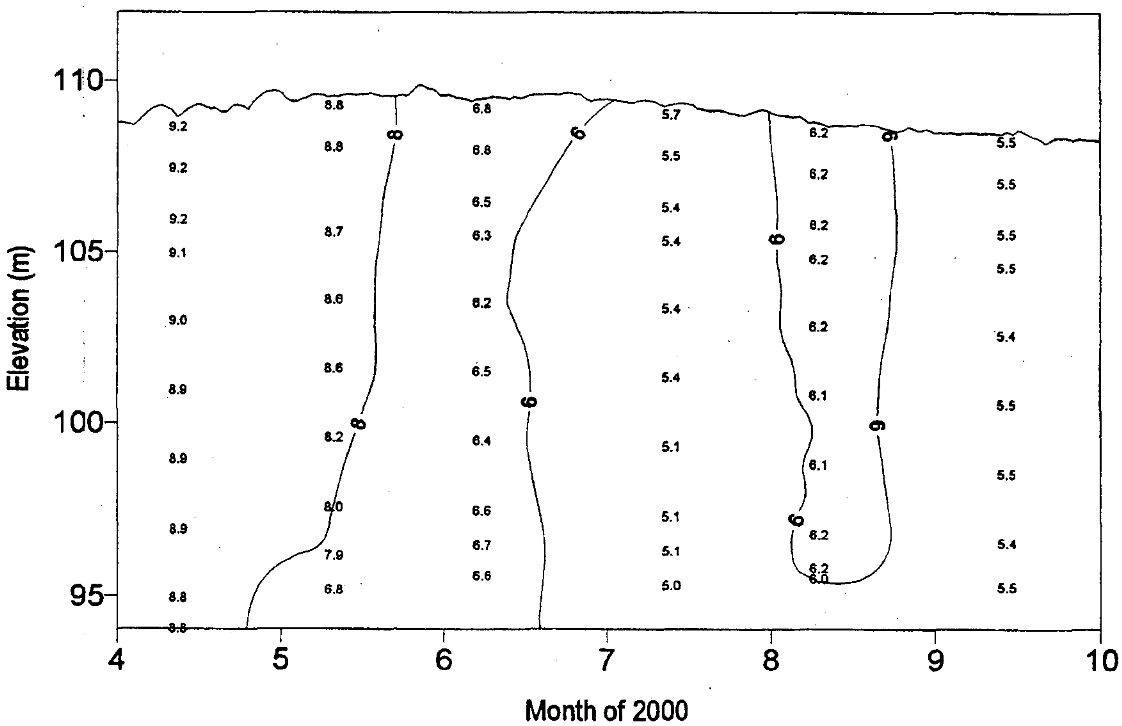


Kentucky Reservoir - TRM 85.0

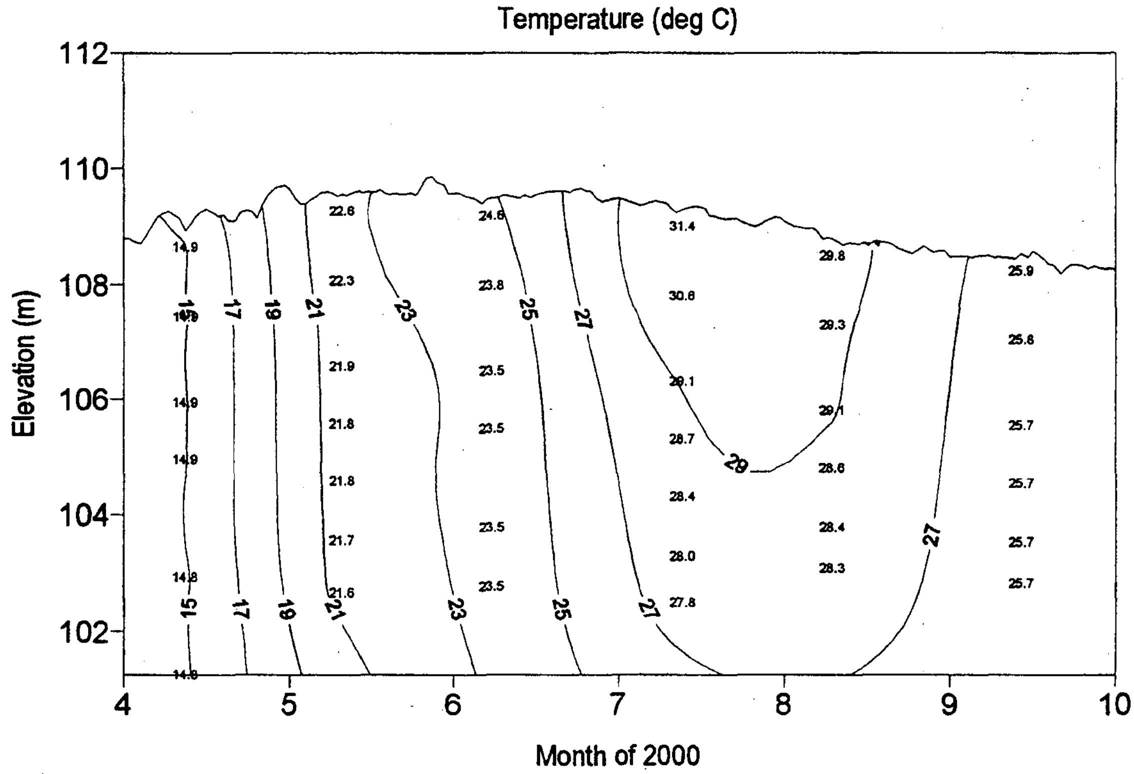
Temperature (deg C)

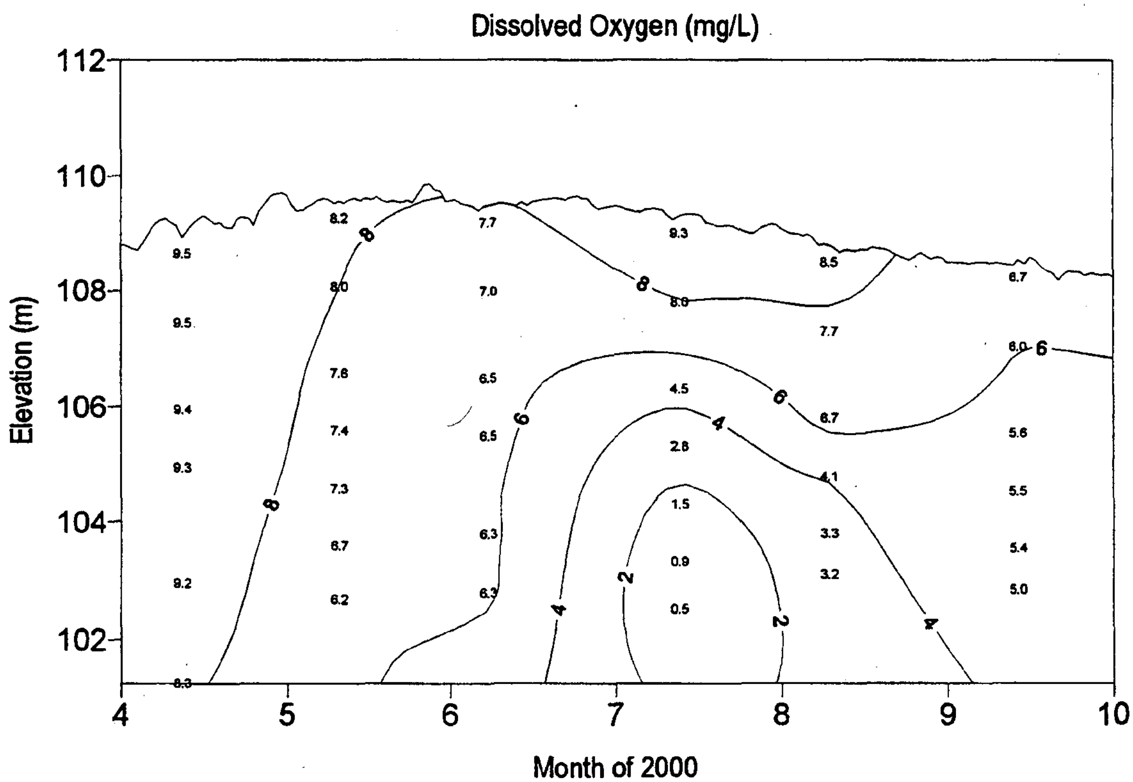


Dissolved Oxygen (mg/L)



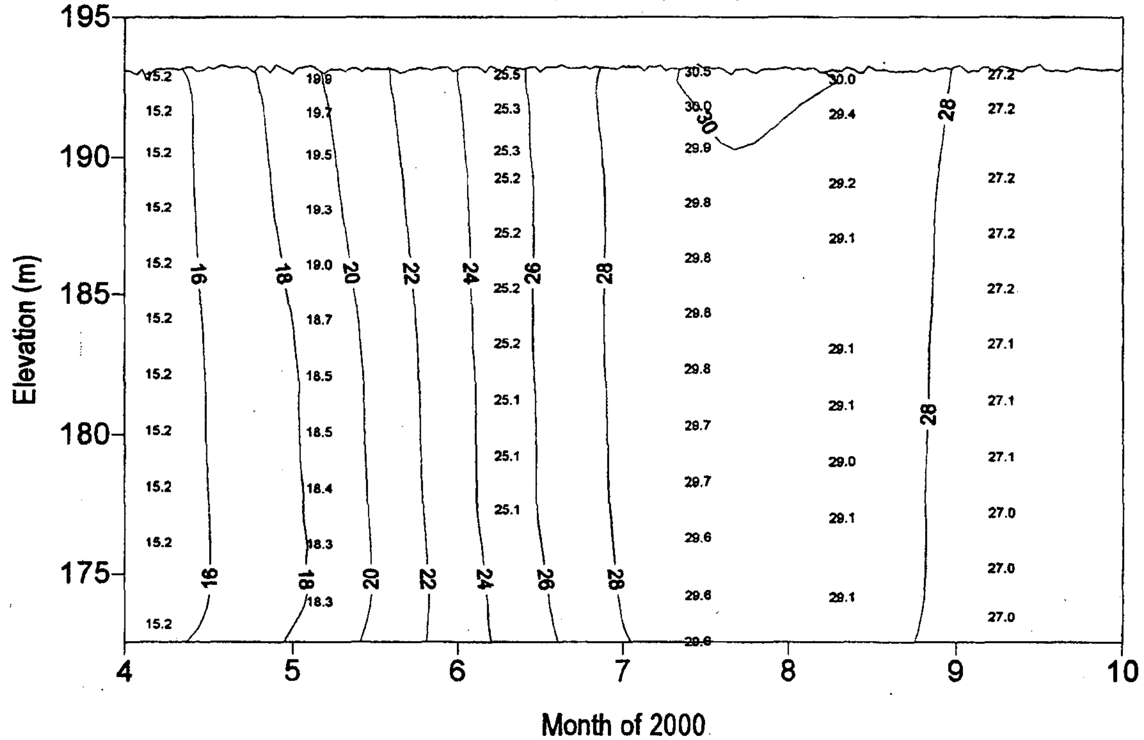
Kentucky Reservoir - Big Sandy 7.4



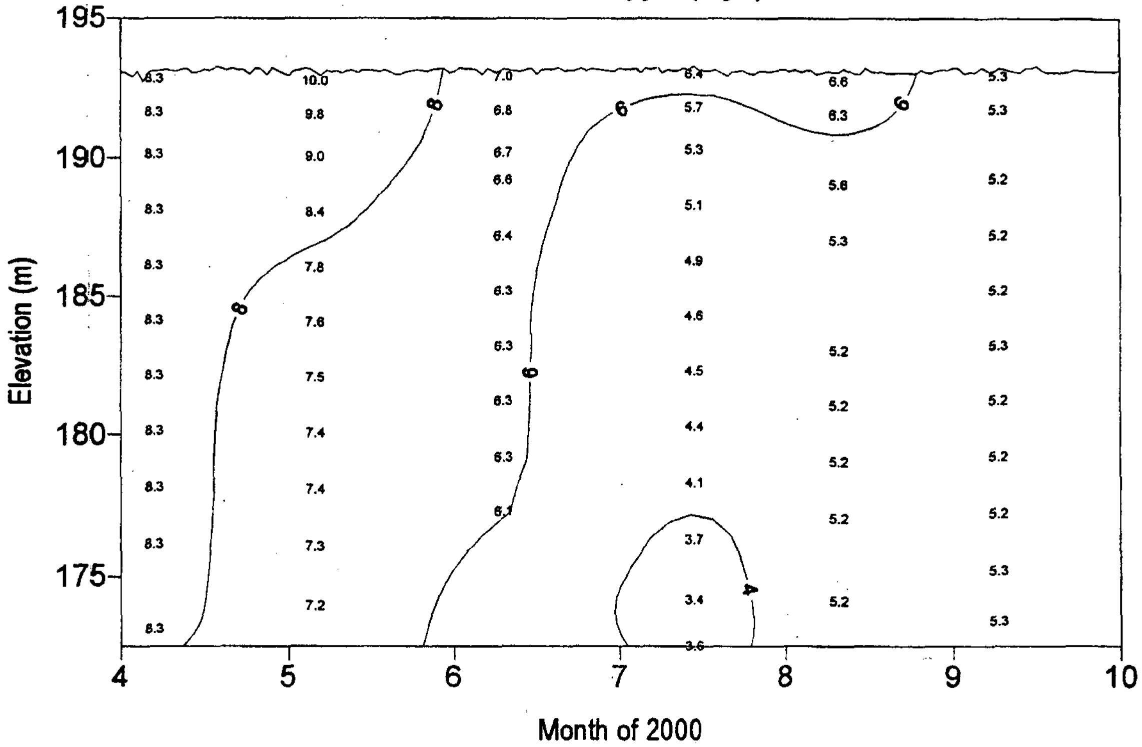


Nickajack Reservoir - TRM 425.5

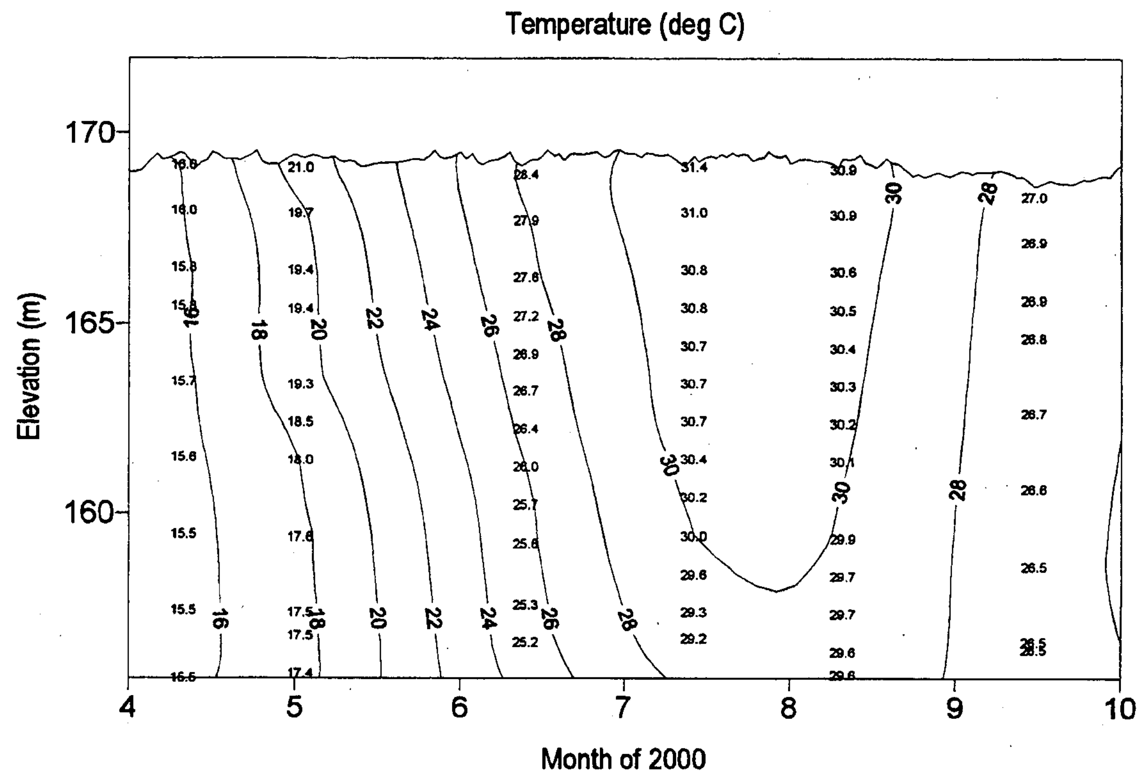
Temperature (deg C)

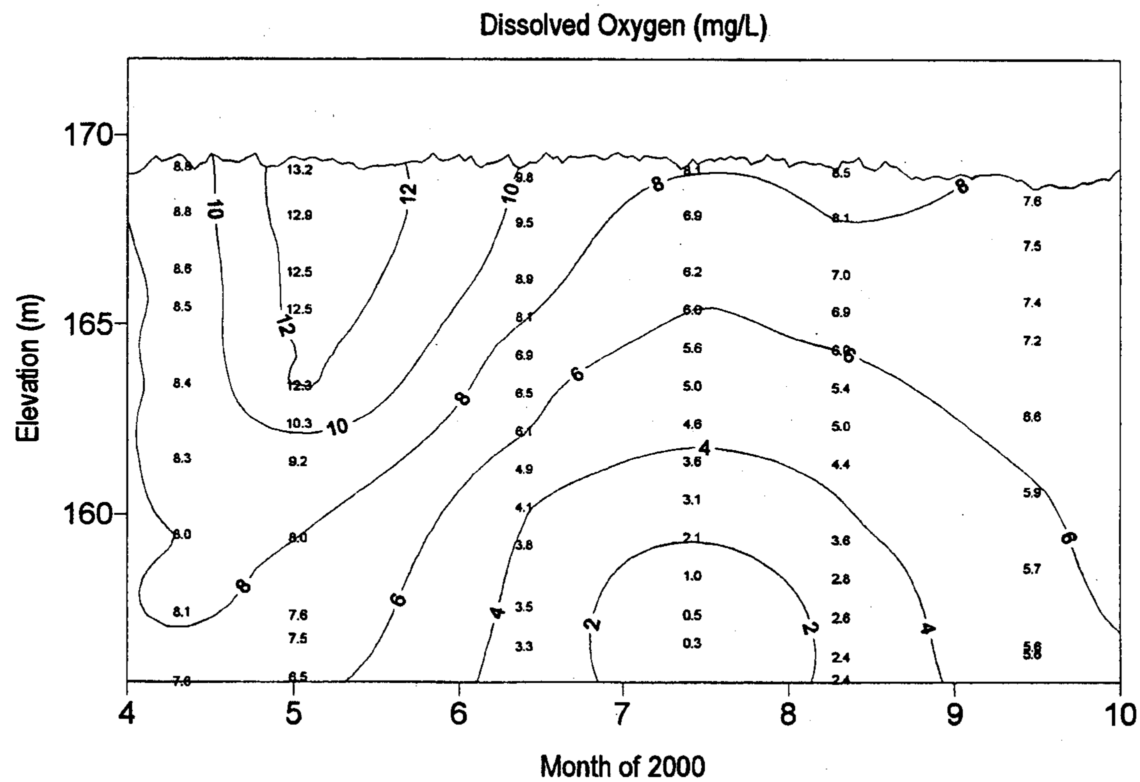


Dissolved Oxygen (mg/L)

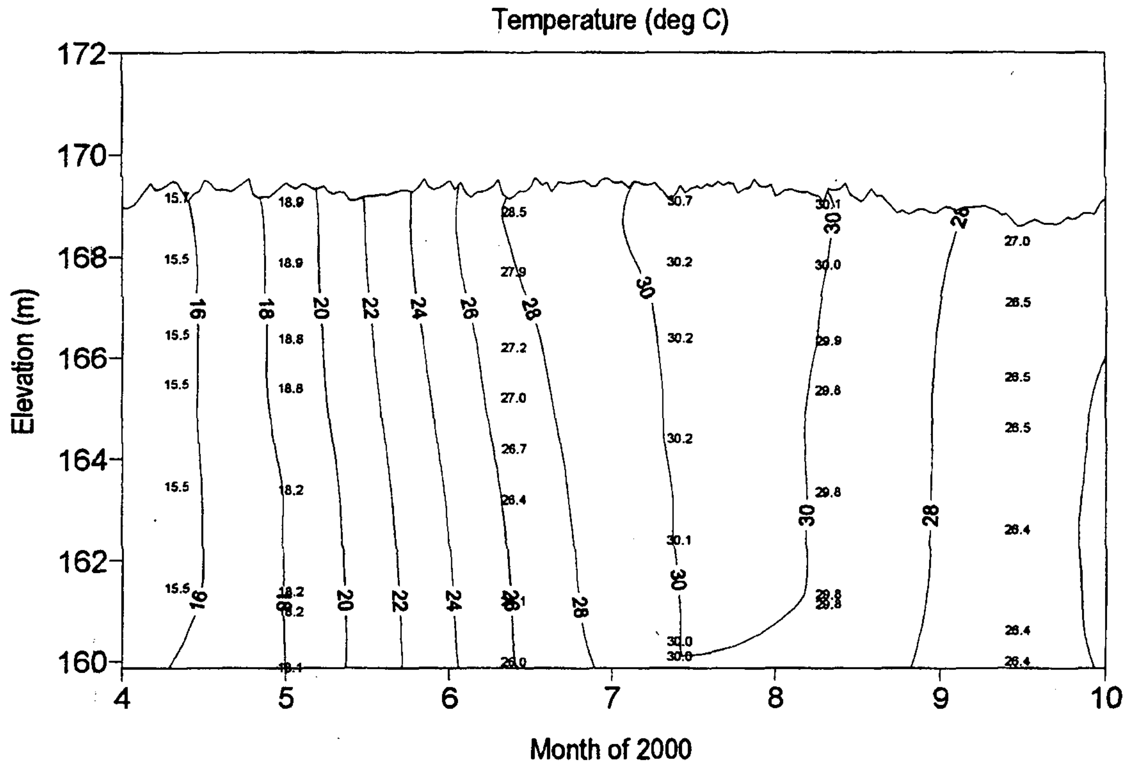


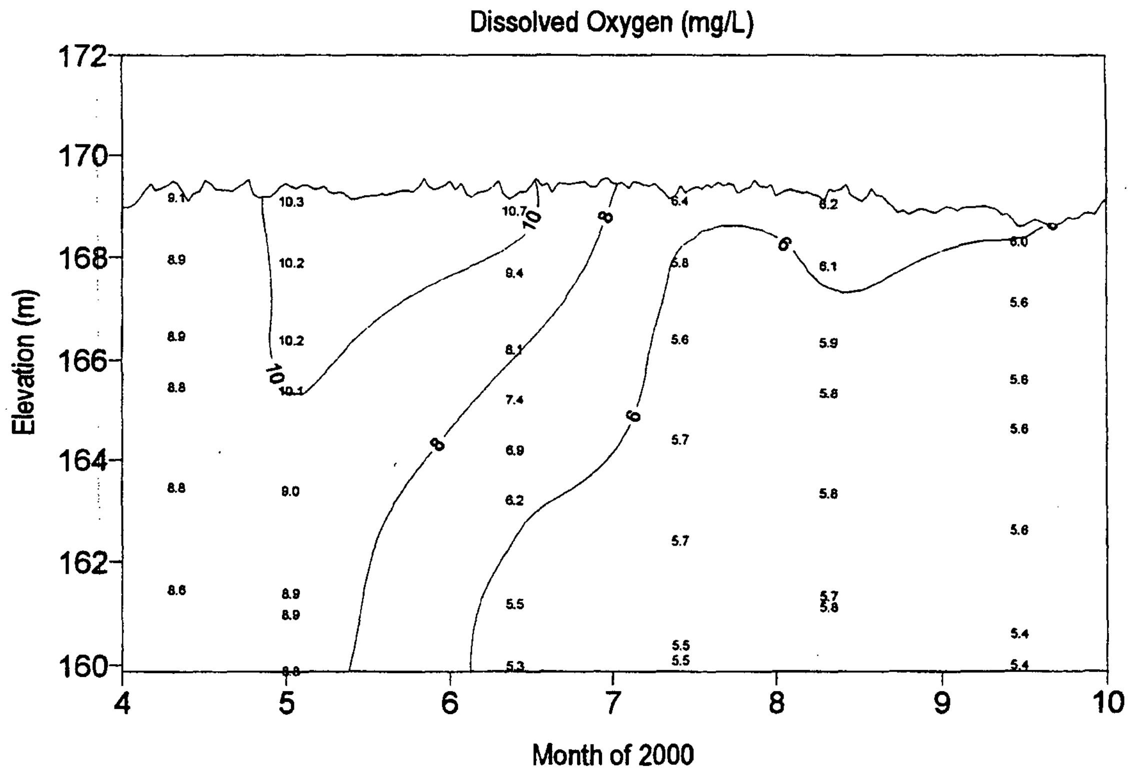
Wheeler Reservoir - TRM 277.0



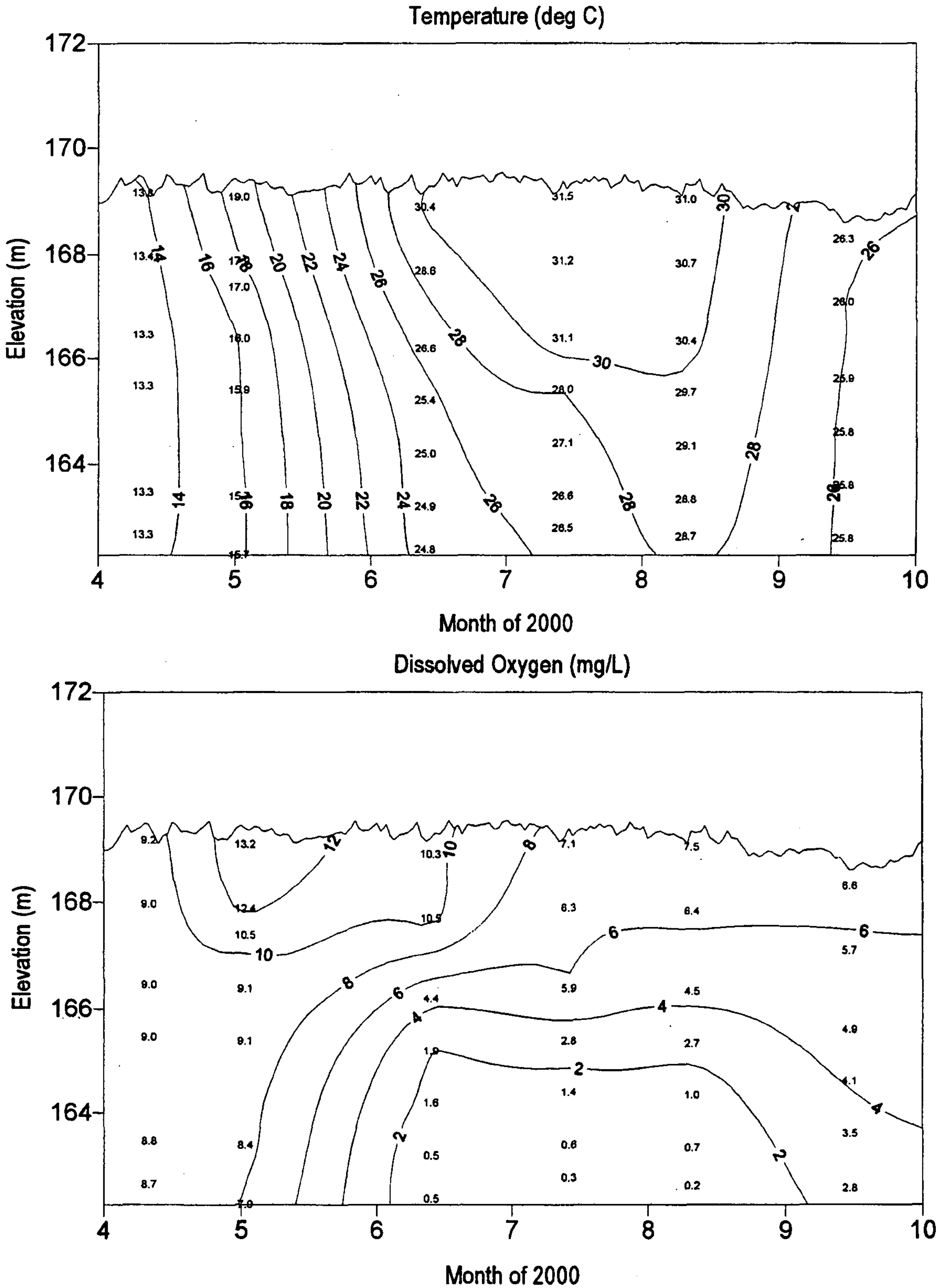


Wheeler Reservoir - TRM 295.9





Wheeler Reservoir - ERM 6.0



Appendix C.

Reservoir Benthic Macroinvertebrates -- Mean Density of Each Taxon at Each Sample Location in 2000 Including Results for Both Field Processed and Lab Processed Samples

Appendix C.

Reservoir Benthic Macroinvertebrates -- Mean Density Results for Field Processed Samples in 2000

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Apalachia Reservoir	**HiRM**
	67.0
Species	
Tubellaria	
Tricladida	
Planariidae	.
Oligocheata	
Oligochaetes	72
Hirudinea	.
Crustacea	
Amphipoda	7
Isopoda	.
Insecta	
Ephemeroptera	
Mayflies	.
Ephemeridae	
Hexagenia (<=10 mm)	.
Hexagenia (>10 mm)	5
Megaloptera	.
Sialidae	
Sialis sp.	
Odonata	
Anisoptera	.
Zygoptera	.
Trichoptera	
Caddisflies	.
Coeleoptera	7
Diptera	
Ceratopogonidae	.
Chironomidae	
Chironomids	217
Gastropoda	
Snails	.
Basommatophora	
Ancylidae	
Ferrissia sp.	.
Bivalvia	
Unionoida	
Unionidae	
Mussels	.
Veneroida	
Corbiculidae	
Corbicula (<=10mm)	.
Corbicula (>10mm)	.
Sphaeriidae	
Fingernail clams	55
Dreissenidae	
Dreissena polymorpha	.
Number of samples	10
Sum	362
Sum	0.60

VS 99 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Beech Reservoir	BRM
Species	
Tubellaria	36
Tricladida	
Planariidae	.
Oligocheata	
Oligochaetes	57
Hirudinea	.
Crustacea	
Amphipoda	.
Isopoda	.
Insecta	
Ephemeroptera	
Mayflies	.
Ephemeridae	
Hexagenia (<=10 mm)	.
Hexagenia (>10 mm)	.
Megaloptera	.
Sialidae	
Sialis sp.	
Odonata	
Anisoptera	.
Zygoptera	.
Trichoptera	
Caddisflies	.
Coeleoptera	.
Diptera	
Ceratopogonidae	3
Chironomidae	
Chironomids	230
Gastropoda	
Snails	.
Basommatophora	
Ancylidae	
Ferrissia sp.	.
Bivalvia	
Unionoida	
Unionidae	
Mussels	.
Veneroida	
Corbiculidae	
Corbicula (<=10mm)	2
Corbicula (>10mm)	.
Sphaeriidae	
Fingernail clams	.
Dreissenidae	
Dreissena polymorpha	.
Number of samples	10
Sum	292
Sum	0.60

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Chatuge Reservoir	SCM	HiRM	
	1.5	122	122QA
Species			
Tubellaria			
Tricladida			
Planariidae	.	.	.
Oligocheata			
Oligochaetes	33	25	48
Hirudinea	.	.	.
Crustacea			
Amphipoda	.	.	.
Isopoda	.	.	.
Insecta			
Ephemeroptera			
Mayflies	.	.	.
Ephemeridae			
Hexagenia (<=10 mm)	.	.	.
Hexagenia (>10 mm)	3	5	12
Megaloptera	.	.	.
Sialidae			
Sialis sp.			
Odonata			
Anisoptera	2	.	.
Zygoptera	.	.	.
Trichoptera			
Caddisflies	.	.	.
Coeleoptera	.	.	.
Diptera			
Ceratopogonidae	.	.	.
Chironomidae			
Chironomids	7	20	32
Gastropoda			
Snails	.	.	.
Basommatophora			
Ancylidae			
Ferrissia sp.	.	.	.
Bivalvia			
Unionoida			
Unionidae			
Mussels	.	.	.
Veneroida			
Corbiculidae			
Corbicula (<=10mm)	.	.	2
Corbicula (>10mm)	.	.	3
Sphaeriidae			
Fingernail clams	.	.	.
Dreissenidae			
Dreissena polymorpha	.	.	.
Number of samples	10	10	10
Sum	45	50	97
Sum	0.60	0.60	0.60

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Cherokee Reservoir	HiRM	
	55	76
Species		
Tubellaria		
Tricladida		
Planariidae	.	.
Oligocheata		
Oligochaetes	35	28
Hirudinea	.	.
Crustacea		
Amphipoda	.	.
Isopoda	.	.
Insecta		
Ephemeroptera		
Mayflies	.	.
Ephemeridae		
Hexagenia (<=10 mm)	.	.
Hexagenia (>10 mm)	.	.
Megaloptera	.	.
Sialidae		
Sialis sp.		
Odonata		
Anisoptera	.	.
Zygoptera	.	.
Trichoptera		
Caddisflies	.	.
Coeleoptera		
Diptera		
Ceratopogonidae	.	.
Chironomidae		
Chironomids	320	708
Gastropoda		
Snails	.	.
Basommatophora		
Ancylidae		
Ferrissia sp.	.	.
Bivalvia		
Unionoida		
Unionidae		
Mussels	.	.
Veneroida		
Corbiculidae		
Corbicula (<=10mm)	.	.
Corbicula (>10mm)	.	.
Sphaeriidae		
Fingernail clams	.	.
Dreissenidae		
Dreissena polymorpha	.	.
Number of samples	10	10
Sum	355	737
Sum	0.60	0.60

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Fontana Reservoir	LTRM
	62
Species	
Tubellaria	
Tricladida	
Planariidae	. .
Oligocheata	
Oligochaetes	23
Hirudinea	.
Crustacea	
Amphipoda	2
Isopoda	.
Insecta	
Ephemeroptera	
Mayflies	.
Ephemeridae	
Hexagenia (<=10 mm)	.
Hexagenia (>10 mm)	.
Megaloptera	.
Sialidae	
Sialis sp.	
Odonata	
Anisoptera	.
Zygoptera	.
Trichoptera	
Caddisflies	.
Coeleoptera	.
Diptera	
Ceratopogonidae	.
Chironomidae	
Chironomids	12
Gastropoda	
Snails	.
Basommatophora	
Ancylidae	
Ferrissia sp.	.
Bivalvia	
Unionoida	
Unionidae	
Mussels	.
Veneroida	
Corbiculidae	
Corbicula (<=10mm)	.
Corbicula (>10mm)	.
Sphaeriidae	
Fingernail clams	.
Dreissenidae	
Dreissena polymorpha	.
Number of samples	10
Sum	37
Sum	0.60

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Fort Loudoun Reservoir	TRM		
	605.5	624.6	652
Species			
Tubellaria			
Tricladida			
Planariidae	.	.	.
Oligocheata			
Oligochaetes	230	55	55
Hirudinea	.	.	.
Crustacea			
Amphipoda	.	.	2
Isopoda	.	.	.
Insecta			
Ephemeroptera			
Mayflies	.	.	.
Ephemeridae			
Hexagenia (<=10 mm)	.	.	.
Hexagenia (>10 mm)	.	22	.
Megaloptera	.	.	.
Sialidae			
Sialis sp.			
Odonata			
Anisoptera	.	.	2
Zygoptera	.	.	2
Trichoptera			
Caddisflies	.	.	.
Coeleoptera	.	.	.
Diptera			
Ceratopogonidae	.	5	.
Chironomidae			
Chironomids	152	388	205
Gastropoda			
Snails	.	.	.
Basommatophora			
Ancylidae			
Ferrissia sp.	.	.	.
Bivalvia			
Unionoida			
Unionidae			
Mussels	.	.	.
Veneroida			
Corbiculidae			
Corbicula (<=10mm)	5	2	13
Corbicula (>10mm)	.	.	2
Sphaeriidae			
Fingernail clams	.	22	.
Dreissenidae			
Dreissena polymorpha	.	.	.
Number of samples	10	10	10
Sum	387	493	280
Sum	0.60	0.60	0.60

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Guntersville Reservoir	**TRM**			
Species	**350**	**375.2**	**420**	**420QA**
Tubellaria				
Tricladida				
Planariidae	.	.	55	57
Oligocheata				
Oligochaetes	40	70	32	27
Hirudinea	2	2	10	.
Crustacea				
Amphipoda	.	65	42	88
Isopoda	.	.	.	.
Insecta				
Ephemeroptera				
Mayflies	.	.	13	20
Ephemeridae				
Hexagenia (<=10 mm)	.	17	.	.
Hexagenia (>10 mm)	12	67	.	2
Megaloptera	.	.	5	.
Sialidae				
Sialis sp.				
Odonata				
Anisoptera	.	5	3	2
Zygoptera	.	.	2	3
Trichoptera				
Caddisflies	.	.	2	2
Coeleoptera	.	2	.	.
Diptera				
Ceratopogonidae	.	.	.	.
Chironomidae				
Chironomids	515	138	10	15
Gastropoda				
Snails	20	22	37	30
Basommatophora				
Ancylidae				
Ferrissia sp.	.	.	8	13
Bivalvia				
Unionoida				
Unionidae				
Mussels	5	.	.	.
Veneroida				
Corbiculidae				
Corbicula (<=10mm)	13	88	267	410
Corbicula (>10mm)	27	230	475	348
Sphaeriidae				
Fingernail clams	3	32	.	.
Dreissenidae				
Dreissena polymorpha	.	.	2	2
Number of samples	10	10	10	10
Sum	637	737	962	1018
Sum	0.60	0.60	0.60	0.60

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Hiwassee Reservoir		**HiRM**	
	77	**85**	**85QA**
Species			
Tubellaria			
Tricladida			QA
Planariidae	.	.	.
Oligocheata			
Oligochaetes	342	708	473
Hirudinea	.	.	.
Crustacea			
Amphipoda	.	2	.
Isopoda	8	.	.
Insecta			
Ephemeroptera			
Mayflies	.	.	.
Ephemeridae			
Hexagenia (<=10 mm)	.	.	.
Hexagenia (>10 mm)	.	.	.
Megaloptera	.	.	.
Sialidae			
Sialis sp.			
Odonata			
Anisoptera	.	.	.
Zygoptera	.	.	.
Trichoptera			
Caddisflies	.	.	.
Coeleoptera	.	.	.
Diptera			
Ceratopogonidae	.	.	.
Chironomidae			
Chironomids	62	208	155
Gastropoda			
Snails	.	.	.
Basommatophora			
Ancylidae			
Ferrissia sp.	.	.	.
Bivalvia			
Unionoida			
Unionidae			
Mussels	.	.	.
Veneroida			
Corbiculidae			
Corbicula (<=10mm)	.	.	.
Corbicula (>10mm)	.	.	.
Sphaeriidae			
Fingernail clams	18	.	.
Dreissenidae			
Dreissena polymorpha	.	.	.
Number of samples	10	10	10
Sum	430	918	628
Sum	0.60	0.60	0.60

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Melton Hill Reservoir	CRM		
	24	45	58.8
Species			
Tubellaria			
Tricladida			
Planariidae	.	.	.
Oligocheata			
Oligochaetes	62	37	42
Hirudinea	.	.	.
Crustacea			
Amphipoda	.	.	.
Isopoda	.	.	.
Insecta			
Ephemeroptera			
Mayflies	.	.	.
Ephemeridae			
Hexagenia (<=10 mm)	.	22	.
Hexagenia (>10 mm)	2	82	.
Megaloptera	.	.	.
Sialidae			
Sialis sp.			
Odonata			
Anisoptera	.	.	.
Zygoptera	.	.	.
Trichoptera			
Caddisflies	.	.	.
Coeleoptera	.	.	.
Diptera			
Ceratopogonidae	.	.	.
Chironomidae			
Chironomids	270	27	77
Gastropoda			
Snails	.	.	.
Basommatophora			
Ancylidae			
Ferrissia sp.	.	.	.
Bivalvia			
Unionoida			
Unionidae			
Mussels	.	.	.
Veneroida			
Corbiculidae			
Corbicula (<=10mm)	5	.	8
Corbicula (>10mm)	.	5	.
Sphaeriidae			
Fingernail clams	.	107	.
Dreissenidae			
Dreissena polymorpha	.	.	.
Number of samples	10	10	10
Sum	338	278	127
Sum	0.60	0.60	0.60

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Normandy Reservoir	DRM
Species	
Tubellaria	249.5
Tricladida	
Planariidae	.
Oligocheata	
Oligochaetes	50
Hirudinea	.
Crustacea	
Amphipoda	.
Isopoda	.
Insecta	
Ephemeroptera	
Mayflies	.
Ephemeridae	
Hexagenia (<=10 mm)	.
Hexagenia (>10 mm)	.
Megaloptera	.
Sialidae	
Sialis sp.	
Odonata	
Anisoptera	.
Zygoptera	.
Trichoptera	
Caddisflies	.
Coeleoptera	.
Diptera	
Ceratopogonidae	.
Chironomidae	
Chironomids	260
Gastropoda	
Snails	.
Basommatophora	
Ancylidae	
Ferrissia sp.	.
Bivalvia	
Unionoida	
Unionidae	
Mussels	.
Veneroida	
Corbiculidae	
Corbicula (<=10mm)	.
Corbicula (>10mm)	2
Sphaeriidae	
Fingernail clams	.
Dreissenidae	
Dreissena polymorpha	.
Number of samples	10
Sum	312
Sum	0.60

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Pickwick Reservoir	TRM				BCM
	207.3	207.3QA	230	253.2	8.4
Species					
Tubellaria					
Tricladida		QA			
Planariidae	.	.	.	353	.
Oligocheata					
Oligochaetes	28	25	42	5	107
Hirudinea	.	.	2	5	3
Crustacea					
Amphipoda	.	.	.	.	.
Isopoda	.	8	.	2	.
Insecta					
Ephemeroptera					
Mayflies	.	.	.	17	.
Ephemeridae					
Hexagenia (<=10 mm)	.	.	2	.	.
Hexagenia (>10 mm)	15	8	5	.	2
Megaloptera	.	.	.	.	.
Sialidae					
Sialis sp.					
Odonata					
Anisoptera	.	.	.	.	.
Zygoptera	.	.	.	.	.
Trichoptera					
Caddisflies	.	.	.	3	.
Coeleoptera	.	.	2	.	.
Diptera					
Ceratopogonidae	.	.	.	.	.
Chironomidae					
Chironomids	170	157	183	2	533
Gastropoda					
Snails	10	8	2	87	2
Basommatophora					
Ancylidae					
Ferrissia sp.	.	.	.	.	.
Bivalvia					
Unionoida					
Unionidae					
Mussels	2	2	2	3	.
Veneroida					
Corbiculidae					
Corbicula (<=10mm)	10	23	3	47	.
Corbicula (>10mm)	112	23	167	.	.
Sphaeriidae					
Fingernail clams	28	2	3	2	2
Dreissenidae					
Dreissena polymorpha	.	.	.	.	.
Number of samples	10	10	10	10	10
Sum	375	257	412	525	648
Sum	0.60	0.60	0.60	0.60	0.60

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

South Holston Reservoir	SFHR	
	51	62.5
Species		
Tubellaria		
Tricladida		
Planariidae	.	.
Oligocheata		
Oligochaetes	60	170
Hirudinea	.	.
Crustacea		
Amphipoda	.	.
Isopoda	.	.
Insecta		
Ephemeroptera		
Mayflies	.	.
Ephemeridae		
Hexagenia (<=10 mm)	.	.
Hexagenia (>10 mm)	.	.
Megaloptera	.	.
Sialidae		
Sialis sp.		
Odonata		
Anisoptera	.	.
Zygoptera	.	.
Trichoptera		
Caddisflies	.	.
Coeleoptera	.	.
Diptera		
Ceratopogonidae	.	.
Chironomidae		
Chironomids	22	10
Gastropoda		
Snails	.	.
Basommatophora		
Ancylidae		
Ferrissia sp.	.	.
Bivalvia		
Unionoida		
Unionidae		
Mussels	.	.
Veneroida		
Corbiculidae		
Corbicula (<=10mm)	.	.
Corbicula (>10mm)	.	.
Sphaeriidae		
Fingernail clams	.	.
Dreissenidae		
Dreissena polymorpha	.	.
Number of samples	10	10
Sum	82	180
Sum	0.60	0.60

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Tims Ford Reservoir	ERM		
	135	135QA	150
Species			
Tubellaria			
Tricladida		QA	
Planariidae	.	.	.
Oligocheata			
Oligochaetes	33	55	7
Hirudinea	.	.	.
Crustacea			
Amphipoda	.	.	.
Isopoda	.	.	.
Insecta			
Ephemeroptera			
Mayflies	.	.	.
Ephemeridae			
Hexagenia (<=10 mm)	.	.	.
Hexagenia (>10 mm)	.	.	.
Megaloptera	.	.	.
Sialidae			
Sialis sp.			
Odonata			
Anisoptera	.	.	.
Zygoptera	.	.	.
Trichoptera			
Caddisflies	.	.	.
Coeleoptera	.	.	.
Diptera			
Ceratopogonidae	.	.	.
Chironomidae			
Chironomids	.	.	58
Gastropoda			
Snails	2	.	.
Basommatophora			
Ancylidae			
Ferrissia sp.	.	.	.
Bivalvia			
Unionoida			
Unionidae			
Mussels	.	.	.
Veneroida			
Corbiculidae			
Corbicula (<=10mm)	.	.	.
Corbicula (>10mm)	.	3	.
Sphaeriidae			
Fingernail clams	.	.	.
Dreissenidae			
Dreissena polymorpha	.	.	.
Number of samples	10	10	10
Sum	35	58	65
Sum	0.60	0.60	0.60

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Watts Bar Reservoir	TRM				CRM
	532.5	560.8	560.8(QA)	600	19
Species					
Tubellaria					
Tricladida					
Planariidae	.	.	.	578	.
Oligocheata					
Oligochaetes	108	18	32	.	2
Hirudinea	.	.	.	2	1
Crustacea					
Amphipoda	.	.	.	2	.
Isopoda	.	.	.	.	.
Insecta					
Ephemeroptera					
Mayflies	.	.	.	5	.
Ephemeridae					
Hexagenia (<=10 mm)	.	12	3	.	.
Hexagenia (>10 mm)	.	7	.	.	.
Megaloptera	.	.	.	.	.
Sialidae					
Sialis sp.					
Odonata					
Anisoptera	.	.	.	.	.
Zygoptera	.	.	.	.	.
Trichoptera					
Caddisflies	.	.	.	52	.
Coeleoptera	.	.	.	.	.
Diptera					
Ceratopogonidae	.	.	.	.	.
Chironomidae					
Chironomids	173	330	318	5	6
Gastropoda					
Snails	.	2	2	5	4
Basommatophora					
Ancylidae					
Ferrissia sp.	.	.	.	43	.
Bivalvia					
Unionoida					
Unionidae					
Mussels	.	.	.	.	.
Veneroida					
Corbiculidae					
Corbicula (<=10mm)	2	2	2	15	34
Corbicula (>10mm)	.	.	.	.	.
Sphaeriidae					
Fingernail clams	10	157	100	.	.
Dreissenidae					
Dreissena polymorpha	.	.	.	2	.
Number of samples	10	10	10	10	10
Sum	293	527	457	708	46
Sum	0.60	0.60	0.60	0.60	0.75

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Watauga Reservoir	WRM
	37.4
Species	
Tubellaria	
Tricladida	
Planariidae	.
Oligocheata	
Oligochaetes	520
Hirudinea	.
Crustacea	
Amphipoda	.
Isopoda	.
Insecta	
Ephemeroptera	
Mayflies	.
Ephemeridae	
Hexagenia (<=10 mm)	.
Hexagenia (>10 mm)	.
Megaloptera	.
Sialidae	
Sialis sp.	
Odonata	
Anisoptera	.
Zygoptera	.
Trichoptera	
Caddisflies	.
Coeleoptera	.
Diptera	
Ceratopogonidae	.
Chironomidae	
Chironomids	18
Gastropoda	
Snails	.
Basommatophora	
Ancylidae	
Ferrissia sp.	.
Bivalvia	
Unionoida	
Unionidae	
Mussels	.
Veneroida	
Corbiculidae	
Corbicula (<=10mm)	.
Corbicula (>10mm)	.
Sphaeriidae	
Fingernail clams	.
Dreissenidae	
Dreissena polymorpha	.
Number of samples	10
Sum	538
Sum	0.60

VS 2000 RAPID BIOASSESSMENT
MeanDensity/SQMeter

Wilson Reservoir	TRM	
	260.8	**273**
Species		
Tubellaria		
Tricladida		
Planariidae	.	.
Oligocheata		
Oligochaetes	143	7
Hirudinea	5	3
Crustacea		
Amphipoda	.	15
Isopoda	.	.
Insecta		
Ephemeroptera		
Mayflies	.	.
Ephemeridae		
Hexagenia (<=10 mm)	.	5
Hexagenia (>10 mm)	.	12
Megaloptera	.	.
Sialidae		
Sialis sp.		
Odonata		
Anisoptera	.	.
Zygoptera	.	.
Trichoptera		
Caddisflies	.	.
Coeleoptera	.	.
Diptera		
Ceratopogonidae	.	.
Chironomidae		
Chironomids	610	12
Gastropoda		
Snails	2	45
Basommatophora		
Ancylidae		
Ferrissia sp.	.	.
Bivalvia		
Unionoida		
Unionidae		
Mussels	.	5
Veneroida		
Corbiculidae		
Corbicula (<=10mm)	.	97
Corbicula (>10mm)	.	633
Sphaeriidae		
Fingernail clams	3	22
Dreissenidae		
Dreissena polymorpha	.	.
Number of samples	10	10
Sum	763	855
Sum	0.60	0.60

Appendix C.

Reservoir Benthic Macroinvertebrates -- Mean Density Results for Lab Processed Samples in 2000

VS 2000 LAB PROCESSED
MEAN DENSITY/SQMETER

Chatuge Reservoir	122.0

Species	Mean Density	Occurrence Per Site
Nematoda	5	2
Oligocheata		
Tubificidae	33	5
Limnodrilus hoffmeisteri	3	1
Insecta		
Ephemeroptera		
Ephemeridae		
Hexagenia limbata <10mm	2	1
Hexagenia limbata >10mm	3	1
Megaloptera		
Sialidae		
Sialis sp.	2	1
Diptera		
Ceratopogonidae		
Bezzia sp.	2	1
Chironomidae		
Chironomus sp.	7	3
Cladotanytarsus sp.	8	2
Coelotanypus sp.	3	1
Cryptochironomus fulvus	7	2
Polypedilum illinoense	3	1
Procladius sp.	23	3
Pseudochironomus sp.	15	1
Zalutschia zalutschicola	215	10
Bivalvia		
Veneroida		
Corbiculidae		
Corbicula fluminea (<10mm)	2	1
Sphaeriidae		
Musculium transversum	2	1
Sphaerium sp.	2	1

Number of samples	10
Sum	337
Number of taxa	16
Number of EPT taxa	1
Sum of area sampled	0.60

VS 2000 LAB PROCESSED
MEAN DENSITY/SQMETER

Guntersville Reservoir TRM 420.0

Species	Mean Density	Occurrence Per Site
Turbellaria		
Tricladida		
Planariidae		
Dugesia tigrina	120	9
Oligocheata		
Naididae		
Pristina sp.	2	1
Tubificidae	40	5
Branchiura sowerbyi	8	1
Limnodrilus hoffmeisteri	5	2
Lumbricidae	2	1
Lumbriculidae	2	1
Coelenterata		
Hydra americana	2	1
Hirudinea	2	1
Erpobdellidae	13	1
Glossiphoniidae	2	1
Helobdella sp.	3	2
Crustacea		
Amphipoda		
Corophium lacustre		
Talitridae		
Hyalella azteca	7	1
Gammaridae		
Gammarus sp.	90	8
Insecta		
Odonata		
Gomphus sp.	5	2
Ephemeroptera		
Heptageniidae	7	1
Stenacron interpunctatum	22	4
Tricorythodes sp.	3	2
Stenonema sp.	7	3
Trichoptera		
Psychomyiidae		
Cymellus fraternus	2	1
Leptoceridae		
Ceraclea sp.	7	3
Megaloptera		
Sialidae		
Sialis sp.	2	1

Guntersville Reservoir TRM 420.0 (continued)		
Diptera		
Chironomidae		
Ablabesmyia mallochi	2	1
Chironomus sp.	12	2
Coelotanypus tricolor	10	2
Cricotopus sp.	3	2
Cryptochironomus fulvus	22	6
Dicrotendipes sp.	10	3
Nanocladius sp.	2	1
Polypedilum convictum	2	1
Polypedilum halterale	2	1
Pseudochironomus sp.	20	3
Stictochironomus sp.	2	1
Synorthocladius semivires	2	1
Coleoptera		
Elmidae		
Stenelmis sp.	2	1
Gastropoda		
Ancylidae		
Ferrissia rivularis	7	2
Planorbidae		
Menetus dilatatus	5	1
Pleuroceridae		
Pleurocera canaliculata	20	1
Lithasia verrucosa	8	3
Bulimidae		
Somatogyrus sp.	13	4
Mesogastropoda		
Viviparidae		
Campeloma decisum	2	1
Bivalvia		
Veneroida		
Corbiculidae		
Corbicula fluminea (<10mm)	265	8
Corbicula fluminea (>10mm)	425	8
Dressenidae		
Dreissena polymorpha	7	3
Number of samples	10	
Sum	1190	
Number of taxa	38	
Number of EPT taxa	5	
Sum of area sampled	0.60	

VS 2000 LAB PROCESSED
MEAN DENSITY/SQMETER

Hiwassee Reservoir HiRM 85.0

Species	Mean Density	Occurrence Per Site
Oligocheata		
Tubificidae	1120	10
Limnodrilus hoffmeisteri	63	4
Crustacea		
Isopoda		
Caecidotea sp.	2	1
Insecta		
Diptera		
Ceratopogonidae		
Bezzia sp.	2	1
Chironomidae		
Chironomus sp.	182	8
Polypedilum flavum	2	1
Procladius sp.	72	8
Bivalvia		
Veneroida		
Sphaeriidae	13	2
Musculium transversum	7	2
Acari		
Parasitengonia		
Acariformes	2	1
Number of samples	10	
Sum	1463	
Number of taxa	8	
Number of EPT taxa	0	
Sum of area sampled	0.60	

VS 2000 LAB PROCESSED
MEAN DENSITY/SQMETER

Pickwick Reservoir TRM 207.3

Species	Mean Density	Occurrence Per Site
Oligocheata		
Tubificidae	55	6
Limnodrilus hoffmeisteri	3	1
Lumbricidae	5	2
Crustacea		
Amphipoda		
Corophium lacustre	2	1
Insecta		
Ephemeroptera		
Ephemeridae		
Hexagenia limbata >10mm	13	5
Trichoptera		
Leptoceridae		
Oecetis sp.	2	1
Diptera		
Chironomidae		
Ablabesmyia annulata	12	2
Chironomus sp.	5	2
Coelotanypus tricolor	188	9
Mollusca		
Gastropoda		
Mesogastropoda		
Viviparidae		
Viviparus Georgianus	40	3
Pelecypoda		
Unionidae	3	1
Bivalvia		
Veneroida		
Corbiculidae		
Corbicula fluminea (<10mm)	12	3
Corbicula fluminea (>10mm)	113	6
Sphaeriidae	2	1
Musculium transversum	3	2

Number of samples	10
Sum	458
Number of taxa	11
Number of EPT taxa	2
Sum of area sampled	0.60

VS 2000 LAB PROCESSED
MEAN DENSITY/SQMETER

Tims Ford Reservoir	ERM 135.0	
Species	**Mean Density**	**Occurrence Per Site**
Oligocheata		
Tubificidae	112	6
Gastropoda		
Mesogastropoda		
Bulimidae		
Somatogyrus sp.	2	1
Bivalvia		
Veneroida		
Corbiculidae		
Corbicula fluminea (<10mm)	2	1
Sphaeriidae	2	1
Number of samples	10	
Sum	117	
Number of taxa	4	
Number of EPT taxa	0	
Sum of area sampled	0.60	

VS 2000 LAB PROCESSED
MEAN DENSITY/SQMETER

Watauga Reservoir	WRM 37.4	

Species	Mean Density	Occurrence Per Site
Oligocheata		
Tubificidae	652	7
Limnodrilus hoffmeisteri	2	1
Insecta		
Diptera		
Chironomidae		
Chironomus sp.	17	4
Procladius sp.	2	1
Tanytarsus sp.	5	3
Bivalvia		
Veneroida		
Corbiculidae		
Corbicula fluminea (<10mm)	5	2
Sphaeriidae	3	1

Number of samples	10
Sum	685
Number of taxa	6
Number of EPT taxa	0
Sum of area sampled	0.60

VS 2000 LAB PROCESSED
MEAN DENSITY/SQMETER

Watts Bar Reservoir TRM 560.8		
Species	Mean Density	Occurrence Per Site
Nematoda	2	1
Oligocheata		
Tubificidae	15	5
Limnodrilus hoffmeisteri	3	2
Insecta		
Ephemeroptera		
Ephemeridae		
Hexagenia limbata <10mm	2	1
Hexagenia limbata >10mm	17	5
Diptera		
Chironomidae		
Ablabesmyia annulata	12	5
Chironomus sp.	72	10
Coelotanypus tricolor	243	10
Gastropoda		
Planorbidae		
Menetus dilatatus	2	1
Bivalvia		
Veneroida		
Corbiculidae		
Corbicula fluminea (<10mm)	5	3
Sphaeriidae		
Musculium transversum	97	6
Number of samples	10	
Sum	468	
Number of taxa	9	
Number of EPT taxa	1	
Sum of area sampled	0.60	

Appendix D.

Results and Ratings for Individual Metrics and Final RAFI Score for Each Sample Location in 2000 Including Both Regular and Repeat QA Sampling

Appendix D.

Results and Ratings for Individual Metrics and Final RAFI Score for Each Sample Location in 2000 Regular Sampling

Table 1. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Apalachia - - 2000

Metric		Forebay HiRM 66.5 Obs	Score
A. Species richness and composition			
1. Number of species		**15**	**3**
2. Number of sunfish species		**3**	**3**
3. Number of sucker species		**0**	**1**
4. Number of intolerant species		**0**	**1**
5. Percent tolerant individuals	Electro Fishing	**44.7**	**0.5**
	Gill Netting	**25.0**	**0.5**
6. Percent dominance *	Electro Fishing	**21.3**	**2.5**
	Gill Netting	**17.5**	**2.5**
7. Number of piscivore species		**7**	**5**
B. Trophic composition			
8. Percent omnivores	Electro Fishing	**21.3**	**0.5**
	Gill Netting	**37.5**	**0.5**
9. Percent insectivores	Electro Fishing	**42.6**	**0.5**
	Gill Netting	**10.0**	**2.5**
C. Reproductive composition			
10. Number of Lithophilic spawning species		**1**	**1**
D. Fish abundance and health			
11. Average number of individuals	Electro Fishing	**3.1**	**0.5**
	Gill Netting	**4.0**	**0.5**
12. Percent anomalies		**0.0**	**5**
RFAI			**30** Poor

* Percent composition of the most abundant species

Table 2. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Beech - - 2000

Metric		Beech 36.0 Obs	Score
A. Species richness and composition			
1. Number of species		**11**	**3**
2. Number of sunfish species		**4**	**5**
3. Number of sucker species		**1**	**1**
4. Number of intolerant species		**1**	**1**
5. Percent tolerant individuals	Electro Fishing	**28.9**	**1.5**
	Gill Netting	**34.2**	**1.5**
6. Percent dominance*	Electro Fishing	**28.9**	**2.5**
	Gill Netting	**36.8**	**1.5**
7. Number of piscivore species		**3**	**3**
B. Trophic composition			
8. Percent omnivores	Electro Fishing	**32.9**	**0.5**
	Gill Netting	**71.1**	**0.5**
9. Percent insectivores	Electro Fishing	**38.6**	**0.5**
	Gill Netting	**3.9**	**1.5**
C. Reproductive composition			
10. Number of Lithophilic spawning species		**1**	**1**
D. Fish abundance and health			
11. Average number of individuals	Electro Fishing	**15.2**	**0.5**
	Gill Netting	**7.6**	**0.5**
12. Percent anomalies		**0.0**	**5**
RFAI			**30** **Poor**

*Percent composition of the most abundant species

Table 3 Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Chatuge - - 2000

		Forebay HiRM 122.0		Transition Shooting Cr 1.5	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		**15**	**3**	**14**	**3**
2. Number of sunfish species		**4**	**5**	**3**	**3**
3. Number of sucker species		**0**	**1**	**1**	**1**
4. Number of intolerant species		**0**	**1**	**1**	**1**
5. Percent tolerant individuals	Electro Fishing	**5.4**	**2.5**	**18.8**	**1.5**
	Gill Netting	**2.6**	**2.5**	**17.5**	**1.5**
6. Percent dominance *	Electro Fishing	**76.4**	**0.5**	**38.3**	**2.5**
	Gill Netting	**51.9**	**0.5**	**45.6**	**1.5**
7. Number of piscivore species		**6**	**5**	**5**	**3**
B. Trophic composition					
8. Percent omnivores	Electro Fishing	**0.2**	**2.5**	**2.7**	**2.5**
	Gill Netting	**9.1**	**2.5**	**21.1**	**1.5**
9. Percent insectivores	Electro Fishing	**85.2**	**2.5**	**73.8**	**0.5**
	Gill Netting	**2.6**	**0.5**	**0.0**	**0.5**
C. Reproductive composition					
10. Number of Lithophilic spawning		**2**	**1**	**3**	**3**
D. Fish abundance and health					
11. Average number of individuals	Electro Fishing	**31.1**	**1.5**	**9.9**	**0.5**
	Gill Netting	**7.7**	**0.5**	**5.7**	**0.5**
12. Percent anomalies		**16.6**	**1**	**1.9**	**5**
RFAI			**33**		**32**
			Fair		**Fair**

* Percent composition of the most abundant species

Table 4. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Cherokee - - 2000

Metric		Forebay HRM 53.0 Obs	Forebay HRM 53.0 Score	Transition HRM 76.0 Obs	Transition HRM 76.0 Score
A. Species richness and composition					
1. Number of species		22	5	25	5
2. Number of sunfish species		1	1	4	5
3. Number of sucker species		4	3	3	3
4. Number of intolerant species		0	1	1	1
5. Percent tolerant individuals	Electro Fishing	19.2	1.5	42.5	0.5
	Gill Netting	17.7	2.5	28.3	2.5
6. Percent dominance *	Electro Fishing	48.6	1.5	39.8	2.5
	Gill Netting	20.8	2.5	16.2	2.5
7. Number of piscivore species		8	5	10	5
B. Trophic composition					
8. Percent omnivores	Electro Fishing	22.5	1.5	41.0	0.5
	Gill Netting	70.0	0.5	55.5	1.5
9. Percent insectivores	Electro Fishing	61.1	1.5	24.2	0.5
	Gill Netting	2.3	0.5	0.0	0.5
C. Reproductive composition					
10. Number of Lithophilic spawning		3	3	2	1
D. Fish abundance and health					
11. Average number of individuals	Electro Fishing	24.0	0.5	29.5	0.5
	Gill Netting	13.0	0.5	17.3	1.5
12. Percent anomalies		1.2	5	1.0	5
RFAI			36		38
			Fair		Fair

*Percent Composition of the most abundant species

Table 5. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Fontana - - 2000

		Forebay LTRM 62.0		Transition LTRM 81.5		Transition TKRM 3.0	
Metric		Obs	Score	Obs	Score	Obs	Score
A. Species richness and							
1. Number of species		15	3	18	5	15	3
2. Number of sunfish species		2	3	2	3	2	3
3. Number of sucker species		1	1	4	5	3	3
4. Number of intolerant species		1	1	1	1	1	1
5. Percent tolerant individuals	Electro	8.3	2.5	34.3	0.5	50.9	0.5
	Gill Netting	4.4	2.5	26.3	0.5	26.1	0.5
6. Percent dominance *	Electro	46.9	1.5	32.8	2.5	50.9	1.5
	Gill Netting	35.3	1.5	21.2	2.5	29.6	2.5
7. Number of piscivore species		6	5	7	5	7	5
B. Trophic composition							
8. Percent omnivores	Electro	1.4	2.5	1.5	2.5	1.9	2.5
	Gill Netting	5.9	2.5	27.7	1.5	28.2	1.5
9. Percent insectivores	Electro	76.6	1.5	65.0	0.5	68.9	0.5
	Gill Netting	1.5	0.5	10.9	2.5	12.0	2.5
C. Reproductive composition							
10. Number of Lithophilic spawning		5	5	7	5	5	5
D. Fish abundance and health							
11. Average number of individuals	Electro	9.7	0.5	9.1	0.5	7.1	0.5
	Gill Netting	13.6	1.5	13.7	1.5	15.8	1.5
12. Percent anomalies		1.1	5	1.8	5	0.0	5
RFAI			40		44		39
			Fair		Good		Fair

* Percent composition of the most abundant species

Table 6. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Fort Loudon - - 2000

Metric		Forebay TRM 605.5 Obs	Forebay TRM 605.5 Score	Transition TRM 624.6 Obs	Transition TRM 624.6 Score	Inflow TRM 652.0 Obs	Inflow TRM 652.0 Score
A. Species richness and							
1. Number of species		30	5	31	5	29	5
2. Number of sunfish species		4	3	4	3	5	5
3. Number of sucker species		6	3	6	3	5	3
4. Number of intolerant species		3	3	3	3	3	3
5. Percent tolerant individuals	Electro	28.4	1.5	25.0	1.5	29.7	5
	Gill Netting	9.6	2.5	18.1	2.5	0	0
6. Percent dominance*	Electro	38.0	2.5	38.5	2.5	22.6	5
	Gill Netting	34.7	1.5	18.1	2.5	0.0	0
7. Number of piscivore species		9	5	9	5	7	3
B. Trophic composition							
8. Percent omnivores	Electro	26.8	1.5	25.0	1.5	28.6	5
	Gill Netting	19.7	2.5	29.5	2.5	0	0
9. Percent insectivores	Electro	47.7	1.5	53.2	1.5	53.0	5
	Gill Netting	3.2	0.5	19.0	2.5	0	0
C. Reproductive composition							
10. Number of Lithophilic spawning		8	5	8	5	7	3
D. Fish abundance and health							
11. Average number of individuals	Electro	48.1	0.5	37.1	0.5	17.7	1
	Gill Netting	31.4	1.5	10.5	0.5	0	0
12. Percent anomalies		0.9	5	1.4	5	0.4	5
RFAI			45		47		48
			Good		Good		Good

* Percent composition of the most abundant species

Table 7. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Guntersville - - 2000

Metric		Forebay TRM 350.0 Obs	Forebay TRM 350.0 Score	Transition TRM 375.2 Obs	Transition TRM 375.2 Score	Inflow TRM 424.0 Obs	Inflow TRM 424.0 Score
A. Species richness and							
1. Number of species		**25**	**3**	**18**	**3**	**20**	**3**
2. Number of sunfish species		**3**	**3**	**3**	**3**	**4**	**3**
3. Number of sucker species		**2**	**1**	**0**	**1**	**3**	**3**
4. Number of intolerant species		**3**	**3**	**1**	**1**	**2**	**3**
5. Percent tolerant individuals	Electro	**51.9**	**0.5**	**48.4**	**1.5**	**56.8**	**1**
	Gill Netting	**15.0**	**2.5**	**7.9**	**2.5**	**0**	**0**
6. Percent dominance	Electro	**51.6**	**1.5**	**47.6**	**1.5**	**48.4**	**3**
	Gill Netting	**40.0**	**1.5**	**31.5**	**1.5**	**0.0**	**0**
7. Number of piscivore species		**10**	**5**	**8**	**5**	**7**	**3**
B. Trophic composition							
8. Percent omnivores	Electro	**52.4**	**0.5**	**48.4**	**1.5**	**60.4**	**1**
	Gill Netting	**20.0**	**2.5**	**12.6**	**2.5**	**0**	**0**
9. Percent insectivores	Electro	**28.5**	**0.5**	**33.7**	**1.5**	**21.6**	**1**
	Gill Netting	**2.5**	**0.5**	**7.1**	**1.5**	**0**	**0**
C. Reproductive composition							
10. Number of Lithophilic spawning		**5**	**3**	**2**	**1**	**4**	**3**
D. Fish abundance and health							
11. Average number of individuals	Electro	**24.8**	**0.5**	**23.5**	**0.5**	**25.6**	**1**
	Gill Netting	**12.0**	**0.5**	**12.7**	**0.5**	**0**	**0**
12. Percent anomalies		**0.0**	**5**	**0.0**	**5**	**0.5**	**5**
RFAI			**34**		**34**		**30**
			Fair		**Fair**		**Poor**

* Percent composition of the most abundant species

Table 8. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Hiwassee - - 2000

Metric		Forebay HIRM 77.0 Obs	Forebay HIRM 77.0 Score	Transition HIRM 85.0 Obs	Transition HIRM 85.0 Score
A. Species richness and composition					
1. Number of species		17	5	20	5
2. Number of sunfish species		3	3	3	3
3. Number of sucker species		4	5	6	5
4. Number of intolerant species		1	1	2	3
5. Percent tolerant individuals	Electro Fishing	30.0	1.5	16.8	1.5
	Gill Netting	14.6	1.5	12.7	1.5
6. Percent dominance *	Electro Fishing	38.6	2.5	38.9	2.5
	Gill Netting	41.7	1.5	25.4	2.5
7. Number of piscivore species		6	5	7	5
B. Trophic composition					
8. Percent omnivores	Electro Fishing	0.7	2.5	0.0	2.5
	Gill Netting	25.0	1.5	16.9	1.5
9. Percent insectivores	Electro Fishing	78.6	1.5	64.1	0.5
	Gill Netting	22.9	2.5	32.4	2.5
C. Reproductive composition					
10. Number of Lithophilic spawning		6	5	8	5
D. Fish abundance and health					
11. Average number of individuals	Electro Fishing	9.3	0.5	11.1	0.5
	Gill Netting	4.8	0.5	7.1	0.5
12. Percent anomalies		1.6	5	0.4	5
RFAI			45 Good		47 Good

* Percent composition of the most abundant species

Table 9. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Melton Hill - - 2000

		Forebay CRM 24.0		Transition CRM 45.0		Inflow CRM 66.0	
Metric		**Obs**	**Score**	**Obs**	**Score**	**Obs**	**Score**
A. Species richness and							
1. Number of species		**37**	**5**	**35**	**5**	**18**	**3**
2. Number of sunfish species		**5**	**5**	**5**	**5**	**4**	**3**
3. Number of sucker species		**8**	**5**	**7**	**3**	**5**	**3**
4. Number of intolerant species		**4**	**3**	**2**	**3**	**3**	**3**
5. Percent tolerant individuals	Electro	**8.6**	**2.5**	**41.5**	**1.5**	**59.3**	**1**
	Gill Netting	**22.4**	**1.5**	**15.9**	**2.5**	**0**	**0**
6. Percent dominance *	Electro	**45.8**	**1.5**	**32.6**	**2.5**	**56.9**	**3**
	Gill Netting	**19.2**	**2.5**	**15.0**	**2.5**	**0.0**	**0**
7. Number of piscivore species		**14**	**5**	**10**	**5**	**5**	**3**
B. Trophic composition							
8. Percent omnivores	Electro	**7.8**	**2.5**	**39.3**	**1.5**	**61.0**	**1**
	Gill Netting	**44.2**	**1.5**	**54.0**	**0.5**	**0**	**0**
9. Percent insectivores	Electro	**41.8**	**1.5**	**33.8**	**1.5**	**27.6**	**3**
	Gill Netting	**6.4**	**1.5**	**18.6**	**2.5**	**0**	**0**
C. Reproductive composition							
10. Number of Lithophilic spawning		**9**	**5**	**8**	**5**	**5**	**3**
D. Fish abundance and health							
11. Average number of individuals	Electro	**49.7**	**0.5**	**26.8**	**0.5**	**8.2**	**1**
	Gill Netting	**15.6**	**1.5**	**11.3**	**0.5**	**0**	**0**
12. Percent anomalies		**3.7**	**3**	**1.9**	**5**	**0.0**	**5**
RFAI			**48**		**47**		**32**
			Good		**Good**		**Fair**

* Percent composition of the most abundant species

Table 10. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Normandy - - 2000

Metric		Forebay DRM 249.5 Obs	Forebay DRM 249.5 Score
A. Species richness and composition			
1. Number of species		**26**	**5**
2. Number of sunfish species		**4**	**5**
3. Number of sucker species		**5**	**3**
4. Number of intolerant species		**5**	**5**
5. Percent tolerant individuals	Electro Fishing	**66.4**	**0.5**
	Gill Netting	**21.7**	**1.5**
6. Percent dominance *	Electro Fishing	**60.0**	**1.5**
	Gill Netting	**22.5**	**2.5**
7. Number of piscivore species		**10**	**5**
B. Trophic composition			
8. Percent omnivores	Electro Fishing	**66.0**	**0.5**
	Gill Netting	**27.5**	**2.5**
9. Percent insectivores	Electro Fishing	**24.2**	**0.5**
	Gill Netting	**9.4**	**2.5**
C. Reproductive composition			
10. Number of Lithophilic spawning species		**8**	**5**
D. Fish abundance and health			
11. Average number of individuals	Electro Fishing	**17.7**	**0.5**
	Gill Netting	**13.8**	**1.5**
12. Percent anomalies		**0.0**	**5**
RFAI			**47**
			Good

* Percent composition of the most abundant species

Table 11. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Pickwick - - 2000

		Embayment BCM 8.4		Inflow TRM 259.0	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		**29**	**5**	**28**	**5**
2. Number of sunfish species		**4**	**3**	**4**	**3**
3. Number of sucker species		**6**	**3**	**7**	**3**
4. Number of intolerant species		**5**	**5**	**6**	**3**
5. Percent tolerant individuals	Electro Fishing	**57.9**	**0.5**	**12.6**	**5**
	Gill Netting	**18.9**	**2.5**	**0**	**0**
6. Percent dominance *	Electro Fishing	**56.1**	**1.5**	**14.2**	**5**
	Gill Netting	**62.8**	**0.5**	**0.0**	**0**
7. Number of piscivore species		**10**	**5**	**9**	**5**
B. Trophic composition					
8. Percent omnivores	Electro Fishing	**59.1**	**0.5**	**20.4**	**5**
	Gill Netting	**21.1**	**2.5**	**0**	**0**
9. Percent insectivores	Electro Fishing	**28.9**	**0.5**	**50.1**	**5**
	Gill Netting	**6.8**	**0.5**	**0**	**0**
C. Reproductive composition					
10. Number of Lithophilic spawning		**9**	**5**	**9**	**5**
D. Fish abundance and health					
11. Average number of individuals	Electro Fishing	**22.8**	**0.5**	**24.9**	**1**
	Gill Netting	**35.5**	**2.5**	**0**	**0**
12. Percent anomalies		**0.1**	**5**	**0.5**	**5**
RFAI			**43**		**50**
			Good		**Good**

* Percent composition of the most abundant species

Table 12. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Pickwick - - 2000

Metric		Forebay TRM 207.3 Obs	Forebay TRM 207.3 Score	Transition TRM 230.0 Obs	Transition TRM 230.0 Score
A. Species richness and composition					
1. Number of species		**25**	**3**	**30**	**5**
2. Number of sunfish species		**4**	**3**	**3**	**3**
3. Number of sucker species		**4**	**3**	**7**	**3**
4. Number of intolerant species		**3**	**3**	**4**	**3**
5. Percent tolerant individuals	Electro Fishing	**69.6**	**0.5**	**18.3**	**2.5**
	Gill Netting	**37.9**	**1.5**	**17.4**	**2.5**
6. Percent dominance *	Electro Fishing	**68.4**	**0.5**	**61.6**	**0.5**
	Gill Netting	**37.9**	**1.5**	**14.3**	**2.5**
7. Number of piscivore species		**8**	**5**	**10**	**5**
B. Trophic composition					
8. Percent omnivores	Electro Fishing	**69.4**	**0.5**	**21.3**	**2.5**
	Gill Netting	**46.4**	**0.5**	**32.9**	**1.5**
9. Percent insectivores	Electro Fishing	**25.3**	**0.5**	**72.4**	**2.5**
	Gill Netting	**2.9**	**0.5**	**13.0**	**1.5**
C. Reproductive composition					
10. Number of Lithophilic spawning		**6**	**3**	**9**	**5**
D. Fish abundance and health					
11. Average number of individuals	Electro Fishing	**26.3**	**0.5**	**22.2**	**0.5**
	Gill Netting	**14.0**	**0.5**	**16.1**	**1.5**
12. Percent anomalies		**0.2**	**5**	**0.0**	**5**
RFAI			**32**		**47**
			Fair		**Good**

* Percent composition of the most abundant species

Table 13. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

South Holston - - 2000

		Forebay SFHRM 51.0		Transition SFHRM 62.5	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		**17**	**3**	**20**	**3**
2. Number of sunfish species		**2**	**3**	**3**	**3**
3. Number of sucker species		**3**	**3**	**6**	**3**
4. Number of intolerant species		**3**	**5**	**3**	**5**
5. Percent tolerant individuals	Electro Fishing	**14.3**	**2.5**	**23.2**	**1.5**
	Gill Netting	**17.0**	**2.5**	**32.0**	**1.5**
6. Percent dominance *	Electro Fishing	**47.7**	**1.5**	**34.1**	**2.5**
	Gill Netting	**48.0**	**1.5**	**38.4**	**1.5**
7. Number of piscivore species		**7**	**5**	**6**	**3**
B. Trophic composition					
8. Percent omnivores	Electro Fishing	**16.5**	**1.5**	**23.2**	**1.5**
	Gill Netting	**25.0**	**2.5**	**44.8**	**1.5**
9. Percent insectivores	Electro Fishing	**66.9**	**1.5**	**62.9**	**1.5**
	Gill Netting	**2.0**	**0.5**	**3.5**	**1.5**
C. Reproductive composition					
10. Number of Lithophilic spawning		**4**	**3**	**7**	**5**
D. Fish abundance and health					
11. Average number of individuals	Electro Fishing	**17.7**	**0.5**	**22.7**	**0.5**
	Gill Netting	**10.0**	**0.5**	**17.2**	**1.5**
12. Percent anomalies		**2.7**	**3**	**0.8**	**5**
RFAI			**40**		**42**
			Fair		**Good**

* Percent composition of the most abundant species

Table 14. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Tims Ford - - 2000

		Forbay ERM 135.0		Transition ERM 150.0	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		**22**	**5**	**19**	**5**
2. Number of sunfish species		**3**	**3**	**2**	**3**
3. Number of sucker species		**3**	**3**	**4**	**1**
4. Number of intolerant species		**2**	**3**	**1**	**1**
5. Percent tolerant individuals	Electro Fishing	**25.3**	**1.5**	**22.4**	**1.5**
	Gill Netting	**21.6**	**1.5**	**39.6**	**0.5**
6. Percent dominance *	Electro Fishing	**34.9**	**2.5**	**48.0**	**1.5**
	Gill Netting	**25.5**	**2.5**	**32.8**	**1.5**
7. Number of piscivore species		**10**	**5**	**7**	**5**
B. Trophic composition					
8. Percent omnivores	Electro Fishing	**25.3**	**0.5**	**21.4**	**1.5**
	Gill Netting	**33.3**	**2.5**	**59.0**	**1.5**
9. Percent insectivores	Electro Fishing	**42.2**	**0.5**	**58.2**	**1.5**
	Gill Netting	**2.0**	**0.5**	**0.7**	**0.5**
C. Reproductive composition					
10. Number of Lithophilic spawning		**5**	**3**	**4**	**3**
D. Fish abundance and health					
11. Average number of individuals	Electro Fishing	**5.5**	**0.5**	**6.5**	**0.5**
	Gill Netting	**5.1**	**0.5**	**13.4**	**1.5**
12. Percent anomalies		**0.0**	**5**	**0.0**	**5**
RFAI			**40** **Fair**		**35** **Fair**

* Percent composition of the most abundant species

Table 15. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Watauga - - 2000

		Forebay WRM 37.4		Transition WRM 45.5	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		**14**	**3**	**17**	**5**
2. Number of sunfish species		**1**	**1**	**1**	**1**
3. Number of sucker species		**0**	**1**	**3**	**3**
4. Number of intolerant species		**1**	**1**	**3**	**5**
5. Percent tolerant individuals	Electro Fishing	**15.7**	**1.5**	**29.4**	**1.5**
	Gill Netting	**7.9**	**2.5**	**8.9**	**2.5**
6. Percent dominance *	Electro Fishing	**49.7**	**1.5**	**29.0**	**2.5**
	Gill Netting	**68.5**	**0.5**	**68.8**	**0.5**
7. Number of piscivore species		**8**	**5**	**6**	**5**
B. Trophic composition					
8. Percent omnivores	Electro Fishing	**27.9**	**0.5**	**44.8**	**0.5**
	Gill Netting	**9.0**	**2.5**	**11.6**	**2.5**
9. Percent insectivores	Electro Fishing	**58.5**	**0.5**	**39.9**	**0.5**
	Gill Netting	**0.0**	**0.5**	**2.7**	**0.5**
C. Reproductive composition					
10. Number of Lithophilic spawning		**1**	**1**	**4**	**3**
D. Fish abundance and health					
11. Average number of individuals	Electro Fishing	**25.1**	**0.5**	**35.6**	**1.5**
	Gill Netting	**8.9**	**0.5**	**11.2**	**1.5**
12. Percent anomalies		**3.0**	**3**	**1.4**	**5**
RFAI			**26**		**41**
			Poor		**Good**

* Percent composition of the most abundant species

Table 16. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Watts Bar - - 2000

		Inflow CRM 22.0		Inflow TRM 601.0	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		**20**	**3**	**33**	**5**
2. Number of sunfish species		**3**	**3**	**5**	**5**
3. Number of sucker species		**4**	**3**	**6**	**3**
4. Number of intolerant species		**4**	**3**	**5**	**3**
5. Percent tolerant individuals	Electro Fishing	**3.5**	**5**	**35.0**	**3**
	Gill Netting	**0**	**0**	**0**	**0**
6. Percent dominance *	Electro Fishing	**18.4**	**5**	**29.6**	**5**
	Gill Netting	**0.0**	**0**	**0.0**	**0**
7. Number of piscivore species		**5**	**3**	**11**	**5**
B. Trophic composition					
8. Percent omnivores	Electro Fishing	**6.1**	**5**	**33.6**	**3**
	Gill Netting	**0**	**0**	**0**	**0**
9. Percent insectivores	Electro Fishing	**71.1**	**5**	**42.3**	**3**
	Gill Netting	**0**	**0**	**0**	**0**
C. Reproductive composition					
10. Number of Lithophilic spawning		**4**	**3**	**9**	**5**
D. Fish abundance and health					
11. Average number of individuals	Electro Fishing	**7.6**	**1**	**33.7**	**1**
	Gill Netting	**0**	**0**	**0**	**0**
12. Percent anomalies		**4.4**	**3**	**4.0**	**3**
RFAI			**42**		**44**
			Good		**Good**

* Percent compostion of the most abundant species

Table 17. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Watts Bar - - 2000

		Forebay TRM 531.0		Transition TRM 560.8	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		33	5	34	5
2. Number of sunfish species		5	5	6	5
3. Number of sucker species		5	3	4	3
4. Number of intolerant species		3	3	3	3
5. Percent tolerant individuals	Electro Fishing	21.6	1.5	17.5	2.5
	Gill Netting	33.5	1.5	24.0	1.5
6. Percent dominance *	Electro Fishing	46.7	1.5	35.3	2.5
	Gill Netting	31.8	1.5	28.6	2.5
7. Number of piscivore species		10	5	12	5
B. Trophic composition					
8. Percent omnivores	Electro Fishing	15.3	2.5	19.1	2.5
	Gill Netting	39.4	1.5	29.5	2.5
9. Percent insectivores	Electro Fishing	75.9	2.5	65.5	2.5
	Gill Netting	8.5	1.5	2.3	0.5
C. Reproductive composition					
10. Number of Lithophilic spawning		6	3	5	3
D. Fish abundance and health					
11. Average number of individuals	Electro Fishing	47.0	0.5	48.1	0.5
	Gill Netting	34.0	1.5	21.7	1.5
12. Percent anomalies		1.0	5	1.5	5
RFAI			45 Good		48 Good

* Percent composition of the most abundant species

Table 18. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Wilson - - 2000

		Forebay TRM 260.8		Inflow TRM 274.0	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		22	3	16	3
2. Number of sunfish species		4	3	3	3
3. Number of sucker species		2	1	4	3
4. Number of intolerant species		4	3	3	3
5. Percent tolerant individuals	Electro Fishing	36.8	1.5	57.9	1
	Gill Netting	19.7	2.5	0	0
6. Percent dominance *	Electro Fishing	36.1	2.5	57.9	3
	Gill Netting	35.8	1.5	0	0
7. Number of piscivore species		9	5	2	1
B. Trophic composition					
8. Percent omnivores	Electro Fishing	38.6	1.5	59.0	1
	Gill Netting	23.4	2.5	0	0
9. Percent insectivores	Electro Fishing	40.4	1.5	35.5	3
	Gill Netting	2.9	0.5	0	0
C. Reproductive composition					
10. Number of Lithophilic spawning		4	3	3	1
D. Fish abundance and health					
11. Average number of individuals	Electro Fishing	19.0	0.5	39.9	1
	Gill Netting	13.7	0.5	0	0
12. Percent anomalies		0.2	5	0.3	5
RFAI			38		28
			Fair		Poor

* Percent composition of the most abundant species

Appendix D.

Results and Ratings for Individual Metrics and Final RAFI Score for Each Sample Location in 2000 Repeat QA Sampling

Table 1. Scoring result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Chatuge - QA - 2000

Metric		Forebay HiRM 122 Obs	Forebay HiRM 122 Score
A. Species richness and composition			
1. Number of species		**10**	**3**
2. Number of sunfish species		**3**	**3**
3. Number of sucker species		**0**	**1**
4. Number of intolerant species		**0**	**1**
5. Percent tolerant individuals	Electro Fishing	**6.3**	**2.5**
	Gill Netting	**34.4**	**0.5**
6. Percent dominance *	Electro Fishing	**45.0**	**1.5**
	Gill Netting	**40.6**	**1.5**
7. Number of piscivore species		**4**	**3**
B. Trophic composition			
8. Percent omnivores	Electro Fishing	**1.3**	**2.5**
	Gill Netting	**46.9**	**0.5**
9. Percent insectivores	Electro Fishing	**52.5**	**0.5**
	Gill Netting	**0.0**	**0.5**
C. Reproductive composition			
10. Number of Lithophilic spawning species		**1**	**1**
D. Fish abundance and health			
11. Average number of individuals	Electro Fishing	**5.3**	**0.5**
	Gill Netting	**3.2**	**0.5**
12. Percent anomalies		**0.0**	**5**
RFAI			**28** **Poor**

* Percent composition of the most abundant species

Table 2. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Guntersville - QA - 2000

Metric		Inflow TRM 424.0 Obs	Score
A. Species richness and composition			
1. Number of species		**28**	**5**
2. Number of sunfish species		**5**	**5**
3. Number of sucker species		**6**	**3**
4. Number of intolerant species		**3**	**3**
5. Percent tolerant individuals	Electro Fishing	**17.6**	**5**
	Gill Netting	**0**	**0**
6. Percent dominance *	Electro Fishing	**15.9**	**5**
	Gill Netting	**0.0**	**0**
7. Number of piscivore species		**7**	**3**
B. Trophic composition			
8. Percent omnivores	Electro Fishing	**13.6**	**5**
	Gill Netting	**0**	**0**
9. Percent insectivores	Electro Fishing	**59.3**	**5**
	Gill Netting	**0**	**0**
C. Reproductive composition			
10. Number of Lithophilic spawning species		**9**	**5**
D. Fish abundance and health			
11. Average number of individuals	Electro Fishing	**39.3**	**1**
	Gill Netting	**0**	**0**
12. Percent anomalies		**3.1**	**3**
RFAI			**48** Good

* Percent composition of the most abundant species

Table 3. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Hiwassee - QA - 2000

Metric		Transition HIRM 85.0 Obs	Score
A. Species richness and composition			
1. Number of species		**15**	**3**
2. Number of sunfish species		**2**	**3**
3. Number of sucker species		**4**	**5**
4. Number of intolerant species		**2**	**3**
5. Percent tolerant individuals	Electro Fishing	**6.8**	**2.5**
	Gill Netting	**15.9**	**1.5**
6. Percent dominance *	Electro Fishing	**34.1**	**2.5**
	Gill Netting	**22.7**	**2.5**
7. Number of piscivore species		**6**	**5**
B. Trophic composition			
8. Percent omnivores	Electro Fishing	**0.0**	**2.5**
	Gill Netting	**20.5**	**1.5**
9. Percent insectivores	Electro Fishing	**34.1**	**0.5**
	Gill Netting	**25.0**	**2.5**
C. Reproductive composition			
10. Number of Lithophilic spawning species		**6**	**5**
D. Fish abundance and health			
11. Average number of individuals	Electro Fishing	**2.9**	**0.5**
	Gill Netting	**4.4**	**0.5**
12. Percent anomalies		**0.0**	**5**
RFAI			**46** **Good**

Percent composition of the most abundant species

Table 4. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Pickwick - QA - 2000

Metric		Forebay TRM 207.3 Obs	Score
A. Species richness and composition			
1. Number of species		29	5
2. Number of sunfish species		4	3
3. Number of sucker species		4	3
4. Number of intolerant species		4	3
5. Percent tolerant individuals	Electro Fishing	26.6	1.5
	Gill Netting	38.6	1.5
6. Percent dominance	Electro Fishing	25.4	2.5
	Gill Netting	38.6	1.5
7. Number of piscivore species		8	5
B. Trophic composition			
8. Percent omnivores	Electro Fishing	26.6	1.5
	Gill Netting	44.7	1.5
9. Percent insectivores	Electro Fishing	56.7	1.5
	Gill Netting	4.5	0.5
C. Reproductive composition			
10. Number of Lithophilic spawning species		5	3
D. Fish abundance and health			
11. Average number of individuals	Electro Fishing	41.1	0.5
	Gill Netting	13.2	0.5
12. Percent anomalies		1.2	5
RFAI			40
			Fair

Table 5. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Tims Ford - QA - 2000

Metric		Forebay ERM135 Obs	Score
A. Species richness and composition			
1. Number of species		**23**	**5**
2. Number of sunfish species		**5**	**5**
3. Number of sucker species		**3**	**3**
4. Number of intolerant species		**2**	**3**
5. Percent tolerant individuals	Electro Fishing	**3.6**	**2.5**
	Gill Netting	**41.4**	**0.5**
6. Percent dominance *	Electro Fishing	**74.4**	**0.5**
	Gill Netting	**34.3**	**1.5**
7. Number of piscivore species		**10**	**5**
B. Trophic composition			
8. Percent omnivores	Electro Fishing	**1.1**	**2.5**
	Gill Netting	**28.6**	**2.5**
9. Percent insectivores	Electro Fishing	**94.9**	**2.5**
	Gill Netting	**0.0**	**0.5**
C. Reproductive composition			
10. Number of Lithophilic spawning species		**3**	**3**
D. Fish abundance and health			
11. Average number of individuals	Electro Fishing	**50.6**	**1.5**
	Gill Netting	**7.0**	**0.5**
12. Percent anomalies		**0.8**	**5**
RFAI			**44**
			Good

* Percent composition of the most abundant species

Table 6. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Watauga - QA - 2000

Metric		Forebay WRM 37.4 Obs	Score
A. Species richness and composition			
1. Number of species		**11**	**3**
2. Number of sunfish species		**1**	**1**
3. Number of sucker species		**0**	**1**
4. Number of intolerant species		**1**	**1**
5. Percent tolerant individuals	Electro Fishing	**73.2**	**0.5**
	Gill Netting	**7.6**	**2.5**
6. Percent dominance *	Electro Fishing	**73.2**	**0.5**
	Gill Netting	**65.2**	**0.5**
7. Number of piscivore species		**6**	**5**
B. Trophic composition			
8. Percent omnivores	Electro Fishing	**73.2**	**0.5**
	Gill Netting	**8.7**	**2.5**
9. Percent insectivores	Electro Fishing	**7.0**	**0.5**
	Gill Netting	**0.0**	**0.5**
C. Reproductive composition			
10. Number of Lithophilic spawning species		**1**	**1**
D. Fish abundance and health			
11. Average number of individuals	Electro Fishing	**4.7**	**0.5**
	Gill Netting	**9.2**	**0.5**
12. Percent anomalies		**0.0**	**5**
			26
			Poor

* Percent composition of the most abundant species

Table 7. Scoring Result for the Twelve Metrics and Overall Reservoir Fish Assemblage Index (RFAI)

Watts Bar - QA - 2000

Metric		Transition TRM 560.8 Obs	Score
A. Species richness and composition			
1. Number of species		**26**	**3**
2. Number of sunfish species		**5**	**5**
3. Number of sucker species		**3**	**1**
4. Number of intolerant species		**3**	**3**
5. Percent tolerant individuals	Electro Fishing	**53.1**	**0.5**
	Gill Netting	**10.7**	**2.5**
6. Percent dominance *	Electro Fishing	**51.2**	**1.5**
	Gill Netting	**67.6**	**0.5**
7. Number of piscivore species		**9**	**5**
B. Trophic composition			
8. Percent omnivores	Electro Fishing	**52.6**	**0.5**
	Gill Netting	**15.5**	**2.5**
9. Percent insectivores	Electro Fishing	**33.3**	**1.5**
	Gill Netting	**2.0**	**0.5**
C. Reproductive composition			
10. Number of Lithophilic spawning species		**5**	**3**
D. Fish abundance and health			
11. Average number of individuals	Electro Fishing	**28.0**	**0.5**
	Gill Netting	**59.9**	**2.5**
12. Percent anomalies		**0.3**	**5**
RFAI			**38** **Fair**

* Percent composition of the most abundant species

Appendix E.

Mean Catch Per Effort by Species For Electrofishing and Gill Netting Efforts at Each Location in 2000 Including Both Regular and Repeat QA Sampling

Appendix E.

Mean Catch Per Effort by Species
For Electrofishing and Gill Netting Efforts
at Each Location in 2000 for Regular Sampling

Table 1. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Apalachia - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Names	Forebay HiRM 67.0	Forebay HiRM 67.0	Forebay HiRM 67.0
Gizzard shad	0.47	2.77	0.70
Common carp	0.07	0.40	0.30
Channel catfish	0.13	0.79	0.50
Flathead catfish	0.13	0.79	.
Redbreast sunfish	0.53	3.16	.
Green sunfish	0.33	1.98	.
Bluegill	0.47	2.77	0.30
Smallmouth bass	.	.	0.60
Spotted bass	0.33	1.98	0.20
Largemouth bass	0.67	3.95	0.40
White crappie	.	.	0.10
Black crappie	.	.	0.10
Yellow perch	.	.	0.10
Walleye	.	.	0.50
Blueback herring	.	.	0.20
Total	3.13	18.59	4
Number Samples	15		10
Number Collected	47		40
Species Collected	9		12

Table 2. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Beech - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Names	Forebay BRM 36.0	Forebay BRM 36.0	Forebay BRM 36.0
Gizzard shad	4.40	27.16	2.10
Common carp	.	.	0.50
Lake chubsucker	0.07	0.41	.
Channel catfish	0.60	3.70	2.80
Yellow bass	0.47	2.88	1.50
Warmouth	0.07	0.41	.
Bluegill	3.53	21.81	0.10
Longear sunfish	0.20	1.23	.
Redear sunfish	2.00	12.35	0.20
Largemouth bass	3.53	21.81	0.40
Black crappie	0.33	2.06	.
Total	15.2	93.82	7.6
Number Samples	15		10
Number Collected	228		76
Species Collected	10		7

Table 3. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Chatuge - - 2000

Common Names	Electrofishing Forebay HiRM 122.0	Electrofishing Catch Rate Per Hour Forebay HiRM 122.0	Gill Netting Forebay HiRM 122.0	Electrofishing Transition Shooting Cr 1.5	Electrofishing Catch Rate Per Hour Transition Shooting Cr 1.5	Gill Netting Transition Shooting Cr 1.5
Gizzard shad	.	.	0.20	0.27	1.56	0.80
Common carp	0.07	0.37	.	.	.	0.20
Whitetail shiner	0.07	0.37	.	0.67	3.91	.
Channel catfish	.	.	0.50	.	.	0.20
Snail bullhead	0.20	1.12	.	0.20	1.17	.
White bass	.	.	0.20	.	.	0.70
Hybrid striped x white bass	.	.	0.60	.	.	0.10
Warmouth	0.60	3.36	.	0.87	5.08	.
Nortern hog sucker	.	.	.	0.13	0.78	.
Redbreast sunfish	1.60	8.96	.	1.60	9.38	.
Bluegill	23.67	132.46	0.10	3.80	22.27	.
Redear sunfish	0.13	0.75	0.10	.	.	.
Hybrid sunfish	0.13	0.75	.	0.07	0.39	.
Smallmouth bass	.	.	0.70	0.07	0.39	.
Spotted bass	3.27	18.28	4.00	1.07	6.25	2.60
Largemouth bass	1.20	6.72	0.10	1.20	7.03	0.10
Black crappie	0.07	0.37	.	.	.	.
Walleye	.	.	1.20	.	.	1.00
Total	31.01	173.51	7.7	9.95	58.21	5.7
Number Samples	15		10	15		10
Number Collected	466		77	149		57
Species Collected	11		10	11		8

Table 4. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights

Cherokee - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Forebay HRM 53.0	Forebay HRM 53.0	Forebay HRM 53.0	Transition HRM 76.0	Transition HRM 76.0	Transition HRM 76.0
Longnose gar	.	.	0.10	.	.	0.50
Gizzard shad	4.47	24.63	1.50	11.73	65.92	2.80
Threadfin shad	*	.	.	3.13	17.60	.
Common carp	0.13	0.74	0.70	0.33	1.87	1.60
Spotfin shiner	2.93	16.18	.	0.20	1.12	0
Bluntnose minnow	0.80	4.41	.	.	.	.
River carpsucker	.	.	2.30	.	.	0.70
Quillback	.	.	2.70	.	.	2.70
Smallmouth buffalo	.	.	0.30	.	.	0.80
Golden redhorse	0.07	0.37	.	.	.	.
Blue catfish	.	.	0.10	.	.	0.10
Channel catfish	.	.	1.50	.	.	0.90
Flathead catfish	0.07	0.37	0.70	.	.	1.00
White bass	0.07	0.37	0.50	1.47	8.24	2.50
Striped bass	.	.	1.20	.	.	1.60
Bluegill	11.67	64.34	0.10	6.27	35.21	.
Smallmouth bass	0.33	1.84	0.60	0.20	1.12	0.20
Spotted bass	0.20	1.10	.	0.67	3.75	.
Largemouth bass	2.27	12.50	0.20	3.13	17.60	0.40
White crappie	.	.	.	.	.	0.10
Black crappie	1.00	5.51	0.10	1.53	8.61	1.10
Walleye	.	.	0.20	.	.	0.20
Hybrid striped x white bass	.	.	.	.	.	0.10
Rock bass	.	.	.	0.07	0.37	.
Warmouth	.	.	.	.	.	.
Green sunfish	.	.	.	0.47	2.62	.
Redear sunfish	.	.	.	0.13	0.75	.
Freshwater drum	.	.	0.20	0.07	0.37	.
Total	24.01	132.36	13	29.4	165.15	17.3
Number Samples	15		10	15		10
Number Collected	360		130	442		173
Species Collected	12		17	14		17

* Indicates only young of the year collected

Table 5. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Fontana - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Transition LTRM 81.5	Transition LTRM 81.5	Transition LTRM 81.5	Transition TKRM 3.0	Transition TKRM 3.0	Transition TKRM 3.0
Gizzard shad	0.13	0.69	2.90	.	.	3.40
Common carp	.	.	0.70	.	.	0.30
Whitetail shiner	0.07	0.35	.	.	.	.
Silver redhorse	.	.	0.80	.	.	.
Shorthead redhorse	0.20	1.04	0.10	.	.	1.10
River redhorse	.	.	0.30	0.07	0.40	.
Golden redhorse	0.20	1.04	0.20	.	.	0.60
Channel catfish	.	.	0.20	0.13	0.80	0.30
Flathead catfish	0.53	2.78	1.90	0.73	4.40	0.80
White bass	.	.	0.90	.	.	1.20
Green sunfish	3.00	15.63	.	3.60	21.60	.
Bluegill	2.27	11.81	0.10	1.13	6.80	.
Hybrid sunfish	.	.	.	0.07	0.40	.
Smallmouth bass	0.60	3.13	1.40	0.47	2.80	0.50
Spotted bass	0.07	0.35	0.10	.	.	.
Largemouth bass	1.67	8.68	1.30	0.87	5.20	0.90
Hybrid bass	0.07	0.35	.	.	.	.
White crappie	.	.	.	.	.	0.50
Black crappie	.	.	0.60	.	.	0.40
Tangerine darter	0.20	1.04	.	.	.	.
Walleye	0.13	0.69	2.20	.	.	4.20
Total	9.14	47.58	13.7	7.07	42.4	14.2
Number Samples	15		10	15		9
Number Collected	137		137	106		142
Species Collected	13		15	8		12

Table 5 Cont'. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Fontana - - 2000

Common Name	Electrofishing Forebay LTRM 62.0	Electrofishing Catch Rate Per hour Forebay LTRM 62.0	Gill Netting Forebay LTRM 62.0
Gizzard shad	.	.	0.60
Whitetail shiner	0.67	3.37	.
Silver shiner	0.53	2.69	.
Spotfin shiner	1.20	6.06	.
Golden redhorse	.	.	0.10
Channel catfish	0.13	0.67	0.20
Flathead catfish	0.27	1.35	1.00
White bass	.	.	2.20
Rock bass	0.13	0.67	.
Green sunfish	0.80	4.04	.
Bluegill	4.53	22.90	0.10
Smallmouth bass	0.87	4.38	4.20
Largemouth bass	0.33	1.68	0.40
Tangerine darter	0.20	1.01	.
Walleye	.	.	4.80
Total	9.66	48.82	13.6
Number Samples	15		10
Number Collected	145		136
Species Collected	11		9

Table 6. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Fort Loudoun - - 2000

Common Name	Electrofishing Forebay TRM 605.5	Electrofishing Catch Rate Per Hour Forebay TRM 605.5	Gill Netting Forebay TRM 605.5	Electrofishing Transition TRM 624.6	Electrofishing Catch Rate Per Hour Forebay TRM 624.6	Gill Netting Forebay TRM 624.6
Skipjack herring	.	.	5.90	.	.	1.90
Gizzard shad	11.27	56.71	2.30	7.00	34.31	1.30
Threadfin shad	*	.	.	0.07	0.33	.
Common carp	1.27	6.38	0.70	1.67	8.17	0.60
Golden shiner	.	.	.	0.07	0.33	.
Emerald shiner	.	.	.	1.20	5.88	.
Spotfin shiner	1.53	7.72	.	0.53	2.61	.
Northern hog sucker	0.40	2.01	.	0.13	0.65	0.10
Smallmouth buffalo	0.20	1.01	1.40	0.13	0.65	0.20
Black buffalo	.	.	0.10	0.13	0.65	.
Spotted sucker	0.13	0.67	0.10	0.33	1.63	.
Silver redhorse	.	.	0.50	.	.	1.10
Golden redhorse	.	.	0.10	0.07	0.33	.
Blue catfish	.	.	1.30	.	.	0.80
Channel catfish	0.13	0.67	0.40	0.27	1.31	0.20
Flathead catfish	0.07	0.34	0.50	0.27	1.31	0.80
White bass	0.13	0.67	4.60	0.13	0.65	0.30
Yellow bass	.	.	10.90	.	.	0.70
Striped bass	.	.	0.90	.	.	0.10
Warmouth	0.13	0.67	.	0.27	1.31	.
Redbreast sunfish	0.40	2.01	.	.	.	.
Green sunfish	0.73	3.69	.	0.53	2.61	.
Bluegill	18.27	91.95	0.20	14.27	69.93	0.40
Redear sunfish	.	.	.	0.27	1.31	.
Hybrid sunfish	.	.	.	0.07	0.33	.
Smallmouth bass	1.27	6.38	0.10	1.20	5.88	.
Largemouth bass	10.47	52.68	0.10	6.07	29.74	.
White crappie	0.13	0.67	.	0.13	0.65	0.20
Black crappie	0.13	0.67	0.10	0.07	0.33	.
Yellow perch	0.33	1.68	.	.	.	.
Logperch	0.20	1.01	.	0.07	0.33	.
Sauger	0.07	0.34	1.10	0.13	0.65	1.40
Freshwater drum	0.13	0.67	0.10	0.13	0.65	0.40
Brook silverside	0.67	3.36	.	1.87	9.15	.
Total	48.06	241.96	31.4	37.08	181.68	10.5
Number Samples	15		10	15		10
Number Collected	721		314	556		105
Species Collected	22		20	27		16

* Indicates only young of the year collected

Table 6 Cont'. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Fort Loudoun - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour
Common Name	Inflow TRM 652.0	Inflow TRM 652.0
American brook lamprey	0.07	0.38
Gizzard shad	4.00	22.64
Threadfin shad	*	.
Common carp	0.67	3.77
Emerald shiner	4.00	22.64
Spotfin shiner	1.33	7.55
Bluntnose minnow	0.13	0.75
Northern hog sucker	0.07	0.38
Black buffalo	0.20	1.13
Spotted sucker	0.20	1.13
Silver redhorse	0.07	0.38
Golden redhorse	0.93	5.28
Channel catfish	0.07	0.38
American eel	0.07	0.38
Yellow bass	0.07	0.38
Rock bass	0.60	3.40
Warmouth	0.13	0.75
Redbreast sunfish	0.47	2.64
Green sunfish	0.13	0.75
Bluegill	1.47	8.30
Redear sunfish	0.33	1.89
Smallmouth bass	0.47	2.64
Spotted bass	0.80	4.53
Largemouth bass	1.13	6.42
White crappie	0.07	0.38
Snubnose darter	0.07	0.38
Logperch	0.07	0.38
Freshwater drum	0.07	0.38
Brook silverside	0.07	0.38
Total	17.76	100.39
Number Samples	15	
Number Collected	266	
Species Collected	28	

* Indicates only young of the year collected

Table 7. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Guntersville - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Forebay TRM 350.0	Forebay TRM 350.0	Forebay TRM 350.0	Transition TRM 375.2	Transition TRM 375.2	Transition TRM 375.2
Spotted gar	0.33	1.99	.	0.60	3.66	.
Longnose gar	.	.	.	.	.	0.10
Skipjack herring	.	.	4.80	.	.	2.50
Gizzard shad	12.80	76.49	1.70	11.20	68.29	0.80
Threadfin shad	*	.	.	*	.	.
Common carp	0.07	0.40	0.10	0.07	0.41	0.10
Smallmouth buffalo	0.07	0.40	0.10	.	.	.
Spotted sucker	0.07	0.40	.	.	.	.
Blue catfish	.	.	0.10	.	.	.
Emerald shiner	.	.	.	6.73	41.06	.
Channel catfish	0.07	0.40	0.40	0.13	0.81	0.70
Flathead catfish	0.47	2.79	.	.	.	.
Yellow bass	.	.	0.90	.	.	4.00
Striped bass	0.13	0.80	0.30	.	.	.
Hybrid striped x white bass	.	.	1.00	.	.	.
Redbreast sunfish	.	.	.	0.13	0.81	.
Bluegill	2.40	14.34	0.10	0.53	3.25	0.20
Longear sunfish	0.27	1.59	.	.	.	.
Redear sunfish	0.60	3.59	0.20	0.47	2.85	0.40
Smallmouth bass	0.07	0.40	.	.	.	.
Spotted bass	0.27	1.59	0.70	0.07	0.41	1.40
Largemouth bass	3.40	20.32	.	3.53	21.54	0.60
Black crappie	.	.	.	.	.	0.20
White crappie	.	.	0.30	.	.	.
Yellow perch	0.07	0.40	.	0.07	0.41	.
Logperch	0.07	0.40	.	.	.	.
Sauger	0.07	0.40	1.20	.	.	1.40
Walleye	.	.	0.10	.	.	.
Freshwater drum	0.13	0.80	.	.	.	0.30
Brook silverside	3.47	20.72	.	.	.	.
Total	24.83	148.22	12	23.53	143.5	12.7
Number Samples	15		10	15		10
Number Collected	372		120	353		127
Species Collected	19		15	11		13

*-Indicates only young of the year collected

Table 7 Cont'. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Guntersville - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour
Common Name	Inflow TRM 424.0	Inflow TRM 424.0
Spotted gar	0.13	0.79
Longnose gar	1.27	7.54
Gizzard shad	12.40	73.81
Common carp	0.13	0.79
Emerald shiner	1.47	8.73
Smallmouth buffalo	1.27	7.54
Spotted sucker	0.13	0.79
Golden redhorse	0.13	0.79
Blue catfish	0.67	3.97
Channel catfish	1.00	5.95
Flathead catfish	0.07	0.40
Yellow bass	0.47	2.78
Redbreast sunfish	0.73	4.37
Bluegill	0.87	5.16
Longear sunfish	0.53	3.17
Redear sunfish	1.33	7.94
Hybrid sunfish	0.07	0.40
Spotted bass	1.20	7.14
Largemouth bass	1.33	7.94
Sauger	0.13	0.79
Freshwater drum	0.27	1.59
Total	25.6	152.38
Number Samples	15	
Number Collected	384	
Species Collected	21	

Table 8. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Hiwassee - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Forebay HiRM 77.0	Forebay HiRM 77.0	Forebay HiRM 77.0	Transition HiRM 85.0	Transition HiRM 85.0	Transition HiRM 85.0
Muskellunge	.	.	.	.	.	0.10
Gizzard shad	0.07	0.38	0.30	.	.	0.60
Common carp	.	.	0.40	.	.	0.30
Whitetail shiner	0.53	3.04	.	0.07	0.35	.
Northern hog sucker	0.33	1.90	0.10	0.47	2.48	.
Silver redhorse	.	.	0.60	.	.	1.80
Shorthead redhorse	.	.	.	0.07	0.35	.
River redhorse	.	.	.	0.20	1.06	.
Golden redhorse	.	.	0.10	.	.	0.20
Sicklefin redhorse	0.13	0.76	0.30	0.13	0.71	0.30
Channel catfish	.	.	0.50	.	.	0.30
Flathead catfish	.	.	0.20	0.33	1.77	.
White bass	.	.	0.10	.	.	0.30
Redbreast sunfish	0.60	3.42	.	0.13	0.71	.
Green sunfish	2.13	12.17	.	1.73	9.22	.
Bluegill	3.60	20.53	.	4.33	23.05	.
Smallmouth bass	0.60	3.42	0.20	0.73	3.90	1.20
Spotted bass	1.00	5.70	.	1.93	10.28	0.20
Largemouth bass	0.33	1.90	.	1.00	5.32	.
Walleye	.	.	2.00	.	.	1.80
Total	9.32	53.22	4.8	11.12	59.2	7.1
Number Samples	15		10	15		10
Number Collected	140		48	167		71
Species Collected	10		11	12		11

Table 9. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Melton Hill - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Forebay CRM 24.0	Forebay CRM 24.0	Forebay CRM 24.0	Transition CRM 45.0	Transition CRM 45.0	Transition CRM 45.0
Spotted gar	.	.	.	0.07	0.36	.
Longnose gar	.	.	0.20	.	.	.
Skipjack herring	.	.	1.00	.	.	0.70
Gizzard shad	1.80	9.22	2.80	8.73	46.95	1.40
Threadfin shad	*	.	.	*	.	.
Brown trout	.	.	.	.	.	0.10
Hybrid shad	0.13	0.68	.	.	.	.
Common carp	1.07	5.46	0.50	1.40	7.53	0.40
Spotfin shiner	0.13	0.68	.	0.73	3.94	.
Bluntnose minnow	0.47	2.39	.	0.13	0.72	.
River carpsucker	.	.	1.00	0.13	0.72	1.00
Quillback	.	.	1.40	0	.	1.00
Northern hog sucker	0.07	0.34	.	.	.	.
Smallmouth buffalo	0.13	0.68	0.30	0	.	0.40
Black buffalo	0.33	1.71	0.40	0	.	0.20
Spotted sucker	.	.	0.10	0.27	1.43	0.10
Silver redhorse	.	.	0.70	.	.	0.20
Golden redhorse	0.07	0.34	.	0.40	2.15	0.10
Blue catfish	.	.	0.10	.	.	.
Channel catfish	0.07	0.34	0.40	0.13	0.72	1.70
Flathead catfish	.	.	0.20	.	.	.
White bass	0.73	3.75	1.80	0	0	0.90
Yellow bass	0.07	0.34	3.00	0.07	0.36	1.10
Striped bass	.	.	0.70	.	.	0.10
Hybrid striped x white bass	.	.	0.20	.	.	.
Rock bass	0.07	0.34	.	.	.	.
Warmouth	0.13	0.68	.	0.53	2.87	.
Redbreast sunfish	0.40	2.05	.	0.80	4.30	.
Green sunfish	1.00	5.12	.	0.20	1.08	.
Bluegill	17.73	90.78	.	4.93	26.52	0.20
Redear sunfish	0.33	1.71	.	0.53	2.87	.
Hybrid sunfish	0.07	0.34	.	0.13	0.72	.
Smallmouth bass	0.67	3.41	0.10	0.27	1.43	.
Spotted bass	.	.	.	0.53	2.87	.
Largemouth bass	22.80	116.72	.	5.87	31.54	.
White crappie	0.33	1.71	.	0.27	1.43	0.10
Black crappie	0.27	1.37	.	0.13	0.72	.
Snubnose darter	.	.	.	0.07	0.36	.
Yellow perch	.	.	.	0.07	0.36	0.20
Logperch	0.07	0.34	.	0.20	1.08	.
Sauger	.	.	0.10	.	.	0.20
Walleye	.	.	0.40	.	.	.
Freshwater drum	.	.	0.20	0.07	0.36	1.20
Brook silverside	0.80	4.10	.	0.13	0.72	.
Total	49.74	254.6	15.6	26.79	144.11	11.3
Number Samples	15		10	15		10
Number Collected	746		156	402		113
Species Collected	25		21	26		20

* Indicates only young of year collected

Table 9. Cont'. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Melton Hill - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour
Common Name	Inflow CRM 66.0	Inflow CRM 66.0
Gizzard shad	4.67	24.91
Rainbow trout	0.20	1.07
White sucker	0.33	1.78
Northern hog sucker	0.13	0.71
Spotted sucker	0.33	1.78
Black redhorse	0.07	0.36
Golden redhorse	0.67	3.56
White bass	0.20	1.07
Striped bass	0.07	0.36
Redbreast sunfish	0.13	0.71
Green sunfish	0.07	0.36
Bluegill	0.73	3.91
Redear sunfish	0.07	0.36
Largemouth bass	0.07	0.36
White crappie	0.13	0.71
Black crappie	0.27	1.42
Banded sculpin	0.07	0.36
Total	8.21	43.79
Number Samples	15	
Number Collected	123	
Species Collected	17	

Table 10. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Normandy - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Forebay DRM 249.5	Forebay DRM 249.5	Forebay DRM 249.5
Gizzard shad	10.60	63.35	1.00
Threadfin shad	*	.	.
Central stoneroller	0.07	0.40	.
Common carp	1.00	5.98	2.00
Spotfin shiner	0.20	1.20	.
Northern hog sucker	0.07	0.40	.
Spotted sucker	0.27	1.59	.
Silver redhorse	.	.	0.70
Black redhorse	.	.	0.20
Golden redhorse	.	.	0.20
Blue catfish	0	0	0.20
Channel catfish	0.07	0.40	0.60
Flathead catfish	0.07	0.40	1.60
White bass	.	.	0.40
Rock bass	.	.	0.30
Green sunfish	0.13	0.80	.
Bluegill	1.60	9.56	0.20
Longear sunfish	1.93	11.55	.
Redear sunfish	0.07	0.40	.
Smallmouth bass	0.27	1.59	3.10
Spotted bass	0.60	3.59	.
Largemouth bass	0.73	4.38	1.60
White crappie	.	.	1.20
Black crappie	.	.	0.30
Sauger	.	.	0.10
Walleye	.	.	0.10
Total	17.68	105.59	13.8
Number Samples	15		10
Number Collected	265		138
Species Collected	15		17

* Indicates only young of year collected

Table 11. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Pickwick - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting	Electrofishing	Electrofishing Catch Rate Per Hour
Common Name	Embayment BCM 8.4	Embayment BCM 8.4	Embayment BCM 8.4	Inflow TRM 259.9	Inflow TRM 259.9
Spotted gar	.	.	0.10	0.07	0.40
Skipjack herring	.	.	2.10	.	.
Gizzard shad	12.80	80.33	6.60	1.40	8.47
Threadfin shad	.	.	22.30	.	.
Common carp	0.40	2.51	0.10	1.67	10.08
Emerald shiner	.	.	.	.	.
Spotfin shiner	.	.	.	0.07	0.40
River carpsucker	.	.	.	0.07	0.40
Northern hog sucker	0.47	2.93	.	0.20	1.21
Smallmouth buffalo	0.13	0.84	0.30	0.40	2.42
Spotted sucker	1.87	11.72	1.00	1.13	6.85
Silver redhorse	0.33	2.090	.	0.40	2.42
River redhorse	0.80	5.02	.	1.00	6.05
Golden redhorse	0.27	1.26	.	1.00	6.05
Blue catfish	.	.	0.30	0.47	2.82
Channel catfish	0.13	0.84	0.30	1.07	6.45
Flathead catfish	.	.	0.10	0.20	1.21
White bass	0.20	1.26	.	0.67	4.03
Yellow bass	0.60	3.77	.50	2.47	14.92
Striped bass	.	.	0.10	1.00	6.05
Rock bass	.	.	.	0.13	0.81
Green sunfish	.	.	.	0.07	0.40
Warmouth	0.70	0.42	.	.	.
Bluegill	1.00	6.28	.	3.53	21.37
Longear sunfish	0.60	3.77	.	1.60	9.68
Redear sunfish	0.27	1.67	.	1.07	6.45
Smallmouth bass	0.40	2.51	.	0.40	2.42
Spotted bass	0.07	0.42	.	1.00	6.05
Largemouth bass	1.33	8.37	.	1.27	7.66
Logperch	0.20	1.26	.	0.27	1.61
Sauger	0.07	0.42	0.20	0.13	0.81
Freshwater drum	0.60	3.77	1.40	2.13	12.90
Brook silverside	0.13	0.84	.	.	.
Total	22.81	143.13	35.5	24.89	150.39
Number Samples	15		10	15	
Number Collected	342		355	373	
Species Collected	23		15	28	

Table 12. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Pickwick - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Forebay TRM 207.3	Forebay TRM 207.3	Forebay TRM 207.3	Forebay TRM 230.0	Forebay TRM 230.0	Forebay TRM 230.0
Spotted gar	0.07	0.41	.	0.13	0.84	.
Longnose gar	.	.	.	.	.	0.20
Skipjack herring	.	.	3.20	.	.	2.30
Gizzard shad	18.00	111.11	5.30	4.07	25.52	2.30
Threadfin shad	.	.	2.00	.	.	0.40
Common carp	0.13	0.82	.	.	.	0.30
Emerald shinner	.	.	.	13.67	85.77	.
Spotfin shinner	.	.	.	0.13	0.84	.
River carpsucker	.	.	.	0.13	0.84	.
Northern hog sucker	.	.	.	0.13	0.84	.
Smallmouth buffalo	0.07	0.41	0	0.13	0.84	0.50
Spotted sucker	0.73	4.53	0.20	0.53	3.35	.
Silver redhorse	.	.	.	.	.	0.50
Shorthead redhorse	.	.	0.10	.	.	0.40
River redhorse	.	.	.	.	.	.
Golden redhorse	0.07	0.41	.	.	.	0.40
Blue catfish	.	.	0.80	.	.	1.90
Channel catfish	0.07	0.41	0.40	0.40	2.51	0.30
Flathead catfish	0.07	0.41	0.70	0.07	0.42	0.40
White bass	.	.	.	.	.	1.70
Yellow bass	.	.	0.10	.	.	0.60
Striped bass	.	.	0.30	.	.	.
Hybrid striped x white bass	.	.	0.10	.	.	0.60
Warmouth	.	.	.	.	.	.
Green sunfish	0.20	1.23	.	.	.	.
Bluegill	1.47	9.05	.	0.53	3.35	0.10
Longear sunfish	2.53	15.64	.	0.07	0.42	.
Redear sunfish	0.67	4.12	.	0.33	2.09	0.30
Smallmouth bass	0.20	1.23	0.30	0.13	0.84	0.40
Spotted bass	0.13	0.82	.	.	.	1.10
Largemouth bass	0.93	5.76	0.10	1.07	6.69	0.30
White crappie	.	.	.	.	.	.
Yellow perch	0.07	0.41	.	0.13	0.84	.
Logperch	0.33	2.06	.	0.27	1.67	.
Sauger	.	.	0.30	.	.	0.70
Freshwater drum	0.60	3.70	0.10	0.27	1.67	0.40
Total	26.34	162.53	14	22.19	139.34	16.1
Number Samples	15		10	15		10
Number Collected	395		140	333		161
Species Collected	18		15	18		22

Table 13. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

South Holston - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Forebay SFHR 51.0	Forebay SFHR 51.0	Forebay SFHR 51.0	Forebay SFHR 62.5	Forebay SFHR 62.5	Forebay SFHR 62.5
Gizzard shad	2.27	13.88	1.00	4.93	27.51	3.90
Threadfin shad	.	.	.	.	.	0.10
Common carp	0.27	1.63	0.70	0.33	1.86	1.60
Silver shiner	.	.	.	0.47	2.60	.
Spotfin shiner	2.93	17.96	.	5.33	29.74	.
River carpsucker	.	.	.	.	.	0.40
Bluntnose minnow	0.40	2.45	.	.	.	.
Quillback	.	.	0.50	.	.	1.20
Northern hog sucker	0.07	0.41	.	0.27	1.49	.
River redhorse	0.20	1.22	0.10	0.47	2.60	0.20
Black redhorse	.	.	.	0.20	1.12	0.10
Golden redhorse	.	.	.	0.07	0.37	.
Channel catfish	.	.	0.30	.	.	0.60
Flathead catfish	0.13	0.82	0.40	.	.	0.80
White bass	.	.	0.20	.	.	0.10
Rock bass	0.87	5.31	0.40	.	.	.
White bass	.	.	.	.	.	0.10
Warmouth	0.20	1.22	.	0.13	0.74	.
Bluegill	8.47	51.84	0.10	7.73	43.12	0.30
Smallmouth bass	1.87	11.43	1.10	2.07	11.52	0.80
Largemouth bass	0.07	0.41	.	0.53	2.97	0.10
Black crappie	.	.	0.40	.	.	0.40
Walleye	.	.	4.80	0.07	0.37	6.60
Total	17.75	108.58	10	22.67	126.38	17.2
Number Samples	15		10	15		10
Number Collected	266		100	340		172
Species Collected	12		12	14		15

Table 14. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Tims Ford - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Forebay ERM 135.05	Forebay ERM 135.05	Forebay ERM 135.05	Transition ERM 150.0	Transition ERM 150.0	Transition ERM 150.0
Longnose gar	.	.	0.60	.	.	.
Gizzard shad	0.93	5.65	0.20	0.47	2.82	4.40
Threadfin shad	*	.	.	*	.	.
Common carp	0.40	2.42	0.30	0.93	5.65	0.90
Spotfin shiner	0.07	0.40	.	0.47	2.82	.
Quillback	.	.	0.30	.	.	1.50
Smallmouth buffalo	.	.	0.70	.	.	0.90
Black redhorse	.	.	0.10	.	.	0.10
Golden redhorse	.	.	.	0.07	0.40	.
Channel catfish	0.07	0.40	0.20	.	.	0.20
Flathead catfish	0.20	1.21	1.30	0.07	0.40	0.40
White bass	.	.	0.30	.	.	.
Yellow bass	.	.	0.30	.	.	2.70
Striped bass	.	.	0.20	.	.	0.90
Green sunfish	0.07	0.40	.	0.07	0.40	.
Bluegill	1.93	11.69	.	3.13	18.95	.
Longear sunfish	0.27	1.61	.	0.33	2.02	0.40
Smallmouth bass	0.27	1.61	0.10	.	.	.
Spotted bass	0.20	1.21	.	.	.	.
Largemouth bass	0.33	2.02	0.10	0.80	4.84	0.40
White crappie	.	.	.	.	.	0.10
Black crappie	0.80	4.84	.	0.07	0.40	.
Sauger	.	.	0.10	.	.	.
Walleye	.	.	0.30	0.07	0.40	0.50
Freshwater drum	.	.	.	0.07	0.40	.
Total	5.54	33.46	5.1	6.55	39.5	13.4
Number Samples	15		10	15		10
Number Collected	83		51	98		134
Species Collected	12		15	12		13

* Indicates only young of year collected

Table 15. Species Listing and Catch per unit Effort During Fall Electrofishing and Gillnetting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Watauga - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Nmae	Forebay WRM 37.7	Forebay WRM 37.7	Forebay WRM 37.7	Transition WRM 45.5	Transition WRM 45.5	Transition WRM 45.5
Alewife	.	.	.	.	.	.
Gizzard shad	3.73	22.13	0.60	9.67	57.77	0.60
Brown trout	.	.	.	.	.	0.10
Common carp	0.20	1.19	0.10	0.80	4.78	0.40
Spotfin shiner	2.20	13.04	.	3.60	21.51	.
Bluntnose minnow	3.00	17.79	.	5.40	32.27	.
River redhorse	.	.	.	0.07	0.40	.
Black redhorse	.	.	.	0.13	0.80	0.10
Golden redhorse	.	.	.	0.07	0.40	0.10
Channel catfish	0.07	0.40	0.10	0.07	0.40	0.30
Flathead catfish	.	.	0.30	0.07	0.40	0.20
Rock bass	0.47	2.77	0.20	1.13	6.77	0.20
Bluegill	12.47	73.91	.	10.33	61.75	.
Smallmouth bass	1.40	8.30	1.20	3.33	19.92	1.30
Spotted bass	0.13	0.79	0.10	0.33	1.99	0.10
Largemouth bass	0.93	5.53	0.20	0.40	2.39	.
Black crappie	0.40	2.37	.	.	.	.
Freshwater drum	.	.	.	.	.	0.10
Walleye	0.07	0.40	6.10	0.20	1.20	7.70
Total	25.07	148.62	8.9	35.6	212.75	11.2
Number Samples	15		10	15		10
Number Collected	376		89	534		112
Species Collected	12		9	15		12

Table 16. Species Listing and Catch per unit Effort During Fall Electrofishing and Gillnetting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Watts Bar - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Electrofishing	Electrofishing Catch Rate Per Hour
Common Name	Inflow CRM 22.0	Inflow CRM 22.0	Inflow TRM 601.0	Inflow TRM 601.0
Spotted gar	.	.	0.07	0.35
Longnose gar	.	.	0.07	0.35
Gizzard shad	11.33	64.89	10.00	52.08
Threadfin shad	0.07	0.38	0.07	0.35
Common carp	0.07	0.38	0.67	3.47
Emerald shiner	.	.	1.93	10.07
Bluntnose minnow	1.20	6.87	.	.
Spotfin shiner	.	.	1.20	6.25
Northern hog sucker	0.07	0.38	0.13	0.69
Smallmouth buffalo	.	.	0.33	1.74
Spotted sucker	0.47	2.67	0.47	2.43
River redhorse	.	.	0.27	1.39
Black redhorse	0.47	2.67	0.33	1.74
Golden redhorse	0.27	1.53	0.40	2.08
Channel catfish	.	.	0.33	1.74
Flathead catfish	0.07	0.38	.	.
White bass	0.33	1.91	0.33	1.74
Yellow bass	0.40	2.29	0.67	3.47
Striped bass	0.20	1.15	0.33	1.74
Rock bass	0.27	1.53	0.13	0.69
Warmouth	.	.	0.13	0.69
Redbreast sunfish	.	.	0.60	3.13
Green sunfish	0.07	0.38	0.47	2.43
Bluegill	1.20	6.87	5.87	30.56
Redear sunfish	0.27	1.53	1.60	8.33
Hybrid sunfish	.	.	0.07	0.35
Smallmouth bass	0.07	0.38	0.60	3.13
Spotted bass	.	.	0.73	3.82
Largemouth bass	0.53	3.05	1.40	7.29
White crappie	0.27	1.53	1.00	5.21
Black crappie	.	.	2.60	13.54
Yellow perch	0.40	2.29	0.20	1.04
Logperch	0.07	0.38	0.07	0.35
Sauger	0.07	0.38	0.13	0.69
Freshwater drum	0.07	0.38	0.40	2.08
Brook silverside	.	.	0.13	0.69
Total	18.24	104.2	33.73	175.7
Number Samples	15		15	
Number Collected	273		506	
Species Collected	23		34	

Table 17. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Watts Bar - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Forebay TRM 531.0	Forebay TRM 531.0	Forebay TRM 531.0	Transition TRM 560.8	Transition TRM 560.8	Transition TRM 560.8
Spotted gar	.	.	.	0.07	0.34	0
Longnose gar	.	.	.	.	.	0.10
Skipjack herring	.	.	0.50	.	.	4.30
Gizzard shad	5.27	27.15	10.50	7.20	37.24	4.70
Threadfin shad	.	.	0.10	.	.	1.50
Common carp	0.73	3.78	0.90	0.40	2.07	0.40
Golden shiner	0.33	1.72	.	0.07	0.34	.
Emerald shiner	.	.	.	3.80	19.66	.
Spotfin shiner	4.40	22.68	.	4.60	23.79	.
Steelcolor shiner	0.07	0.34	.	.	.	.
Striped shiner	0.07	0.34	.	.	.	.
Bluntnose minnow	0.60	3.09	.	0.87	4.48	.
River carpsucker	.	.	.	.	.	0.20
Quillback	.	.	.	0.07	0.34	.
Smallmouth buffalo	0.07	0.34	0.30	.	.	.
Bigmouth buffalo	0.07	0.34	.	.	.	.
Black buffalo	.	.	0.10	.	.	.
Spotted sucker	0.40	2.06	1.00	.	.	0.40
Black redhorse	0.07	0.34	.	.	.	.
Blue catfish	.	.	0.80	.	.	.
Channel catfish	0.13	0.69	0.80	0.07	0.34	0.60
Flathead catfish	0.40	2.06	1.50	0.13	0.69	0.70
White bass	.	.	0.20	0.13	0.69	.
Yellow bass	.	.	10.80	0.07	0.34	6.20
Striped bass	.	.	0.40	.	.	.
Hybrid striped x white bass	.	.	0.30	.	.	.
Warmouth	0.20	1.03	.	0.33	1.72	.
Redbreast sunfish	2.33	12.03	.	0.20	1.03	.
Green sunfish	1.40	7.22	.	0.53	2.76	.
Bluegill	21.93	113.06	0.10	17.00	87.93	0.10
Longear sunfish	.	.	.	0.40	2.07	.
Redear sunfish	2.93	15.12	.	1.67	8.62	.
Smallmouth bass	1.13	5.84	.	1.47	7.59	.
Spotted bass	1.07	5.50	.	0.20	1.03	.
Largemouth bass	1.00	5.15	1.30	5.13	26.55	0.30
White crappie	.	.	2.00	0.07	0.34	0.60
Black crappie	0.47	2.41	0.20	0.13	0.69	.
Sauger	.	.	0.40	.	.	1.10
Logperch	.	.	.	0.07	0.34	
Freshwater drum	0.33	1.72	1.80	0.53	2.76	0.30
Brook silverside	1.60	8.25	.	2.27	11.72	.
Total	47	242.26	34	48.14	248.92	21.7
Number Samples	15		10	15		10
Number Collected	705		340	722		217
Species Collected	24		20	28		17

Table 18. Species Listing and Catch per unit Effort During Fall Electrofishing and Gillnetting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Wilson - - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting	Electrofishing	Electrofishing Catch Rate Per Hour
Common Name	Forebay TRM 260.8	Forebay TRM 260.8	Forebay TRM 260.8	Inflow TRM 274.0	Inflow TRM 274.0
Spotted gar	0.93	5.56	.	.	.
Longnose gar	0.07	0.40	.	.	.
Skipjack herring	.	.	4.90	.	.
Gizzard shad	6.87	40.87	2.70	23.07	137.85
Threadfin shad	.	.	3.00	*	.
Emerald shiner	.	.	.	3.33	19.92
Smallmouth buffalo	.	.	.	0.07	0.40
Spotted sucker	0.07	0.40	.	0.40	2.39
River redhorse	0.13	0.79	.	0.53	3.19
Golden redhorse	.	.	.	0.33	1.99
Blue catfish	.	.	0.50	0.07	0.40
Channel catfish	0.47	2.78	.	0.33	1.99
Flathead catfish	.	.	0.50	.	.
White bass	0.13	0.79	0.10	.	.
Yellow bass	.	.	0.20	.	.
Striped bass	0.07	0.40	.	.	.
Hybrid striped x white bass	.	.	0.10	.	.
Green sunfish	0.07	0.40	.	.	.
Bluegill	2.67	15.87	0.10	2.07	12.35
Longear sunfish	0.20	1.19	.	0.80	4.78
Redear sunfish	0.60	3.57	.	0.47	2.79
Smallmouth bass	1.40	8.33	0.10	1.27	7.57
Spotted bass	.	.	0.90	.	.
Largemouth bass	1.40	8.33	0.30	0.93	5.58
Freshwater drum	0.60	3.57	0.30	1.20	7.17
Brook silverside	3.33	19.84	.	5.00	29.88
Total	19.01	113.09	13.7	39.87	238.25
Number Samples	15		10	15	
Number Collected	285		137	598	
Species Collected	16		13	15	

* Indicates only young of year collected

Appendix E.

Mean Catch Per Effort by Species
For Electrofishing and Gill Netting Efforts
at Each Location in 2000 for Repeat QA Sampling

Table 1. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Chatuge - QA - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Names	Forebay HiRM 122.0	Forebay HiRM 122.0	Forebay HiRM 122.0
Gizzard shad	.	.	1.00
Common carp	.	.	0.10
Channel catfish	0.07	0.44	0.40
Flathead catfish	.	.	0.10
Redbreast sunfish	0.33	2.19	.
Bluegill	2.40	15.79	.
Redear sunfish	0.07	0.44	.
Spotted bass	1.87	12.28	1.30
Largemouth bass	0.60	3.95	.
Walleye	.	.	0.30
Total	5.34	35.09	3.2
Number Samples	15		10
Number Collected	80		32
Species Collected	6		6

Table 2. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Guntersville - QA - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour
Common Name	Inflow TRM 424.0	Inflow TRM 424.0
Longnose gar	0.33	1.89
Gizzard shad	2.07	11.70
Emerald shiner	4.00	22.64
Spotfin shiner	1.07	6.04
Channel shiner	1.87	10.57
Smallmouth buffalo	0.07	0.38
Black buffalo	0.40	2.26
Spotted sucker	0.33	1.89
Shorthead redhorse	0.07	0.38
Black redhorse	0.13	0.75
Golden redhorse	0.13	0.75
Blue catfish	1.27	7.17
Channel catfish	1.53	8.68
White bass	0.07	0.38
Yellow bass	1.73	9.81
Redbreast sunfish	4.07	23.02
Green sunfish	0.47	2.64
Bluegill	6.27	35.47
Longear sunfish	2.87	16.23
Redear sunfish	2.40	13.58
Spotted bass	4.93	27.92
Largemouth bass	1.53	8.68
Black crappie	0.13	0.75
Logperch	1.07	6.04
Sauger	0.07	0.38
Freshwater drum	0.20	1.13
Brook silverside	0.20	1.13
Inland silverside	0.07	0.38
Total	39.35	222.64
Number Samples	15	
Number Collected	590	
Species Collected	28	

Table 3. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Hiwassee - QA- 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Transition HiRM 85.0	Transition HiRM 85.0	Transition HiRM 85.0
Gizzard shad	.	.	0.50
Common carp	.	.	0.20
Northern hog sucker	0.07	0.40	0
Silver redhorse	.	.	0.30
Black redhorse	.	.	0.10
Golden redhorse	0.07	0.40	0.70
Channel catfish	.	.	0.20
Flathead catfish	.	.	0.40
White bass	.	.	0.30
Green sunfish	0.20	1.20	.
Bluegill	0.67	4.00	.
Smallmouth bass	0.27	1.60	0.60
Spotted bass	1.00	6.00	0.10
Largemouth bass	0.67	4.00	.
Walleye	.	.	1.00
Total	2.95	17.6	4.4
Number Samples	15		10
Number Collected	44		44
Species Collected	7		11

Table 4. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Pickwick - QA - 2000

	Electofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Forebay TRM 207.3	Forebay TRM 207.3	Forebay TRM 207.3
Skipjack herring	.	.	2.70
Gizzard shad	10.33	59.62	5.10
Threadfin shad	2.53	14.62	2.60
Central stoneroller	0.07	0.38	.
Common carp	0.20	1.15	.
Emerald shiner	0.27	1.54	.
Spotfin shiner	0.13	0.77	.
Northern hog sucker	0.07	0.38	.
Smallmouth buffalo	.	.	0.10
Bigmouth buffalo	0.07	0.38	.
Spotted sucker	0.73	4.23	0.30
Blue catfish	.	.	0.10
Channel catfish	0.40	2.31	0.60
Flathead catfish	1.80	10.38	0.10
Yellow bass	0.13	0.77	0.60
Striped bass	.	.	0.10
Green sunfish	0.40	2.31	.
Bluegill	3.73	21.54	.
Longear sunfish	10.47	60.38	.
Redear sunfish	0.53	3.08	0.10
Smallmouth bass	1.20	6.92	0.10
Spotted bass	0.20	1.15	.
Largemouth bass	0.80	4.62	.
White crappie	.	.	0.10
Yellow perch	0.07	0.38	.
Logperch	0.27	1.54	.
Sauger	0.07	0.38	0.40
Freshwater drum	1.07	6.15	0.20
Inland silverside	5.53	31.92	.
Totals	41.07	236.9	13.2
Number Samples	15		10
Number Fish Collected	617		132
Number Species Collected	24		15

Table 5. Species Listing and Catch per unit Effort During Fall Electrofishing and Gill netting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Tims Ford - QA - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Forebay ERM 135.05	Forebay ERM 135.05	Forebay ERM 135.05
Longnose gar	0.07	0.37	2.40
Gizzard shad	.	.	0.40
Common carp	0.40	2.24	0.10
Spotfin shiner	2.80	15.67	.
River carpsucker	.	.	0.20
Quillback	.	.	0.20
Smallmouth buffalo	.	.	0.70
Channel catfish	0.13	0.75	0.40
Flathead catfish	0.27	1.49	0.80
White bass	.	.	0.10
Yellow bass	.	.	0.50
Striped bass	.	.	0.50
Rock bass	.	.	0.10
Warmouth	0.20	1.12	.
Green sunfish	1.33	7.46	.
Bluegill	37.67	210.82	.
Longear sunfish	5.93	33.21	.
Hybrid sunfish	0.07	0.37	.
Smallmouth bass	0.53	2.99	.
Spotted bass	0.40	2.24	.
Largemouth bass	0.40	2.24	.
Black crappie	0.40	2.24	.
Walleye	.	.	0.60
Total	50.6	283.21	7
Number Samples	15		10
Number Collected	759		70
Species Collected	14		13

Table 6. Species Listing and Catch per unit Effort During Fall Electrofishing and Gillnetting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Watauga - QA - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Nmae	Forebay WRM 37.7	Forebay WRM 37.7	Forebay WRM 37.7
Gizzard shad	3.47	20.80	0.30
Rainbow trout	0.07	0.40	.
Common carp	.	.	0.30
Channel catfish	.	.	0.10
Flathead catfish	.	.	0.40
Rock bass	.	.	0.20
Rock bass	0.13	0.80	.
Bluegill	0.33	2.00	.
Smallmouth bass	0.27	1.60	1.80
Largemouth bass	0.33	2.00	.
Walleye	0.13	0.80	6.00
Total	4.73	28.4	9.2
Number Samples	15		10
Number Collected	71		92
Species Collected	7		7

Table 7. Species Listing and Catch per unit Effort During Fall Electrofishing and Gillnetting (Electrofishing Effort = 300 Meters of Shoreline and Gill netting Effort = net-nights)

Watts Bar - QA - 2000

	Electrofishing	Electrofishing Catch Rate Per Hour	Gill Netting
Common Name	Transition TRM 560.8	Transition TRM 560.8	Transition TRM 560.8
Skipjack herring	.	.	1.20
Gizzard shad	14.33	87.40	5.90
Threadfin shad	.	.	0.10
Common carp	0.33	2.03	0.50
Emerald shiner	2.40	14.63	.
Smallmouth buffalo	0.07	0.41	0.50
Spotted sucker	0.20	1.22	0.60
Golden redhorse	0.07	0.41	.
Blue catfish	.	.	2.10
Channel catfish	.	.	0.30
Flathead catfish	.	.	0.50
White bass	0.07	0.41	40.50
Yellow bass	.	.	3.10
Striped bass	.	.	0.90
Redbreast sunfish	0.13	0.81	.
Green sunfish	0.07	0.41	.
Bluegill	2.93	17.89	0.10
Longear sunfish	0.13	0.81	.
Redear sunfish	1.80	10.98	.
Smallmouth bass	1.53	9.35	.
Largemouth bass	2.20	13.41	.
White crappie	.	.	0.70
Black crappie	0.13	0.81	.
Sauger	.	.	2.40
Freshwater drum	0.27	1.63	0.50
Brook silverside	1.33	8.13	.
Total	27.99	170.74	59.9
Number Samples	15		10
Number Collected	420		599
Species Collected	17		16

RESPONSE TO NRC ENVIRONMENTAL REPORT INFORMATION NEEDS

ALTERNATIVES (Alt)

This enclosure provides the BLN response to an NRC information need related to the review of Alternatives (Alt) in the Bellefonte Nuclear Plant, Units 3 and 4 (BLN) Environmental Report (ER).

Updated Status of "Alt" Information Needs

NRC Information Need Number	Status
• Alt-23	Response provided in this enclosure.

NRC Review of the BLN Environmental Report

NRC Information Needs - BLN ER Site Audit Exit Meeting

NRC Environmental Category: ALTERNATIVES

During the BLN Environmental Report site audit exit meeting on April 4, 2008, the NRC staff identified the following information need:

Alt-23: Were any previous environmental studies performed on the Murphy Hill site when it was being considered as the site of a coal gasification plant? If so, please provide formal reference.

BLN INFORMATION NEED: Alt-23

BLN RESPONSE:

During the week of March 31 through April 4, 2008, the NRC staff conducted an audit of the BLN site, including a review of the documentation supporting the BLN ER. At the site audit exit meeting, NRC alternative site reviewers identified additional documentation needs. The document requested for Information Need Alt-23 is the Final Environmental Impact Statement for the coal gasification project at the Murphy Hill site. Based on discussions with the NRC's reviewers for alternative sites, and subsequent confirmation at audit exit meeting, TVA understands that by providing this document, the NRC staff considers this comment resolved and no additional documentation is required in response to this information request.

ASSOCIATED BLN COL APPLICATION REVISIONS:

None.

ATTACHMENTS:

The following document is provided as Attachment A to this enclosure:

A. Tennessee Valley Authority, Final Environmental Impact Statement – Coal Gasification Project, July 1981.

Tennessee Valley Authority

Final Environmental Impact Statement
Coal Gasification Project

July 1981

TVA/ONR/PCS-81/3

Tennessee Valley Authority Final Environmental Impact Statement

COAL GASIFICATION PROJECT

United States Army Corps of Engineers
Nashville District
Cooperating Agency
Regulatory Action

July 1981

Index No. 22

ENVIRONMENTAL IMPACT STATEMENT
TVA COAL GASIFICATION PROJECT

( ) Draft (X) Final environmental impact statement prepared by the Tennessee Valley Authority (TVA) in cooperation with the U.S. Army Corps of Engineers. For additional information, contact:

Dr. M. T. El-Ashry, Assistant Manager
Natural Resources (Environment)
Tennessee Valley Authority
Natural Resources Building
Norris, Tennessee 37828
(615) 632-6450

1. (X) Administrative Action ( ) Legislative Action ( ) Information Document

2. Lead Agency - Tennessee Valley Authority

3. Cooperating Agency - U.S. Army Corps of Engineers

4. Title - TVA Coal Gasification Project

5. Abstract - TVA is proposing to cooperate in the design and construction of a commercial-scale coal gasification plant consisting of 2 modules processing about 10,000 tons of coal per day with the capability of being expanded to 4 modules at a later date. TVA commenced evaluating this proposal in 1979 using Congressionally appropriated funds. Subsequently, the U.S. Synthetic Fuels Corporation (SFC) was established and additional incentives were provided for private sector financing of synthetic fuels projects. In view of this, it now appears appropriate to seek private equity financing with assistance from the SFC, and TVA is proposing to transfer the project to the private sector if a private consortium is formed to finance, own, and operate the project. TVA would sell its interests in the project to such a private entity and act as project manager until the project was transferred to the private entity. TVA would make the land available to site the proposed facility. The private entity would assume legal ownership of the plant and all obligations for completing and operating the facility. The TVA-owned Murphy Hill site in Marshall County, Alabama, has been identified as the preferred location for the facility. The facility would process eastern, high-sulfur coal into approximately 600 million standard cubic feet per day of medium-Btu product gas. Some of this product gas would be methanated to produce synthetic natural gas to be sold to existing pipeline companies. The remainder would be used to produce methanol, other liquid chemicals or gasoline. Gas from subsequent modules might also be used as industrial fuel gas, possibly to supply dispersed electric generating fuel cells. Alternative sites and alternative gasification technologies which would effectively demonstrate coal gasification to produce a medium-Btu gas are evaluated.

6. The draft environmental impact statement (DEIS) was sent to the Environmental Protection Agency (EPA) and made available to the public on August 1, 1980. On June 1, 1981, a supplement to the DEIS was sent to all agencies and persons who commented on the DEIS or were otherwise known to be interested in the proposal. A notice of availability of the supplement was published in the Federal Register on June 12, 1981. The final environmental impact statement (FEIS) was sent to EPA and made available to the public on July 24, 1981.

7. No action on this matter will be taken until 30 days after the notice of availability for the FEIS has been published in the Federal Register .

8. Volume 1 comprises the body of the FEIS, summaries of the public comments, and responses thereto. Volume 2 presents more detailed discussions of the affected environments and environmental consequences. Volume 3 contains all of the public comments received on the DEIS and on the DEIS supplement. Additional copies of this FEIS may be obtained by writing to Dr. M. T. El-Ashry or by phoning TVA's Citizen Action Office on their toll-free line, 1-800-362-9250 (in Tennessee) or 1-800-251-9242 (in Alabama, Georgia, Kentucky, Missippi, North Carolina, Virginia, Missouri, and Arkansas).

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EXECUTIVE SUMMARY

COAL GASIFICATION PROJECT
ENVIRONMENTAL IMPACT STATEMENT

Proposal

In 1979, the Tennessee Valley Authority (TVA) began evaluating the technical, economic, and environmental feasibility of a synthetic fuel facility in the Tennesee Valley region. Based on these studies, TVA proposed to demonstrate that a commercial-scale coal gasification plant producing medium-Btu gas (MBG) could be permitted, constructed, and operated, and the synthetic gas marketed in an environmentally and economically acceptable manner to provide a clean, coal-derived fuel or chemical feedstock. Congressional appropriations were provided to evaluate the proposal. In the summer of 1980, Congress established the U.S. Synthetic Fuels Corporation (SFC) and provided additional incentives for private sector financing and ownership of synthetic fuels projects. As a result, TVA also began considering ways to reduce Federal outlays and depend more on private sector financing for the project. In view of these developments, private sector financing with SFC financial assistance now appears to provide the most appropriate mechanism for funding the demonstration of commercial production of synthetic fuels.

TVA proposes to take a series of actions which would allow a private entity to construct and operate a commercial coal gasification plant in the Tennessee Valley. These actions include:

- preparation of the preferred Murphy Hill site, including construction of a barge slip and related facilities;
- transfer of all TVA's rights in the project to a private entity
- sale of the preferred Murphy Hill site to a private entity
- provision of continuing TVA support and cooperation to the private entity during design, permitting, construction, and operation.

TVA would be reimbursed for the Federal investment in the project.

Demonstrating this new use of one of the Tennessee Valley region's most important natural resources, coal, would make a positive contribution to our Nation's efforts to resolve the energy crisis and reduce dependence upon foreign petroleum and natural gas.

Based on TVA's evaluation, the Texaco or the Koppers-Totzek (K-T) gasification process have been identified as the preferred gasification process. Technical and environmental evaluations to date indicate that selection of either of these two processes would minimize potential health and environmental impacts. The processes also offer significant technical advantages for the gasification of eastern coals.

Although early planning efforts focused on a 4-module plant, it is now proposed to build 2 modules initially, processing approximately 10,000 tons per day of eastern high-sulfur coal into a clean product gas. The facility would have the capability of being expanded to 4-modules at a later date if it were technically and economically justified. The gas would be processed into liquid fuels and chemicals such as gasoline or methanol and into pipeline quality synthetic natural gas. Some of the gas from subsequent modules might be used as industrial fuel gas. The plant would be constructed in a stepwise manner. There would probably be at least a 2-3 year delay between the start of construction for the first 2 modules and the second 2 modules, should they be constructed. The 2-module plant, including all appurtenant facilities, is estimated to cost about $1.5 billion in 1980 dollars. The total investment in as-spent dollars, including interest during construction, is estimated to be $2.8 billion.

TVA has designated its Murphy Hill site in Marshall County, Alabama, as the preferred site. The Murphy Hill site offers environmental and economic advantages over other alternative sites considered.

The Army Corps of Engineers (Corps) is a cooperating agency in the preparation of this final environmental impact statement (FEIS). The Corps' direct involvement in the proposed action occurs in the context of the review and possible permitting of various project activities in accordance with Section 404 of the Clean Water Act and Section 10 of the River and Harbors Act. TVA has also worked closely with EPA in the preparation of the FEIS.

Alternative Gasification Processes

Coal gasification is basically a process of combining the carbon in coal with steam and oxygen to produce a product gas composed primarily of hydrogen and carbon monoxide. Town gas, once used widely in the United States and elsewhere until natural gas replaced it, was the product of a coal gasification process. Today, there are several gasification plants in operation in other countries that utilize various processes.

Coal gas presents potential hazards from fire and explosion similar to those from natural gas. In addition, the carbon monoxide (CO) content presents a potential hazard to plant workers and the public due to its toxic nature. Careful consideration of safe plant design and operation and care in pipeline routing, design, and operation can serve to minimize these hazards. TVA is considering reducing the CO content in the product gas for process and marketing considerations. This should reduce the risk of CO exposure.

One of the primary concerns associated with coal conversion processes is the presence of hazardous compounds in the wastes.

However, the application of the best available control technologies (BACT) consistent with applicable regulations should prevent the discharge or release of hazardous substances and wastes in amounts deemed unacceptable or possibly dangerous to human health and the environment.

TVA reviewed the broad spectrum of modern coal gasification processes to determine which ones might be technically ready for use in a commercial-scale plant. Five processes were deemed to be in this category and were selected for detailed evaluation--Babcock & Wilcox (B&W), K-T, Texaco, Lurgi, and the British Gas Corporations's Slagging Lurgi.

Available technical data on these processes were generally sufficient to determine their potential impacts and to compare the acceptability of the processes. However, the level of detail with respect to potential wastewater discharges and solid waste characteristics was not to the degree TVA normally prefers. To the extent possible, TVA utilized the existing data to project potential impacts. TVA collected and is presently analyzing environmental data as part of its operational readiness test program. These data will expand the effluent characterization data base and will assist in the design and permitting process. Comprehensive post-operational environmental monitoring would be conducted.

TVA is assisting the Environmental Protection Agency (EPA) in the formulation of regulatory guidance and the development of more detailed data for coal gasification processes and synthetic fuels. The plant would implement BACT as identified by EPA and prescribed by the State of Alabama. Guidance from these agencies would be factored into the coal gasification plant design. With EPA's and the State of Alabama's cooperation and advice, TVA fully expects that the design of the plant would be environmentally acceptable.

Environmental Consequences of Process Selection

The 5 processes were compared using the following criteria--solid waste disposal, wastewater treatment, presence of hazardous compounds, water requirements, and auxiliary coal burn requirements. In general, the B&W, K-T and Texaco processes were determined to be more environmentally acceptable than the Lurgi and slagging Lurgi processes.

1. Solid Waste Disposal

Those processes which produce solid waste consisting primarily of a vitreous slag material rather than fly ash are expected to facilitate solid waste disposal because this slag material is less susceptible to leaching and can be more easily stacked. The B&W, Texaco, and slagging Lurgi processes produce such a slag and are preferred from a solid waste perspective over the Lurgi process. The K-T process also operates under slagging conditions, but as much as 75% of the coal ash is entrained in the gas stream and must be disposed of as fly ash. Preliminary results of TVA's overseas tests at existing coal gasification plants indicate that wet collection of the ash would remove certain gases from the product gas stream which may cause the wet ash to be classified as hazardous. This potential problem does not occur if the ash is collected dry as proposed.

2. Wastewater Treatment

The B&W, K-T, and Texaco processes were rated higher on simplicity of wastewater treatment. Both the Texaco and K-T processes can incorporate design features which provide for either wastewater recycle or reduction in water use. The Texaco and B&W processes may have slightly higher concentrations of low molecular weight organics in the wastewater than the K-T process. The Lurgi and slagging Lurgi processes would produce a variety of additional organic compounds, some of which are considered hazardous. Removing these organic compounds would be required, and the wastewater treatment systems needed to do this would be more complicated and costly.

3. Presence of Hazardous Compounds

One of the primary concerns associated with coal conversion processes is the presence of hazardous compounds in wastes. Control or treatment measures and techniques currently exist to prevent discharge or release of hazardous substances and wastes in amounts deemed unacceptable or unreasonably dangerous to human health and the environment. However, the various processes pose significantly different risks and provide clear choices.

The B&W, K-T, and Texaco are high temperature processes. They do not produce large quantities of potentially hazardous byproducts or wastestreams that contain significant amounts of hazardous substances and wastes. Texaco and B&W were rated slightly lower than K-T because existing data indicate that these processes would probably generate greater amounts of trace organic constituents. The Lurgi and slagging Lurgi processes were rated very low because they would produce a variety of complex organic compounds, some of which are considered hazardous.

4. Water Requirements

Processes requiring less water were deemed more environmentally acceptable because they would have less of an impact on the aquatic environment by minimizing fish impingement and entrainment. The slagging Lurgi and B&W processes were rated slightly higher than the Texaco and K-T processes. The Lurgi process would require substantially more water than the other gasification systems.

5. Coal Fines to be Burned

Depending on the process selected, some coal may be burned directly to produce additional process steam and/or to use coal fines which cannot be gasified in fixed bed gasifiers. An auxiliary coal burn would contribute significantly to sulfur dioxide and particulate air emissions and to solid waste disposal. It is possible to eliminate an auxiliary coal boiler with the entrained gasifier processes but it would be more practicable for Lurgi processes to burn the fines which could not be gasified.

The B&W, K-T, and Texaco processes were rated high overall and are considered equally acceptable. The Lurgi and slagging Lurgi processes have rather significant associated potential environmental effects. In order to bring these effects down to an acceptable level, significantly more complicated and costly environmental controls would have to be utilized.

Technical Appraisal of Gasification Processes

On the basis of TVA's evaluation of the technical and economic considerations associated with each technology, it appears that the B&W process, because it has not been the subject of intensive development work for many years, is not as commercially viable as the other two high-temperature processes.

So far as the low-temperature processes are concerned, the gasification of eastern caking coals is believed to be a significant technical problem. The Lurgi process is in commercial operation overseas using coals with characteristics different from eastern coals. However, design modifications are being made to a commercial Lurgi unit in South Africa to test the gasification of eastern U.S. coal. It appears that further development work is also required on the slagging Lurgi.

Alternative Sites

The Murphy Hill site is proposed because it appears to result in the lowest overall economic cost of the sites evaluated and because it offers an environmental advantage in the area of solid waste disposal. For most other environmental parameters, it is equivalent or preferable in comparison to other sites.

This site was purchased as a potential power plant site in 1973 and has been in TVA's inventory since then. It is available to be used for other energy projects such as a coal gasification plant. An additional 200 acres of land under TVA control and adjacent to the site are also available for project activities and would be combined with the plant site.

Initially, 11 sites in the Tennessee Valley region were evaluated as possible locations for the plant. In this site screening analysis, each site was evaluated on the basis of engineering characteristics (foundation conditions, land availability, etc), accessibility to transportation routes, water availability, meteorological conditions, environmental constraints, the presence of cultural and recreational resources, and land use compatabilities. Primarily on the basis of engineering and environmental constraints and comparison with the other sites, 5 of the 11 sites were selected for further evaluation.

Early evaluations indicated that proximity to markets was crucial and that of the areas in the Tennessee Valley region, the north Alabama area had the greatest potential market for the product gas. Because of this, 4 additional sites were identified in the north Alabama area and evaluated on the same factors as the 5 previously selected. The 4 additional north Alabama sites appeared to be less environmentally acceptable. Based primarily on coal transportation costs at each site and proximity to markets, 2 sites, the TVA-owned Murphy Hill and Courtland sites, were selected for more detailed evaluation.

The Murphy Hill site is located on Guntersville Lake in Marshall County, Alabama. The Courtland site, a former Air Force base, is located in Lawrence County, Alabama, and is approximately 6 miles from Wheeler Lake.

Environmental Consequences of Site Selection

The Murphy Hill and Courtland sites have been evaluated based on constructing a 4-module plant and compared in detail with respect to site-specific environmental factors. In general, development of a coal gasification plant at either site would have associated environmental impacts. However, proper plant design, operational procedures and maintenance, and appropriate mitigation measures would avoid or minimize many of these impacts. With 2 modules, environmental impacts would be expected to be substantially less than those associated with a 4-module plant.

The Murphy Hill site terrain is gently rolling and is about 30% prime farmland, with the remainder a mixture of forest and open pasture. A ridge about 60 meters (200 feet) higher than the rest of the site cuts across the southeast side of the site in a southwest/northeast direction. Prominant terrain features of the general area are 2 escarpments running in a southwest/northeast direction--one on the north side of the Tennessee River and the other on the south side of the river, southeast of the Murphy Hill site. This terrain is about 150-180 meters (500-600 feet) higher than the site. The site area is in a sparsely populated rural setting. The area surrounding Murphy Hill is used predominantly for recreational purposes. However, fairly large industries have located within 19 kilometers (12 miles) of the site, both upstream and downstream.

The Courtland site is predominantly flat terrain, and approximately 90 percent is prime farmland. The site is about twice the size of the Murphy Hill site, and utilization of this area would result in the loss of approximately 1500 acres of prime farmland presently used for agricultural production. The site is about 3.2 kilometers (2 miles) from the town of Courtland that has a population of about 500. The Courtland site is located in an agricultural area that has experienced some industrial development.

Of those commenting during the EIS scoping process, a majority of the people in the area surrounding the Murphy Hill site favor the use of this site. However, a small segment of the public who live across the river from the site have expressed opposition to using the Murphy Hill site. Their concerns relate primarily to the potential adverse impacts on the area's aesthetic qualities and property values, and water quality. No such opposition has been identified for the Courtland site area.

Based on public comments, TVA has concluded that perceived visual impacts would be greater at Murphy Hill. These could be mitigated by leaving the rise on the northwest boundary of the site intact so as to screen the plant from sight from across the river as well as to reduce noise levels leaving the plant. Certain plant components such as plant stacks, docking facilities, and possibly upper portions of the gas processing units would, however, be visible. The hilly terrain to the southeast of the site would screen the plant from view for most other areas adjacent to the site boundary. Most of the plant would be visible for long distances at the Courtland site. TVA does not believe that this would be a significant impact because of the limited recreational uses of the immediate area; however, the plant would be visible from nearby historic structures.

TVA's analysis determined that constructing the proposed facility would have a greater socioeconomic impact on the existing environment surrounding Murphy Hill than that surrounding Courtland. Housing, educational facilities, and transportation would be more adversely impacted at Murphy Hill given the expected influx of construction workers. It is important to emphasize, however, that with the current plans to construct a 2-module facility initially, the degree of adverse impacts expected is significantly less than that discussed in the draft environmental impact statement (DEIS) for a 4-module plant. This is due to a revised estimated population influx which is about 40% of the earlier estimate that had been based on a peak work force of 6,800. The peak workforce estimated for a 2-module facility is 3,600. Thus, under any form of ownership (private or public), the scope of mitigation activities would also be greatly reduced.

As a result of the proposed private ownership of the north Alabama coal gasification plant, TVA does not anticipate implementing the socioeconomic mitigation program discussed in the DEIS. The relationship of the project to local governments would be similar to that of other industrial developments. The plant would be subject to taxation by Marshall or Lawrence County which would provide significant revenues to pay for expansion of local services and facilities if necessary. Temporary financing arrangements might be necessary in certain cases to account for any possible time lag between the occurrence of impacts and the receipt of tax revenues. Also, any tax exemption granted to the private entity would be taken into account in choosing among various methods of granting assistance. With respect to adjacent counties, accommodating the growth from plant construction would be accomplished in a fashion similar to that of other private industries, which could include seeking industry assistance.

TVA would be responsible for any impacts that might occur from its direct involvement in construction (site preparation phase). However, since virtually no inmovers are expected during that time, no impacts are expected.

Another difference between the 2 sites is the air quality of the existing environment. The Courtland site area is more industrialized and the ambient air quality is poorer than that at Murphy Hill, while at Murphy Hill, terrain considerations are a more significant factor on air quality impacts than at Courtland. There is very little existing industrial development in the immediate Murphy Hill area, although the general region is suited for industrial development. In the vicinity of the Courtland site, unquantified amounts of the initially available PSD air quality increments (the degree to which air quality deterioration by new development is allowed) have been consumed by existing industry. However, available data indicate that portions of these increments are still available. Perhaps more significantly, a PSD Class I area, the Sipsey River Wilderness, is located approximately 35 kilometers (22 miles) from Courtland. These differences and the overall air quality impacts of the facility are minimized by TVA's plan to eliminate the coal-fired auxiliary boiler which is possible using the K-T and Texaco process, and the proposed construciton of a 2-module facility. However, preliminary modeling utilizing conservative assumptions indicates that measures may have to be taken to minimize emissions during startups at either site.

Due to the amount of solid waste generated, disposal would be a major undertaking at either site, although the gasifier slag and ash are not anticipated to be hazardous wastes. Both sites display somewhat similar geological features for at least part of the site area and would require careful design consideration to prevent contamination of ground water. The Courtland site is extremely karst and susceptible to sinkhole formation. In contrast, the Murphy Hill site has a large area between "Murphy Hill" and the ridge to the southeast of the site which is suitable for solid waste disposal. This area is believed to be superior to any other areas on either of the two sites. Careful design efforts would allow all or a large portion of the solid waste to be disposed of in this area of the Murphy Hill site. In terms of maintaining the integrity of a solid waste disposal facility liner, if needed, Murphy Hill is preferable. If the engineering characteristics of the solid waste prevent stacking to the desired height, it is possible that additional land may be needed to supplement the available space at Murphy Hill if the decision is made to go to a 4-module plant.

Water is available from the Tennessee River in more than sufficient quantities at both sites. Investigations indicate that a deep water discharge of the treated effluent to the Tennessee River at either of the two sites would preclude any serious environmental impacts due to chemical or thermal discharges. TVA has evaluated alternative intake designs, and the plant design would employ the best practicable intake technology for the selected site. The Courtland site suffers the economic disadvantage of being approximately 10 kilometers (6 miles) from the Tennessee River. This would necessitate constructing an expensive conduit to the site for plant makeup water and discharge water. Big Nance Creek borders the Courtland site, but inadequate flows and its ecological nature limit the use of this stream as a source of makeup water or point of discharge. The Murphy Hill site, located on the Tennessee River, has productive aquatic areas which cannot be completely avoided, but does not have the same economic drawbacks associated with constructing the intake and discharge pipes that the Courtland site faces. BACT would be employed to protect ambient water quality. From a biological and water quality perspective, given a deep water discharge, best practicable intake technology, best practicable location of docking facilities, and best available wastewater treatment technology, there should be little adverse impacts on the aquatic ecosystem at either of the sites.

Use of the Murphy Hill site would require the clearing of more forested land than Courtland. Approximately 500 acres of mixed agricultural fields, open pastures, and forested areas would have to be cleared at the site. The use of Courtland would require the clearing of agricultural lands and a small amount of thickets. Neither of the affected environments is unique. Impacts would be limited to the immediate site area and are not considered significant. No threatened or endangered species would be affected at either of the sites.

Large numbers of waterfowl and fish utilize overbank areas surrounding the Murphy Hill site for food. These areas are generally very biologically productive. Disturbance of these overbank areas would be minimized to reduce impacts on aquatic life, waterfowl, and wetland wildlife habitat. Construction of docking facilities at Murphy Hill has the potential to impact productive overbank areas. A number of options for the docking facilities at the Murphy Hill site were evaluated. It is clear that an option using an adjacent embayment would create the greatest impacts on the aquatic environment and wetlands and would be avoided if possible. The other options in the main stream of the Tennessee River offer distinct advantages over the extensive dredging required for the embayment option. The Tennessee River near the Courtland site has no extensive overbank areas. Developing the Courtland site would have minimal impacts on wetland wildlife and waterfowl inhabiting Big Nance Creek. From the perspective of protecting waterfowl and wetland wildlife, the Courtland site appears to present the least potential for adverse impacts. The possible impacts at Murphy Hill would, however, be minimized by avoiding, to the extent practicable, construction of facilities in the overbank areas.

Site variable cost studies and pipeline evaluations indicate that Murphy Hill is the less expensive of the 2 sites. The major difference between the 2 sites is the cost for coal handling. Because Courtland is located about 6 miles from the Tennessee River, coal handling would be about twice the cost of that at Murphy Hill. The economics of constructing a MBG gas pipeline to be fed from either Murphy Hill or Courtland have been evaluated. Under the study assumptions, piping gas from Murphy Hill is slightly more expensive due to the requirements for larger diameter pipes covering greater distances to deliver the estimated volume of MBG. The differential pipeline costs for synthetic natural gas (SNG) have not been evaluated in detail since they would be incurred by the specific pipeline firm purchasing the gas and probably are determined by the location of that firm's existing pipelines. One firm which could receive gas from either site would need to build twice as long a pipeline to Courtland as to Murphy Hill. The differential pipeline costs, however, are much smaller than the site development cost differences. Overall, a plant at Murphy Hill would be less expensive to build and operate.

Based on the foregoing environmental and economic evaluation, TVA has identified Murphy Hill as the preferred site for the proposed coal gasification plant. The site is remotely located and typical of land bordering the Tennessee River. While utilizing the site would result in a greater level of socioeconomic impacts, and its location is in a recreationally oriented area, it offers important geological and other environmental benefits over the Courtland site. In addition, the estimated site variable costs show that Murphy Hill is less expensive to develop.

INTRODUCTION

The Tennessee Valley Authority (TVA), since its creation in 1933, has actively pursued the development of resources in the Tennessee Valley Region in a manner that conserves and enhances the environment. Created by the Tennessee Valley Authority Act of 1933 (48 Stat. 58, as amended, 16 U.S.C. § 831-831dd, 1976), TVA's charter includes improving the navigability of the Tennessee River, providing flood control, developing and implementing land conservation and utilization practices, fostering agricultural and industrial development, and providing for the National defense.

As the builder and operator of the Nation's largest power system, TVA has a long standing commitment to developing innovative and environmentally sound solutions to the region's energy problems. In addition, TVA has gained, through its National Fertilizer Development Center, a thorough understanding of the problems involved in the commercial development of chemical processes.

As part of TVA's general mandate to develop resources of the region, TVA is seeking new ways to utilize the region's abundant coal resources. An option that appears attractive is a coal gasification facility that could serve a multi-user market. In addition to the regional benefits, this would assist the realization of the National objective of energy independence by providing a lead plant that could help solve some of the environmental, institutional, and technical difficulties associated with synfuels development. In June 1980, the Congress enacted the Energy Security Act. As stated in the Findings and Purpose of this act "Section 100 (a) The Congress finds and declares that--

(1) the achievement of energy security for the United States is essential to the health of the National economy, the well-being of our citizens, and the maintenance of National security;

(2) dependence on foreign energy resources can be significantly reduced by the production from domestic resources of the equivalent of at least 500,000 barrels of crude oil per day of synthetic fuel by 1987 and of at least 2,000,000 barrels of crude oil per day of synthetic fuel by 1992;

(3) attainment of synthetic fuel production in the United States in a timely manner and in a manner consistent with the protection of the environment will require financial commitments beyond those expected to be forthcoming from nongovernmental capital sources and existing government incentives..."

Consistent with these objectives, TVA proposed in August 1980 the construction and operation of a coal gasification facility as a Federal project financed through a combination of appropriated funds and borrowings. These would have been repaid from product sales. Since issuing the DEIS, TVA has been considering ways to reduce Federal outlays and depend more on private sector financing for the project. It appears appropriate to seek private equity financing with assistance from SFC, and this is now the preferred financing approach for the project. A financial institution, Kidder, Peabody & Co., believes that the economics of the project are such that a consortium of private owners can be developed to fund, own, and operate the project and has applied to the SFC for financial assistance on behalf of the to-be-formed consortium. If the SFC provides financial assistance, then the private consortium would assume the responsibility for design completion, construction, and operation of the proposed facility.

Under contractual arrangements with an appropriately formed consortium, TVA would sell the Government's interest in the project to the consortium. The consortium would assume legal ownership of the plant, all obligations for completing and operating the facility, and an obligation to repay with interest to TVA the Federal investment in the project. TVA would make available to the consortium the project site. Provision of continuing TVA support and cooperation would be made to the private entity as appropriate during design, permitting, construction, and operation.

As part of its environmental assessment activities, TVA evaluated the potential environmental impacts of constructing and operating the proposed north Alabama facility. In so doing, a number of mitigative activities were identified which would minimize environmental impacts. A large number of these environmental activities are required under various regulations and would be carried out either by TVA or the private entity. Other identified mitigative measures would be completed by TVA prior to transfering the land to the private entity, thus, ensuring their completion. The remaining mitigative measures could be made conditions of the land transfer or in the contract with the proposed private entity. Their completion would then become the financial responsibility of the private entity.

The project as presently envisioned would be a 2-module plant processing approximately 10,000 TPD of eastern high-sulfur coal into a clean MBG, with the capability of expanding to 4 modules should it prove to be technically and economically justified. Some of the MBG would be methanated to produce high-Btu gas (synthetic natural gas). The remainder would be used to produce methanol, other liquid chemicals, or gasoline.

As part of TVA's effort, this final environmental impact statement (FEIS) has been prepared in parallel with the conceptual design effort and will serve as a planning document wherein the possible environmental impacts of the proposed coal gasification facility are evaluated at alternate sites. This assessment considered a 4-module plant and, therefore, presents a worst-case assessment of impacts. A 2-module plant would have substantially less environmental impacts. Major design alternatives, such as the selection of the gasification process, are assessed. The

FEIS, along with other pertinent technical and economic information, will be used to decide whether to proceed with the project. By completing the FEIS at this point in the project, management decisions regarding the future of this action will be based on an understanding of the environmental as well as the economic consequences of the project. The Army Corps of Engineers has cooperated in the development of this statement, and TVA has worked closely with the Environmental Protection Agency in preparing the document.

As part of the environmental review process, public input was encouraged in scoping the contents of the EIS. Two public meetings were conducted by TVA in the vicinity of the preferred site and ample opportunity was provided to the public to express their concerns through written or verbal statements including TVA's toll-free telephone Citizen Action Lines. Over 200 people responded during the EIS scoping process. A synopsis of these comments was prepared and used in development of the EIS scope. Listed below are the general areas identified as being of concern to the local citizens:

Air Pollution
Water Pollution
Solid Waste Disposal
Aesthetic Values
Property Values
Recreational Impacts
Increased Noise
Public Health and Safety
Barge Traffic
Increased Road Traffic
Industrial Development
Employment
General Community Benefits

It was found that those favoring the facility generally cited employment opportunities and general benefits to the economic development of the community as desirable results of this proposed action. Opponents to the facility generally cited impacts on aesthetic values, property values, and water quality as their major concerns. A limited number of responses identified the other impact areas listed above. Based on these concerns and others, TVA evaluated in detail the potential environmental impacts of siting this proposed facility at a preferred and at an alternate site. Five coal gasification technologies were evaluated for their technical readiness and environmental desirability. Site descriptions are provided, alternatives are discussed, and environmental impacts are estimated. Where appropriate, mitigative measures to eliminate or reduce adverse environmental impacts are described. TVA's assessments were contained in a draft environmental impact statement (DEIS) issued to the public on August 1, 1980, for review and comment. Approximately 130 persons commented on the DEIS through letters sent to the Agency or at a public hearing held on September 23, 1980. A supplement to the DEIS was issued on June 1, 1981, which explained proposed changes in project ownership and financing and initial project size. It, also, provided updated information in various areas, including socioeconomics, solid waste disposal, navigation impacts, air quality, and noise. Approximately 20 persons commented on the supplement. TVA considered all these public comments and questions in preparing this FEIS. Responses were prepared to comments that raised substantive questions regarding project alternatives or environmental impacts, and appear in Appendix E of this volume. The public letters appear in Volume 3 of the FEIS.

1. PURPOSE AND NEED

The Tennessee Valley Authority (TVA) proposes to take a series of actions which will allow a private entity to demonstrate that a commercial-scale coal gasification plant producing medium-Btu gas (MBG) can be permitted, constructed, operated, and the synthetic gas marketed in an environmentally and economically acceptable manner to provide a clean coal-derived fuel or chemical feedstock. A portion of the MBG would be converted to SNG and sold. The remainder would be used to produce methanol, other liquid chemicals, or gasoline. By demonstrating this new use of one of the Tennessee Valley region's most important natural resources, TVA and the private entity would make a positive contribution to our Nation's efforts to resolve the energy crisis and reduce dependence upon foreign petroleum and natural gas. The use of synthetic fuels to aid in this effort was given high priority by the Congress with the enactment of the Energy Security Act.

The proposed plant would use high sulfur eastern coal to produce the equivalent of 25,000 barrels of oil per day initially, with the capability to expand to 50,000 barrels of oil per day equivalent capacity if technically and economically justified. In addition to providing a clean, domestic substitute for imported oil or natural gas and providing another use for the area's abundant coal reserves, the project would provide valuable design, construction, and operating experience that would be of great use in shaping a domestic synthetic fuels industry. A national synthetic fuels industry also would help to place a cap on the price of imported petroleum and natural gas.

TVA traditionally has played an important role in the development of coal-based technologies. Due to the abundant coal resources in the Tennessee Valley region, coal production has had a significant impact upon the economic well-being of the region which TVA, as a regional resource agency, is charged with promoting. Because TVA operates the Nation's largest power supply system, TVA also has developed a great deal of expertise in the evaluation, management, construction, and operation of energy producing facilities. Further, TVA has gained a great amount of experience in the development of chemical processes with its fertilizer research programs. Therefore, TVA is uniquely situated to facilitate a demonstration of the economic feasibility and environmental acceptability of coal gasification.

A coal gasification plant designed to produce MBG has the potential to serve a number of energy markets that are presently dependent on petroleum and natural gas. These energy markets include: (1) chemical plants which could use the MBG as a fuel or feedstock to produce chemicals and liquid fuels (e.g. methanol and gasoline); (2) natural gas utilities which could use methanated MBG as SNG; and (3) existing and new industry which could use MBG as a fuel gas, eventually in conjunction with fuel cells for onsite electric generation.

The purpose of this effort is to demonstrate a commercial gasification technology that produces MBG. Medium-Btu gas was selected because of its inherent flexibility to serve a variety of energy needs--supplementing natural gas, chemical feedstock, a source of electricity, and gasoline. Presently, there are no commercial-scale coal gasification facilities in this country. The process development units, pilot plants, and technical demonstrations which now exist or are under construction do not adequately address questions concerning the application of coal gasification on a commercial scale within the Tennessee Valley region.

TVA's National Fertilizer Development Center, as part of its fertilizer research effort, has undertaken a coal gasification research and development program to determine the feasibility of using coal rather than natural gas to produce ammonia for fertilizer production. Many technical and operational questions are being answered by this 200 tons per day (TPD) TVA plant recently completed at Muscle Shoals, Alabama, but other questions cannot be answered without the construction and operation of a full-scale (10,000 TPD) coal gasification facility. Commercial-scale coal gasification is carried out overseas in countries whose economic and regulatory climates are quite different from that of the United States. TVA believes it is appropriate to develop this technology for use in the Tennessee Valley area while ensuring that the environment and public health are fully protected.

This environmental statement has been prepared by TVA in cooperation with the Army Corps of Engineers (Corps) and with the assistance of the Environmental Protection Agency (EPA) to evaluate the environmental factors relevant to making 3 major decisions: whether to go ahead with the project; and if it is decided to proceed, the selection of the gasification process and site. With respect to the Corps, the major involvement will be the review and possible permitting of various project activities in accordance with Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act.

The decision-making process will also take into account a number of other significant factors. These factors include questions concerning market potential for the product gas, financing alternatives, and business relationships with existing industrial fuel suppliers.

In addition, the EPA as part of its statutory mandate is developing guidance to be used in defining environmental control technologies for synthetic fuels plants. TVA is assisting EPA in this effort (see Appendix A). TVA has access to EPA's synfuels environmental database and is providing to EPA the data it is developing. These data and EPA's guidance are being factored into the north Alabama coal gasification plant design in furtherance of TVA's effort to develop an environmentally safe facility.

2. ALTERNATIVES

This chapter discusses a number of alternatives that were considered for this project and identifies preferred options. The alternatives of taking no action or having an organization other than TVA and the private entity demonstrate this technology are discussed. Under the discussion of alternate sites, the site evaluation process is described and reasons for eliminating alternate sites given. The present project plans call for constructing a 2-module plant now with the capability to expand to 4 modules at a later date. Siting assessments were based on constructing a 4-module plant and, therefore, envelope or present a worst-case assessment of site-related environmental impacts. Coal gasification technology is evaluated from a number of standpoints and reasons for eliminating alternate technologies from consideration are presented. The environmental impacts of these various alternatives are presented defining the issues and providing a clear basis for choice.

2.1 Discussion of Project Alternatives

The proposed project is designed to demonstrate commerical synthetic fuels production in the Tennessee Valley region. Alternatives to undertaking this coal gasification demonstration project are discussed below.

2.1.1 "No Action" Alternative

The environmental impacts associated with the construction and operation of the proposed coal gasification facility would be avoided if the no-action alternative is selected. However, the no-action alternative would not achieve TVA's objectives in proposing this action--demonstrating the economic feasibility and environmental acceptability of coal gasification in the Tennessee Valley region. Further, the no-action alternative would not do anything to decrease the Nation's growing dependence on imported oil and natural gas. Because the no-action alternative would not achieve TVA's objectives, it has been rejected as the preferred alternative.

The Energy Research and Development Administration (ERDA), now part of the Department of Energy (DOE), issued a final Environmental Impact Statement in 1977 on ERDA's alternative fuels demonstration program. This study assessed the impacts of a proposed program to accelerate alternative fuels production to a specified level in 1985. It was concluded that the outcome of taking no action would require that either oil and gas imports would have to increase to meet the demand or conservation measures would have to be implemented to cope with the shortfall. This study assessed the potential for a number of other alternative options such as direct utilization of coal, increased conservation, nuclear energy, geothermal energy, solar energy, increased domestic oil and gas production, and a number of others. While some of these options had the potential to meet all or a portion of the program's energy and/or security objectives, none would fulfill the objective to develop technical, environmental, and economic information needed prior to major expansion of synthetic fuels production in the U.S.

In a second environmental impact statement issued by ERDA in 1977 on its Coal Research, Development and Demonstration Program, similar conclusions were drawn when the no-action alternative was evaluated for ERDA's coal research programs. Basically, it was concluded that the domestic energy supply would be reduced below that which would have resulted from successfully completing the Research, Development, and Demonstration program. To meet this energy shortfall, there would have to be increases in imports of oil and natural gas, conservation practices, and domestic production of oil and natural gas. Environmental impacts resulting from increased oil and gas imports would relate to tanker operations (tanker exhaust, oil spills, ballast discharges), oil and gas handling transfer operations (emissions to the air, spills), and refining operations (emissions to the air, wastewater). Impacts resulting from increased domestic production of oil and gas would relate to liquid and gaseous wastes from drilling and refining operations. Socioeconomic impacts would result from increased use of oil and gas whether it was imported or produced in this country. Energy conservation would involve the careful use of existing technology and other energy saving devices with resultant physical and biological benefits due to lower emissions, effluents and solid waste levels from primary fuels.

All of these potential impacts have been discussed in the Coal Research EIS noted above. Based on ERDA's analysis, it can be concluded that should increased coal utilization not be implemented the result would be increases in the use of petroleum and natural gas with concomitant increases in national environmental and socioeconomic impacts.

The recently enacted Energy Security Act found that attainment of synthetic fuels production in the U.S. in a manner consistent with protecting the environment was in the National interest.

2.1.2 Synthetic Fuels Demonstration by Other Entities

Should TVA and the private entity not undertake this project to demonstrate the production of synthetic fuel from coal in the Tennessee Valley region, it is possible that other public and private entities would undertake such a demonstration (such as the proposed MBG demonstration plant funded by Memphis Light, Gas and Water and DOE or the proposed Koppers coal gasification project in east Tennessee). Federal funding through the SFC and additional recent incentives for private sector financing have encouraged a number of industries to initiate efforts in synfuel development.

Development of commercial synthetic fuels facilities by other entities would have impacts similar to TVA's proposed action. Because TVA is a large energy producer within the Federal family and can draw on the experience of constructing large electric generating stations and operating them to serve its customers, TVA is in a unique position to facilitate a demonstration that coal can be converted into a clean, economical, and usable fuel. These are benefits other proposed projects do not enjoy.

2.1.3 TVA's Cooperation in the Demonstration of Energy Technologies Other Than Coal Gasification

TVA operates the Nation's largest electric power system. TVA's electric power production facilities presently consist of coal-fired steam plants, nuclear-fueled steam plants, hydro plants, and oil-fired gas turbines. For its projected power needs through the 1990's, TVA is presently embarked on the Nation's largest nuclear power plant construction program.

For its needs beyond the 1990's, TVA is evaluating a spectrum of technologies including solar, small hydro, cogeneration, as well as conventional coal and nuclear plants.

Atmospheric Fluidized Bed Combustion (AFBC) is a promising means to burn eastern high-sulfur coal cleanly, and TVA is constructing a pilot-scale AFBC boiler near its coal-fired Shawnee Steam Plant near Paducah, Kentucky. A larger-scale AFBC demonstration plant is under active consideration.

Fuel cells are also being considered as potential electric power sources for the 1990's. A fuel cell is a device similar to a storage battery, except that a hydrogen-rich fuel continuously replenishes it. Gas-turbine, steam-turbine combined cycle plants also appear promising for future generation. TVA believes that planning for the use of oil or natural gas fuel supplies for these technologies in the 1990's and before is unrealistic and inconsistent with the Nation's goal of minimizing dependence on imported oil and gas. Coal gas appears to be an appropriate fuel for these technologies.

Technology for the direct liquefaction of coal is being developed by others. A major approach being pursued is the conversion of high-sulfur coal to a low-sulfur heavy liquid boiler fuel. This fuel could be used in regions of the country where a high percentage of electric power generation is presently dependent on imported oil (e.g., New England), but where technical and environmental considerations preclude the direct burning of coal.

There are no large-scale commercially available direct liquefaction processes. TVA considers technological readiness to be a major consideration in selection of the synfuels process for the proposed action so that a commercial demonstration can be made in a timely fashion. Furthermore, while TVA could perhaps utilize coal liquefaction products in its power plants, this is not viewed as a major need for the system at this time. TVA does foresee a need for clean coal gas for potential future electric power generation technologies, and the coal gas can be used now as feed stock to produce a host of other materials, including methanol and synthetic natural gas. High temperature coal gasification is one of the most environmentally benign processes for utilizing coals.

The process produces a solid waste similar in nature to power plant ash and slag, and sulfur removal from coal can exceed 99% compared to 90% required for new coal-fired power plants. In addition, TVA has experience in the design, construction, and operation of coal gasification technology from its 200 TPD ammonia from coal project.

TVA either owns, leases, or has mineral rights to large tracts of land in the western United States for the purpose of uranium mining. There are no significant oil shale deposits on this land, nor does TVA control mineral rights which include oil shale on any land it has mining interests in. It is not feasible for TVA to acquire oil shale rights to develop an oil shale synfuel facility, nor is oil shale considered a resource of the TVA region. Therefore, the oil shale synfuel alternative is not practicable.

Consequently, TVA involvement in demonstrating a coal derived synfuel technology other than coal gasification is unwarranted at this time.

2.2 Site Screening Studies

2.2.1 General Information

This section describes the siting activities performed for the proposed north Alabama coal gasification facility. The vehicle used for conducting the siting studies was an interdisciplinary siting working group comprised of a number of disciplines including engineers, chemists, biologists, and regional planners. Site reviews included assessments of engineering and environmental concerns in each potential site area.

Siting studies were initially conducted for 11 previously identified sites within potentially promising market areas for MBG. As additional information became available indicating that the north Alabama area showed a greater potential for developing a coal gas market, 4 additional site areas in that region were identified and reviewed. Of the sites considered, the TVA-owned Murphy Hill site in Marshall County, Alabama, was selected as the preferred location.

2.2.2 Site Screening Process

Siting of a medium-Btu coal gasification plant differs from siting an electric power plant or a high-Btu (synthetic natural) gas plant because the location of existing and potential industrial users is more critical. Electric transmission and natural gas pipeline systems already exist and serve customers throughout the TVA region. With relatively modest changes to an existing natural gas pipeline system or electric transmission system, it would be possible to serve all of the existing customers better by locating a new supply source near the transmission system.

There is, however, no existing MBG pipeline or any existing MBG customers. The lower energy content of the gas makes transportation over long distances more costly than natural gas on a cents per million Btu basis. The economical transport distance for MBG is generally considered to be 160-240 kilometers (km) or 100-150 miles (mi). Coal transportation is also an important economic consideration, but the use of barges on the Tennessee River offers a flexible, economic alternative to locating the facility near the mine mouth.

These facts make it essential to consider the locations of existing and potential customers when selecting a plant site. Furthermore, the capacity of a commercial coal gasification plant (equivalent to about 25,000 to 50,000 barrels of oil per day), while small compared to national energy consumption, is large in comparison with existing industrial energy demands in the Valley.

This led TVA to focus on 3 of the largest industrial regions within the Valley: 1) western Kentucky and Tennessee (Paducah/Calvert City and Memphis); 2) northern Alabama (Florence, Decatur, and Huntsville); and 3) east Tennessee (Knoxville, Chattanooga, and Johnson City-Bristol-Kingsport). A fourth area, middle Tennessee (Nashville), exhibited some limited potential. In addition, although Birmingham and Gadsden are not in the TVA region, their large industrial energy use and proximity to a large industrial market in the TVA region made them potential markets. Table 2-1 gives the potential industrial loads for these 4 areas. Subsequent to completing our siting studies, it was announced that Memphis was to be served by a technical MBG demonstration (approximately 3100 TPD of coal) funded by Memphis Gas, Light, & Water and the Department of Energy. Recently, the Koppers Corporation has announced plans to construct a large coal gasification facility near Oak Ridge, Tennessee. These events do not alter TVA's conclusion regarding the location of the most favorable market area.

Within each of the above areas of interest, sites previously identified under TVA's power plant siting program that appeared to exhibit characteristics suitable for a coal gasification plant were selected for closer review.

Site screening activities were based on generic coal gasification plant parameters and not tied to a specific process with definitive design information or known effluent levels. The assumption was made that the control of effluents from a coal gasification facility could be tailored to fit Federal or State regulatory requirements. Site areas were reviewed, therefore, from the standpoint of estimated air quality increment availability or probable maximum emissions allowable in a given area. Consideration was also given to potential water and solid waste constraints. For the site screening process, the following plant parameters and assumptions were used:

1. Economic Life of Facility Assumed for Siting Purposes - 35-40 yr (Some of the equipment may have a shorter life and would require replacement. The remainder of the document assumes a 20-yr plant life.);
2. Product - Medium-Btu Gas approximately 300 Btu/SCF;

TABLE 2-1

POTENTIAL INDUSTRIAL MEDIUM-BTU GAS LOADS

Potential Market Areas	Energy Demand Billion Btu/Day
I. Western Kentucky and Tennessee	
a. Memphis, TN	93.4
b. Paducah/Calvert City, KY	11.0
II. Northern Alabama	
a. Birmingham, AL	126.0
b. Decatur, AL	38.1
c. Florence, AL	44.2
d. Gadsden, AL	15.2
e. Huntsville/Scottsboro, AL	8.6
III. East Tennessee	
a. Chattanooga, TN	68.5
b. Johnson City/Bristol/ Kingsport, TN	26.9
c. Knoxville, TN	21.9
IV. Middle Tennessee	
Nashville/Davidson Co., TN	44.9

Source: "Tennessee Valley Authority Coal Gasification Project Task Force Report", October 11, 1979; and confidential TVA market surveys.

3. Coal Use - approximately 20,000 TPD; four 5,000 TPD modules;
4. Coal Delivery and Source - by barge and/or rail primarily from western Kentucky and southern Illinois;
5. Water Intake - approximately 50 cfs (22,440 gpm);
6. Water Discharge - 2 scenarios:
   a. Continuous Discharge of 10 cfs;
   b. Closed-Cycle Cooling, 0 Discharge;
7. Solid Waste Disposal Requirements -750 to 900 acrefeet per year (Ac-ft/yr);
8. Optional Auxiliary Coal Burn, 200- to 400-MW equivalent (as TVA's technical and environmental analyses were refined, this feature was eliminated for the K-T and Texaco processes);

Based on the above factors, minimum site requirements included approximately 1,000 to 2,000 acres of land; potentially available air quality increment; accessibility by barge, rail, and/or highway; sufficient water supplies; and sufficient market for the product gas. All of these factors given above provided the basic criteria for site screening, which lead to selecting for interdisciplinary review an initial 11 potential site areas, shown in Figure 2-1, dispersed throughout the TVA region.

2.2.3 Site Area Screening

These 11 potential site areas were reviewed in light of the basic siting criteria and available information and evaluations made in a number of categories. The results of this initial site screening evaluation are provided in Table 2-2. In some cases, prior onsite investigations had been conducted as a part of the power plant siting program.

Brief characterizations of each potential site are given below:

East Tennessee Market Area

1. Clear Creek

   This site is approximately 60% prime farmland. The area immediately adjacent to the site has been considered for industrial development by several large industries in the past and has excellent potential for future development. There appears to be sufficient land base for industries to locate near a gasification facility developed on this site. From an engineering standpoint, the site appears suitable. Environmental considerations include the gray bat (Myotis grisescens), Federally listed as an endangered species, which occupies a cave near the site, 2 tributary streams, productive mussel beds adjacent to the site and Federally listed endangered mussel species in the

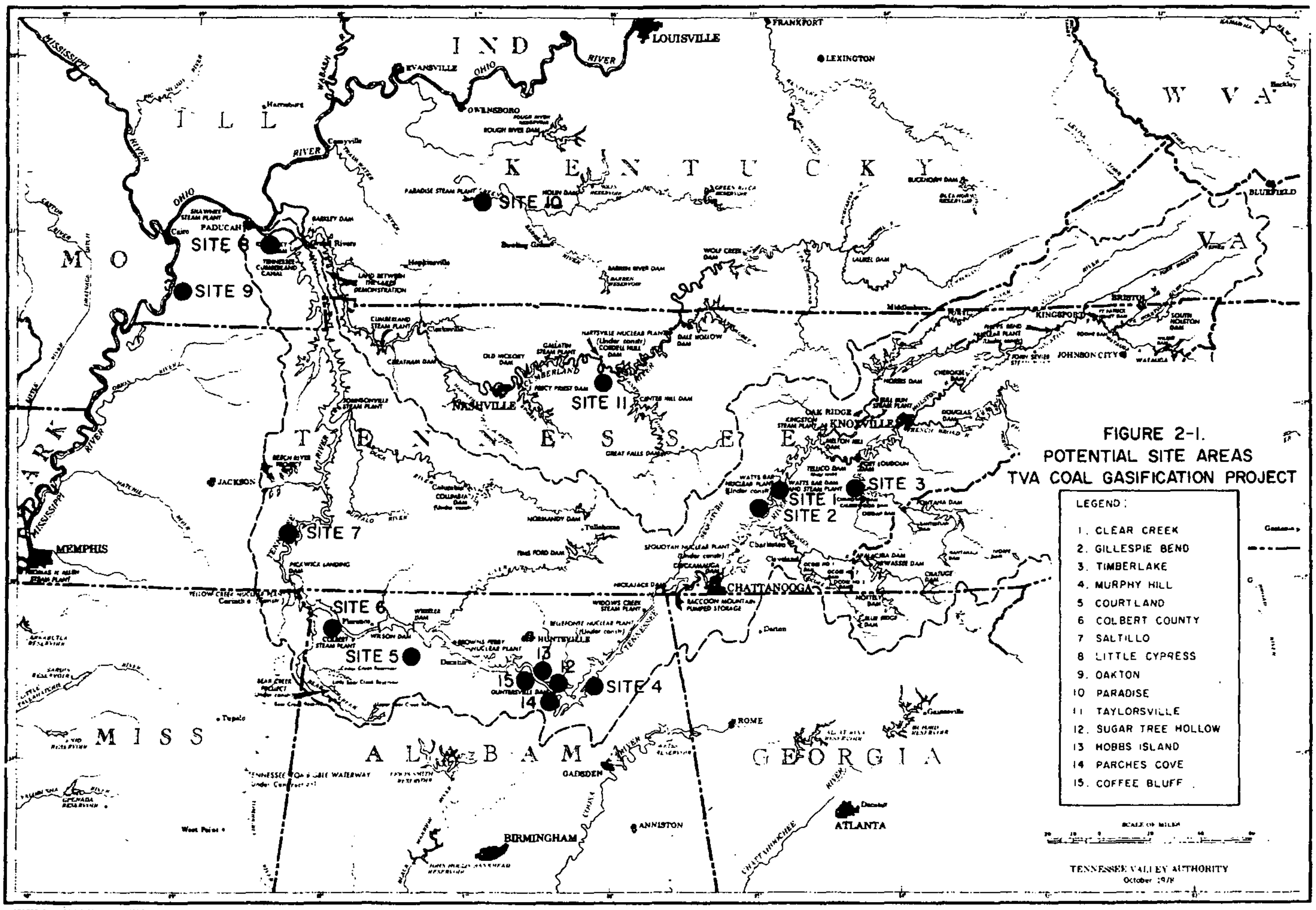

FIGURE 2-1.
POTENTIAL SITE AREAS
TVA COAL GASIFICATION PROJECT

PREPARED BY MAPPING SERVICES BRANCH

Evaluation Categories	Relative Ranking[1] Clear Creek	Gillespie Bend	Timber-lake	Murphy Hill	Court-land	Colbert County	Saltillo	Little Cypress	Oakton	Paradise	Taylors-ville
Land Use-Socioeconomics	B	C	B	C	A	B	C	B	C	A	B
Agricultural Compatibility	C	B	C	B	D	D	C	B	B	A	D
Radioactive Effluents/ Environmental Noise	B/B	B/B	B/C	B/B	B/B	B/C	A/C	B/C	B/C	B/B	B/B
Cultural Resources	B	C	C	A	B	C	C	B	C	B	B
Recreational Compatability	B	C	C	B	B	C	B	B	C	A	B
Water Quality/Nonfish Aquatic Ecology	C/D[2]	B/C[3]	C/D[2]	B/C[4]	A/B[5]	B/C[4]	C	B	A	C/D[2]	B
Fisheries Ecology	C	C	D/C[2]	C	B	C	B	B	B	C	D
Terrestrial Ecology	C	C	C	C	A	D	A	B	C	A	B
Wetlands and Wetlands Wildlife[6]	C	C	B	B	B	B	C	B	C	B	B
Air Quality[7]	C/A	C/A	D/B	A/A	D/C	D/C	A/A	C/C	B/A	D/D	B/B
Flooding[8]	A	A	A	A	B	A	C	C	B	B	B
Water Availability[9]	B/A	B/A	C/B	A/A	A/A	A/A	A/A	A/A	A/A	D/C	B/A
Electrical Hookup[10]	C/A/C	C/A/C	C/C/C	A/A/D	B/C/B	B/C/B	D/D/A	B/B/B	C/D/A	A/A/D	B/B/B
Engineering Site Development[11]	A	C	B/D	D[13]	D[13]	A	B	B	A	B	D
Engineering Feasibility	A	B	C	B	C	C	A	B	D[14]	C	B
Overall Engineering[12]	A	B	C	D[13]	D[13]	B/C	A	B	D[14]	C	C
Fuel Delivery Cost[15]	D	D	D[16]	D	C[17]	C	B	A	B	B/C[18]	C

(see footnotes, p. 2-10)

TABLE 2-2. INITIAL TVA COAL GASIFICATION PLANT SCREENING OF POTENTIAL SITES

FOOTNOTES FOR TABLES 2-2 AND 2-4

1. Sites were given relative rankings for a number of different categories. These rankings were as follows:

   A. desirable for development
   B. acceptable
   C. less acceptable
   D. undesirable

   None of the rankings precluded a site from use or automatically categorized a site as one that should be developed. They were merely used for evaluation purposes to show relationships between the various sites for a given category. Taken together they would provide a general evaluation of the suitability of a given site for a proposed action.

2. Higher ranking assumes zero discharge.

3. Higher ranking assumes zero discharge and avoiding Mud Creek and wetlands.

4. Higher ranking assumes zero discharge and avoiding wetlands.

5. Higher ranking assumes zero discharge and avoiding Big Nance Creek snail habitat.

6. Sufficient area has been identified at each site for entire facility development without location in wetlands areas.

7. Rankings are shown in two cases--Case I/Case II. Case I assumes auxiliary coal burn up to 4500 tons/day. Case II assumes no auxiliary coal burn.

8. This ranking indicates percentage of site below flood levels. In some cases, floodplains could not be avoided--in others, even though ranking is poor, floodplains could be avoided.

9. Two cases are shown--Case I/Case II. Case I assumes 50 cfs intake and 10 cfs discharge. Case II assumes same intake and no discharge.

10. Three cases are given--Case I/Case II/Case III. Case I assumes 50 MWe load on system. Case II assumes 500 MWe load on system. Case III assumes ultimate use of product gas for electrical generation and 1800 MWe capacity on system. (Table 2-2 only)

11. Engineering site development is based on cost range as follows:

    A. less than $20,000,000 over base
    B. $20,000,000 to $30,000,000
    C. $30,000,000 to $40,000,000
    D. $40,000,000 plus

12. Overall engineering is combination of Engineering Site Development and Engineering Feasibility categories.

13. Costs for solid waste disposal could be high.

14. Foundation preparation costs could be extremely high because of high seismic risk in area.

15. Ranking is based on following cost ranges:

    A. base cost
    B. base plus $0.90 to $1.50 per ton
    C. base plus $1.75 to $2.15 per ton
    D. base plus $2.35 or more per ton

16. Difficulty would be expected in getting a sufficient fuel supply to this site. No specific cost estimates were made.

17. Initial ranking did not consider the cost of transporting the coal 6 or more miles from the river to the Courtland site.

18. Delivery costs are uncertain at this site and were given in a broad range.

19. Two cases are given--Case I/Case II. Case I assumes a 50 MW load. Case II assumes a 500 MW load. (Table 2-4 only)

20. More detailed analyses of the Murphy Hill and Courtland sites are presented in Chapters 3 and 4. Evaluations of air quality subsequent to the relative rankings in this table indicate that a C/A rating would be more accurate for Courtland. (Table 2-4 only)

site vicinity. Important wetlands* are located north, east, and west of the site. Two State wildlife management areas, which provide important migrant waterfowl wintering habitat, are adjacent. The adjacent lake has limited assimilative capacity for oxygen-demanding wastes.

2. Gillespie Bend

This site is approximately 40% prime farmland. There are several residential areas in the vicinity. From an engineering standpoint, the site appears suitable, but has relatively poor access. Important wetlands are located in areas surrounding the site. The site is an important feeding area for Great Blue Heron. State wildlife management area lands are located adjacent to the entire south boundary of the site and are important migrant waterfowl areas. A municipal water intake is immediately downstream. Productive embayments and/or sloughs are in the vicinity.

3. Timberlake

This site is approximately 60% prime farmland. The site could be an integral part of the Tellico and Timberlake industrial development plans. From an engineering standpoint, the site appears suitable. Environmental considerations include 2 sensitive terrestrial habitat areas for small game and important waterfowl habitat. The river otter (State listed as threatened) has been sighted in the vicinity. The river is classified as a cold water fishery (trout). The site is 31 km (19 mi) from a PSD class I area and 23 km (14 mi) from a photochemical oxidant non-attainment area.

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*"Wetlands" are defined as those areas inundated by surface or ground water with a frequency sufficient to maintain, and under normal conditions does or would maintain, a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Commonly accepted wetland species will comprise a substantial portion of the biological community. Opportunistic upland-typical plants adapted for colonization of disturbed areas exposed by controlled, receding water levels but incapable of surviving sustained reflooding during the growing season will not be considered as wetland species. Wetlands generally include swamps, marshes, bogs, sloughs, potholes, wet meadows, mud flats, and natural ponds or similar areas where soil and water characteristics and biological communities reflect the influence of predominantly wet conditions.

North Alabama Market Area

4. Murphy Hill

This site is approximately 30% prime farmland and is owned by TVA. There is some second home development in the area. Terrain and access constraints would increase the engineering costs necessary to develop the site. Environmental considerations include potential fishery impacts, sensitive terrestrial habitats on the northern portion of the site, important wetlands along the lake shoreline, and waterfowl populations. The lake area in general receives heavy recreational use.

5. Courtland

This site is approximately 90% prime farmland and is owned by TVA. The distance of the site from the main lake would increase the engineering costs necessary to develop the site. A limited amount of wetlands exist along an adjacent creek. Portions of this creek also constitute a relatively important fishery. Good wood duck nesting and brood habitat exist. This site is 35 km (22 mi) from a PSD Class I area, and a nearby paper mill is planning expansion.

6. Colbert County

This site is about 90% prime farmland and would be generally consistent with the surrounding land use if developed. From an engineering standpoint, the site appears suitable. Environmental considerations include 9 sensitive terrestrial habitat areas within 2 mi of the site which may include populations of State and Federally listed threatened and endangered wildlife. The site is in close proximity to the Natchez Trace Parkway. Potential wetlands and productive mussel areas are in the site vicinity. Two water supply intakes are located immediately downstream. Productive fishery areas are present. This site is in a nonattainment area for sulfur dioxide (SO_2), and there are high levels of total suspended particulates (TSP) in the air.

Western Kentucky/Tennessee Market Area

7. Saltillo

This site is 53% prime farmland and owned by TVA. It is located in a fairly remote area from rail service and major population centers. From an engineering standpoint, the site appears suitable. Environmentally, important wetlands exist on the site and are adjacent. Good wood duck nesting and breeding habitat is present along most of the tributaries and sloughs which transverse the site. There is a substantial portion of the site in the floodplain which provides good migrant-wintering waterfowl habitat during fall and winter seasons. Endangered mussel species and mussel beds exist downstream.

8. Little Cypress

   This site is 48% prime farmland. There are developed residential areas near the site, along with nearby industry. From an engineering standpoint, the site appears suitable. Extensive areas of important wetlands exist in the vicinity providing good wood duck nesting and breeding habitat. Potentially sensitive aquatic habitat are found upstream of the site and in site drainage ways. This site is 14 km (9 mi) from a TSP nonattainment area.

9. Oakton

   This site is approximately 40% prime farmland and is remotely located. From an engineering standpoint, the site would be expensive to develop due to considerations required by the site's proximity to the New Madrid seismic area. A portion of the site is in the floodplain which contains important habitat for migrant-wintering waterfowl, breeding wood ducks, and a diversity of other wetlands wildlife species. The site is in close proximity to a National historic battlefield and State park.

10. Paradise

    This site would represent no conflicts with existing land uses, has good access, and is close to existing coal fields. From an engineering standpoint, the site appears suitable. However, there could be some potential environmental problems by increasing raw water makeup demands on the river. Other environmental considerations include liquid effluent impacts, wetlands, and waterfowl habitat. This site is in a nonattainment area for SO_2 and TSP.

<u>Middle Tennessee Market Area</u>

11. Taylorsville

    The site is approximately 80% prime farmland. There are no apparent land use conflicts. From an engineering standpoint, the site would be relatively expensive to develop due to poor access conditions. Environmental considerations include cedar glades, good migrant-wintering waterfowl habitat, potential mussel beds, and several tributary streams. This site is 29 km (18 mi) from a TSP nonattainment area.

Screening of the potential sites for the coal gasification plant was based on a generic review of available information on engineering, environmental, and socioeconomic concerns associated with each of the sites. A summary of the initial potential site evaluation is given in Table 2-2. As a result of these interdisciplinary generic reviews, the 11 potential site areas were reduced to the 5 candidate locations given below:

1. Clear Creek - Rhea County, Tennessee
4. Murphy Hill - Marshall County, Alabama
5. Courtland - Lawrence County, Alabama
7. Saltillo - Hardin County, Tennessee
8. Little Cypress - Marshall County, Kentucky

The above list represents at least one site from each general market area. These 5 sites appeared relatively more acceptable from an overall viewpoint than other possibilities in a given market area. In addition, the fact that 3 of the 5 sites were owned by TVA (Murphy Hill, Courtland, and Saltillo) and all had undergone evaluations in previous siting studies facilitated detailed evaluations.

As quantitative data on existing industrial use and potential customers became available indicating north Alabama as the region exhibiting the greater MBG market potential, 4 additional site areas in that region were identified and reviewed in conjunction with the above 5. These are shown as Sites 12-15 in Figure 2-1. Brief characterizations of these additional north Alabama site areas follow.

12. Sugar Tree Hollow

This site is 16% prime farmland and has several onsite residences. From an engineering standpoint, the site appears suitable. Environmental considerations include a number of caves which may support the gray bat, Federally listed as endangered; and close proximity to a designated mussel sanctuary, containing 2 mussel species Federally listed as endangered (*Lampsilis orbiculata* and *Plethobasus cooperianus*). Additionally, there are sinkholes and municipal water intakes in the area, and the river in the site area has limited assimilative capacity for oxygen-demanding wastes.

13. Hobbs Island

This site is 48% prime farmland and has considerable residential development. From an engineering standpoint, the site appears suitable. Environmental considerations include a number of caves which may support the gray bat (Federally listed as endangered); large wetland areas; and adjacent productive mussel beds which include a mussel species Federally listed as endangered (*Lampsilis orbiculata*). Additionally, there are sinkholes and municipal water intakes in the area, and the river in the site area has limited assimilative capacity for oxygen-demanding wastes. The area is used heavily for hunting.

14. Parches Cove

The site is 18% prime farmland with some residential development in the area. From an engineering standpoint, the site appears acceptable. Environmental considerations include 11 onsite caves which may support the gray bat (Federally listed as endangered); extensive wetland areas; and adjacent productive mussel beds which include 2 mussel species Federally listed as endangered (Lampsilis orbiculata and Plethobasus cooperianus). Additionally, there are sinkholes and municipal water intakes in the area, and the river in the site area has limited assimilative capacity for oxygen-demanding wastes.

15. Coffee Bluff

This site is 70% prime farmland with extensive residential development occurring on site. A new subdivision is currently under construction. From an engineering standpoint, the site appears suitable. Environmental considerations include 2 onsite caves which may support the gray bat (Federally listed as endangered); large wetland areas; and adjacent to the site is a designated mussel sanctuary which includes a mussel species Federally listed as endangered (Lampsilis orbiculata). The site could impact commercial recreation areas and contains a large number of known archaeological sites. Additionally there are large numbers of sinkholes onsite, municipal water intakes in the immediate vicinity, and the river in the site vicinity has limited assimilative capacity for oxygen-demanding wastes.

These 4 additional sites were subsequently evaluated in a final interdisciplinary site screening along with the previous 5 sites (see Section 2.2.4), after an economic evaluation had been completed on piping gas from and transporting coal to the initial 5 candidate sites (Little Cypress, Saltillo, Courtland, Murphy Hill, and Clear Creek). This economic study was undertaken to determine which of the site areas appeared more cost effective. Present worth cost estimates for the 5 candidate sites were developed and are given in Table 2-3.

These cost estimates considered the cost of coal and transportation by barge to the site or a point on the Tennessee River nearest the site; pipeline site clearing, excavation, bedding, and backfill; piping and coating; cathodic protection; leak detection and pressure monitors; odorization units; crossings for streams, rivers, highways, railroads, and other gas lines; and allowances for pumping stations. Consequently, the total costs given are the total field construction costs for the pipeline and the coal-related costs exclusive of those for moving the coal from the river's edge to the plant. No consideration was given to land purchases, easements, variations in terrain, or engineering design.

TABLE 2-3

COAL GASIFICATION PLANT ALTERNATIVE SITES
SUMMARY OF COSTS FOR PIPELINE CONSTRUCTION
AND COAL CONSUMPTION ($1979)

Site	Pipeline Construction Costs[1] $$10^6$	Lifetime Coal Transportation Costs - $$10^6$	Totals[2]
Courtland, Lawrence Co., Alabama[3]	310	654	3,793
Murphy Hill, Marshall Co., Alabama	362	707	3,898
Saltillo, Hardin Co., Tennessee	531	575	3,935
Little Cypress, Marshall Co., Kentucky	774	376	3,979
Clear Creek, Rhea Co., Tennessee	606	800	4,235

1. These figures assume Memphis is a load center. If Memphis is eliminated (see text), the Murphy Hill pipeline cost becomes $368 x 10^6 and Courtland $466 x 10^6 for the lowest cost scenario.

2. Total figure includes $2,829 x 10^6 for purchase of coal.

3. Courtland is the only site of the five not located on the Tennessee River. The listed coal transportation costs do not include the cost of moving the coal from a barge terminal to the plant. This factor is included in the comparison of site related capital and operating cost differences for the 2 north Alabama locations (see Table 2-5).

The results of this study indicated that the north Alabama locations, in terms of the cost estimates performed, appeared to be the more viable options from the standpoint of economics.

2.2.4 Alternative Site Selection

Upon completing the pipeline and coal transportation cost assessment, the candidate sites including the 4 additional north Alabama sites, underwent a final interdisciplinary review essentially the same as that described previously for the initial 11 potential site areas. The results of this second screening are provided in Table 2-4. As a result of this review, Murphy Hill and Courtland (Figure 2-2) were selected as the preferable alternatives for use by a coal gasification facility producing MBG.

None of the other candidate locations appeared to be any more preferable from an overall standpoint than Murphy Hill or Courtland. To their favor, both Murphy Hill and Courtland are in the preferred market area, appear to be more economical than other site areas in terms of piping the product gas, are owned by TVA, and neither is inhabited by the public. The additional 4 north Alabama sites were eliminated primarily due to the relatively high potential for adverse impacts to environmentally sensitive areas and the considerable residential development associated with the sites.

2.2.5 Economic Site Comparison

This section discusses the results of economic comparisons between Murphy Hill and Courtland. These results show that the overall cost for construction and operation of a coal gasification plant at Murphy Hill would be less than that for Courtland, the next best alternative site. Environmental differences, which are discussed in Chapter 4 also, on balance, favor Murphy Hill.

The economic evaluation results presented in Table 2-5 were performed on a comparative basis. Coal transport to each alternative was by barge with a barge terminal on the Tennessee River assumed. Rail transport was also evaluated but was found to be more costly. As discussed in Chapter 4, Spring Creek embayment is a highly productive area for fisheries and was not, therefore, considered a suitable alternative for construction of barge facilities for Courtland. Because of the location of Murphy Hill on the Tennessee River, its overall site variable cost was lower.

TVA, with the assistance of a large natural gas company, also performed gas pipeline routing and economic studies. These studies were not conducted for the purpose of proposing the construction of an actual pipeline, but rather were conducted to evaluate the variable MBG pipeline costs between Murphy Hill and Courtland. Actual existing industrial gas loads in the north Alabama region were assumed for these studies. These loads would be equivalent to about 1 module (25%) of the total gasification plant (4 module) output. Earlier piping studies summarized in Table 2-3 had assumed the entire plant output was MBG for industrial use.

Evaluation Categories	Relative Ranking[1]								
	Hobbs Island	Parches Cove	Sugar Tree Hollow	Coffee Bluff	Murphy Hill[20]	Court-land[20]	Saltillo	Little Cypress	Clear Creek
Land Use-Socioeconomics	C	C	C-B	D	C	A	C	B	B
Agricultural Compatibility	B	A	A	C	B	D	C	B	C
Radioactive Effluents/ Environmental Noise	-	-	-	-	B/B	B/B	A/C	B/C	B/B
Cultural Resources	C	B	B	C	A	B	C	B	B
Recreational Compatability	C	B	C	D	B	B	B	B	B
Water Quality/Nonfish Aquatic Ecology	C	C	C	D	B/C[4]	A/B[5]	C	B	C/D[2]
Fisheries Ecology	D	C	C	C	C	B	B	B	C
Terrestrial Ecology	D	D	D	D	C	A	A	B	C
Wetlands and Wetlands Wildlife[6]	D	D	D	D	B	B	C	B	C
Air Quality[7]	B	A	B	B	A/A	D/C[20]	A/A	C/C	C/A
Flooding[8]	D	D	C	D	A	B	C	C	A
Water Availability[9]	B/A	B/A	B/A	B/A	A/A	A/A	A/A	A/A	B/A
Electrical Hookup[19]	A/C	A/C	A/C	B/C	A/A	A/A	D/C	B/C	D/B
Engineering Site Development[11]	A	B	B	A	D[13]	D[13]	B	B	A
Engineering Feasibility	-	-	-	-	B	C	A	B	A
Overall Engineering[12]	C	B	A	C	D[13]	D[13]	A	B	A
Fuel Delivery Cost[15]	C-D	C-D	C-D	C-D	D	C[17]	B	A	D

TABLE 2-4. FINAL TVA COAL GASIFICATION PLANT SITE SCREENING

(see footnotes, p. 2-10)

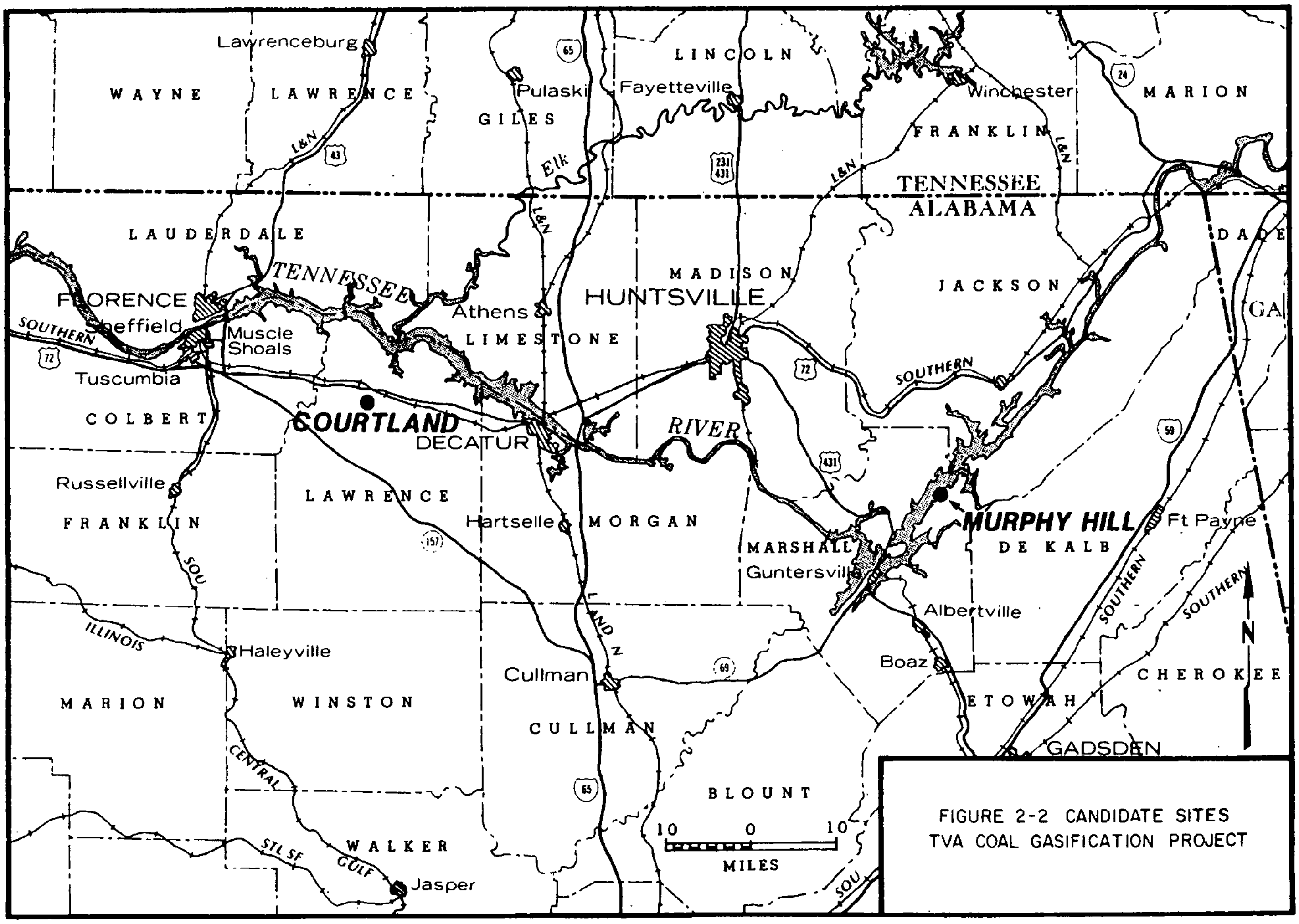


FIGURE 2-2 CANDIDATE SITES
TVA COAL GASIFICATION PROJECT

TABLE 2-5
COAL GASIFICATION PROJECT SITING STUDIES
MURPHY HILL AND COURTLAND SITE-RELATED VARIABLES

	Murphy Hill ($000's)	Courtland ($000's)
Access Highway[1]	7,675	240
Site Preparation	27,937	13,476
Coal Handling and Storage[2]		
Barge Dock	5,410	5,410
Coal Storage Area	4,255	964
Structures	23,764	21,674
Barge to Coal Conditioners	5,879	58,880
Common Facilities--Coal Conditioners to Powerhouse Bunkers	8,843	9,186
Dust Collection	850	850
Fire Protection	1,790	1,825
Service Work--Air and Water	650	1,300
Architectural Work	2,925	5,860
Electrical Work	2,485	6,510
Subtotal Coal Handling and Storage	56,851	112,459
Intake Water System	1,510	7,870
Subtotal	93,973	134,045
Construction Facilities	7,027	9,455
Total Direct Construction	101,000	143,500
Field General Expense	8,600	11,800
Contingency	22,210	31,035
Total Field Construction	131,810	186,335
Engineering Design	13,200	18,600
Manager's Office - OEDC	290	410
Central Services	3,950	5,600
A&G	750	1,055
Total Project--Exclusive of Interest During Construction and Pipeline	$150,000	$212,000
MBG Pipeline Cost, Hypothetical Route	97,500	88,500
Total Project - Exclusive of Interest During Construction	247,500[3]	300,500[3,4]
Total Capital Cost Difference		+53,000
Annual Saving on capital cost for Murphy Hill when converted to an annualized basis at 12% interest, 20 years	-7.1 million	

Site-Related Variable Operating Costs[5]

Coal transportation to Murphy Hill	
Barge transportation to terminal	60¢/ton more
Conveyor from terminal to main plant	30¢/ton less
Net difference	30¢/ton more
Annual difference at 6 million tons/year	+$1.8 million

Net Difference Overall[5]

5.3 million lower cost at Murphy Hill over the estimated 20-year life of the project.	-5.3 million

1. More detailed roadwork estimates for Murphy Hill were completed subsequent to it being identified as the preferred site. Substantially more road miles to be upgraded or rebuilt were identified by TVA. The State of Alabama estimated that approximately $19,979,000 would be required to upgrade the roads in the site area. While it is recognized that additional roadwork would probably need to be done at Courtland, TVA did not prepare a new estimate for this activity. It is expected that if comparable levels of effort were expended on reevaluating all of the cost estimates in Table 2-5, the basic conclusion about the two sites would not change.
2. Capital costs based on using conveyors to transport coal from barge terminal to main plant area.
3. Total project costs exclusive of interest during construction. Figures are in 1985 dollars. Foundation costs at each site were judged to be equivalent and are, therefore, not included.
4. Cost of additional land for coal barge terminal and conveyors is not included for Courtland. It is anticipated that the barge terminal would occupy about 25 acres and the overland conveyor about 150 acres. The cost of land for these facilities is estimated to be about $250,000 to $500,000 depending on whether the land on the conveyor route is purchased in fee or as an easement.
5. Based on 4-module plant construction and operation.

Since the Courtland site is somewhat nearer industrial existing loads, smaller diameter pipelines over much of the assumed route (which is described in Appendix C) were possible and the calculated pipeline cost was somewhat lower for Courtland (see Table 2-6). The costs of a high-Btu gas (SNG) pipeline were not evaluated in detail since they would be borne by the purchaser and depend on the configurations of his existing system. However, one potential pipeline customer which could be served from either location would require a connector pipeline twice as long if served from Courtland rather than Murphy Hill. When the overall costs for Murphy Hill versus Courtland are compared (coal transport, plant design and construction, and pipeline costs), Murphy Hill is found to have lower overall costs.

2.3 Gasification Technology Evaluation

This section discusses alternative gasification technologies considered for this project. Each process is described, unique process characteristics of each are given, and waste characteristics are provided. It has been found that even though some of these technologies have been operating overseas for a number of years, little attention has been given to characterizing waste products.

TVA is working in conjunction with the State of Alabama and the EPA to develop appropriate environmental controls for this facility. As part of this effort, TVA has had access to EPA's data base which is probably the best environmental information available on commercial coal gasification technology. EPA is developing regulatory guidance for the environmental control technology to be employed at synthetic fuels production facilities. As a part of this effort, conceptual design recommendations for medium-Btu coal gasification plants are being formulated. EPA is also developing the extensive data base mentioned previously. TVA is not only utilizing EPA's data base, but it is participating with the EPA working group to ensure that an environmentally sound design is used in the proposed coal gasification plant.

Some of the processes considered, while near commercial, have not developed an extensive data base. Sufficient technical information is available to make relative judgments on the potential environmental impacts or level of environmental controls required for each technology based on estimated or actual waste characteristics. The selection criteria that were used to evaluate alternative gasification technologies are discussed and TVA's process selection is explained.

2.3.1 General Coal Gasification Information

Coal gasification is, basically, a process of combining the carbon in coal with steam and oxygen (O_2) to produce a product gas composed primarily of hydrogen (H_2) and carbon monoxide (CO). Coal gasification technology goes back over 100 years to the town gas which was made and distributed in cities throughout the world until it was replaced by natural gas. Much of the

TABLE 2-6

TVA COAL GASIFICATION PROJECT
MEDIUM-BTU GAS PIPELINE SYSTEM COST

Courtland Site		Murphy Hill Site	
Description	Cost, million 1980$	Description	Cost, million 1980$
40 mi., 16" pipe	$11.1	40 mi., 10" pipe	$ 9.7
55.5 mi., 16" pipe	19.5	55.5 mi., 24" + 20" pipe	23.9
19 mi., 20" pipe	7.1	19 mi., 20" pipe	7.1
15 mi., 16" pipe	4.0	15 mi., 20" pipe	4.5
24 mi., 12" pipe	5.4	24 mi., 20" pipe	7.3
10 mi., 10" pipe	6.0	10 mi., 6" pipe	5.7
10 mi., 10" pipe	2.2	10 mi., 8" pipe	2.1
6 mi., 12" pipe	1.4	6 mi., 10" pipe	1.4
6.5 mi., 8" pipe	1.4	6.5 mi., 10" pipe	1.5
TOTALS: 192 miles	$59 million	192 miles	$65 million

gasification technology commercially available today is based on improvements that were initiated in Germany prior to World War II. Since that time several processes have been developed and are in commercial operation. A number of others developed in the U.S. and elsewhere are still under development. The spectrum of available processes and the choice among them depends on the overall project objectives and timing. Relatively few processes have been built and operated at sufficient scale to justify a commitment now to a commercial scale plant. Many more are still at the bench or pilot plant stage and would require several years of research, development, and technical demonstration prior to construction of a commercial demonstration.

After evaluating the broad spectrum of modern coal gasification technologies, TVA identified 8 processes which were thought to be technically ready. The 8 gasification process vendors were given our objectives and technical data and were asked whether their processes should be considered for the TVA project. Five responded affirmatively. These processes fall into 2 general classes:

1. Entrained Bed--Coal particles are carried along by the gas in concurrent flow similar to a conventional pulverized coal-fired boiler.

2. Fixed Bed--A bed of coal moves counter to the gas stream producing discrete temperature zones.

Of the 5 technologies considered, 3 of them, Babcock & Wilcox, Koppers-Totzek, and Texaco are entrained bed gasifiers. The remaining 2 processes, Lurgi dry-ash and the British Gas Corporation's slagging Lurgi, are fixed bed systems.

2.3.2 Alternate Gasification Processes

This section presents the 5 medium-Btu gasification technologies that were evaluated for this project. The operation of each technology is briefly described pointing out salient features of each system. Although the gasification process affects the overall plant design, the gasification step is only one relatively small part of the overall plant. Figure 2-3 shows a simplified block diagram of a coal gasification plant. The discussions which follow focus on the gasifiers since the rest of the plant would consist of commercially available coal handling, air separation, gas cleanup and related technology. The size and detailed design of these other systems would vary based on the gasification process selection, but are within current industry practice. The environmental control technologies would be selected considering both the recommendations being developed by EPA for synfuels technology and current regulations. To facilitate the reader's understanding of these gasification systems, process block flow diagrams have been provided in Appendix B for each of the processes under consideration.

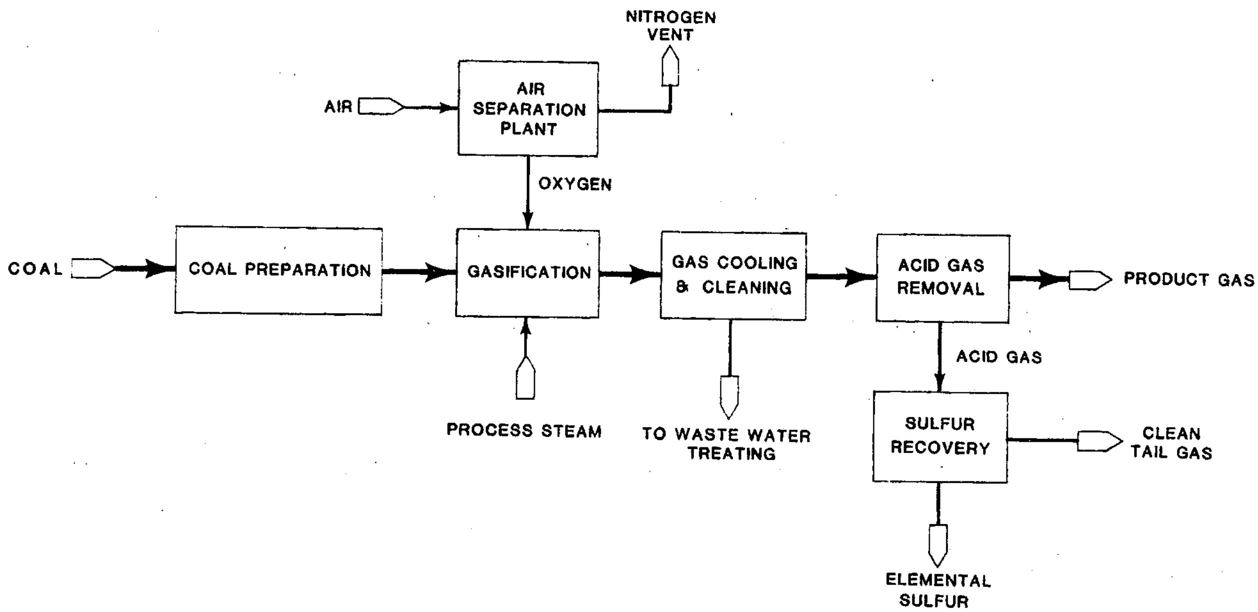


FIGURE 2-3. SIMPLIFIED BLOCK DIAGRAM OF A COAL GASIFICATION PLANT

2.3.2.1 Koppers-Totzek [1]

The K-T coal gasifier is an atmospheric pressure, entrained bed, slagging process developed and sponsored by GKT, GmbH, Essen, West Germany. A number of commercial coal gasification plants throughout the world (Europe, Africa, and Asia) utilize K-T gasifiers in their process demonstrating its commercial availability. A majority of these commercial operations use the synthesis gas to produce ammonia (NH_3).

The K-T gasifier requires dry, pulverized (70-90% through 200 mesh) coal, O_2 and steam. It takes about 0.7-0.9 lb (pound) of O_2 and 0.25-0.5 lb of steam per lb of coal to carry out the reaction.

The gasifier is a refractory-lined, double wall, horizontal shell that resembles intersecting ellipsoids with burners mounted in each of the 4 heads. The 3 reactants are injected through these burners and the coal is gasified almost completely and instantaneously taking less than 1 second to complete the reaction. Reaction temperature at the burner discharge is 3300° -3500°F (1815°-1927°C). Heat losses occur rapidly and the temperature of the gas in the gasifier is reduced to about 2700° F (1482° C). A waste heat boiler is mounted on top of the gasifier to recover heat escaping from these hot effluent gases and generate steam. Heat escaping through the gasifier refractory is recovered by water circulating through the annulus between the inner and outer shell. The annulus is connected to a steam drum. At these high gasification temperatures the mineral matter in coal, commonly called ash, becomes molten. About 25 to 35% of this molten ash adheres to the gasifier walls and runs down the side into a slag quench tank at the base of the unit. The remaining ash is entrained in the exit gas and leaves the gasifier as fine slag particles. A water quench at the gasifier exit solidifies the molten ash before it enters the waste heat boiler. This prevents the molten ash from adhering to the boiler tubes.

The gas leaving the waste heat boiler has routinely been water scrubbed and cooled. Please refer to Section 2.3.6.12 for additional information on ash collection. The gas is cooled from approximately 660° F (350°C) to about 95° F (35°C). The particulate-laden water is sent to a clarifier for solids removal. The separated clarifier solids are sent to disposal along with slag from the gasifier quench tank. The clarifier effluent is then cooled and recycled to the gas cooling and cleaning system. The cleaned and cooled gas is processed in an acid gas removal (AGR) system to produce a medium-Btu product gas.

2.3.2.2 Texaco [1]

The Texaco gasifier is a high pressure, entrained bed process developed and sponsored by the Texaco Development Corporation, White Plains, New York. The gasifier was initially developed to convert gaseous or liquid hydrocarbon feed to a low or medium-Btu product gas. This process is commercially proven, but its application to coal gasification is in the advanced development stage.

The Texaco gasifier requires pulverized coal, O_2 and steam. Pulverized coal is slurried in water (over 50% solids) before it is fed to the gasifier. It takes about 0.8-0.9 lb of O_2 per lb of coal to carry out the reaction. The reactants are injected into the upper portion of a refractory lined, cylindrical, partial oxidation chamber and the gases flow downward. The reaction is carried out under high temperatures (2200° F (1204° C)) and pressure (600-1200 pounds per square inch gauge, or psig). A portion of the feed coal is burned to provide heat to gasify the remaining coal and to vaporize water in the slurry. At the high reaction temperatures the ash in coal becomes molten and a portion forms slag droplets which fall into a slag quench bath at the base of the unit. The remaining finer solid soot particles are carried along with the product gas stream. The raw product gas exits the gasifier and passes through heat recovery and water scrub systems to remove the entrained particulates. The particulate-laden water is treated in a clarifier where the solid soot is separated and recycled to the coal slurry makeup tank. The water is subsequently cooled and recycled either to the coal slurry system, slag quench bath, water scrubber, or wastewater treating. The cleaned and cooled gas is processed in an AGR system producing a medium-Btu product gas.

2.3.2.3 Babcock and Wilcox [1]

The Babcock and Wilcox (B&W) coal gasifier is a medium pressure, entrained bed slagging process developed by the Babcock and Wilcox Company, Barberton, Ohio. The B&W gasifier was demonstrated in a semi-commercial unit and other pilot scale units in the 1950's. This system has undergone comparatively little recent developmental work and essentially no commercial applications.

The B&W gasifier requires dry, pulverized (70-90% through 200 mesh) coal and O_2. It takes about 0.8-1.0 lb of O_2 per lb of coal to carry out the reaction. Steam is not required for the gasification reaction, but the system uses about 0.05 lb of water per lb of coal for temperature control.

The gasifier is a vertical, cylindrical pressure shell with an inner shell of a tube-wall type construction which is covered with refractory in the reaction zone. The tubes above the reaction zone are uncovered. Coal and O_2 or air are injected into the lower portion of the pressure shell where the coal is gasified instantaneously at about 3400° F (1871° C). Operating pressures range from atmospheric to 300 psig. Heat losses occur rapidly, reducing the temperature of the gas leaving the gasifier to 1800° F (982° C). Heat from the rising gases is recovered by the boiler feed water flowing through the water wall tubes.

Since the operating temperature is above the ash fusion temperature, the ash in coal forms a molten slag. This slag is continuously withdrawn from the gasification chamber into a slag quench tank at the base of the unit, discharged intermittently into a slag lock hopper, and sluiced to disposal. The remaining ash or char particles exit the gasifier with the hot gases. This ash is collected in cyclone collectors and recycled to the reaction zone to recover unreacted carbon from the first pass.

The exit gas is further cooled in a waste heat boiler where additional steam is generated, and then passed through a second set of cyclones provided for char separation. This char is recycled to the gasifier. The raw gas is subsequently cooled and cleaned using a venturi water scrubber and packed tower. Particulate-laden scrubber water is treated in a clarifier where solids are separated and sent to disposal with the slag. Clarified water is recycled to the scrubber or discharged. The cooled, clean gas is finally treated in an AGR system producing an intermediate pressure, medium-Btu product gas.

2.3.2.4 Lurgi Dry-Ash [1]

The Lurgi dry-ash gasifier is a medium pressure, fixed bed process developed by Lurgi in Germany during the mid-1930's. Since then a number of commercial plants have been installed worldwide. Several commercial U.S. coal gasification projects in the planning stages have utilized the Lurgi gasification process for conceptual and detailed designs. Most of these proposed plants are based on producing synthetic natural gas (SNG) from Western bituminous or lignite coals.

The Lurgi gasifier requires sized coal (1/8" x 1 1/2"), O_2 and steam. It takes about 0.6 lb of O_2 and 2-3.2 lb of steam per lb of coal to carry out the reaction depending on the kind of coal used. The gasifier operates at pressures of 350-450 psig and utilizes a water jacket to produce steam from heat escaping from the gasifier shell.

Sized coal is introduced into the top of the gasifier through a coal lock hopper. A distributor is used to spread the feed coal evenly over the coal bed. Coal moves downward in a plug flow manner as the carbon is converted into a gas. In order to use caking coals, such as eastern U.S. coals, it is necessary to install a stirring arm in the reaction bed. This prevents the coal from adhering to adjacent coal fragments and clogging the reaction bed. Eventually the coal ash remaining at the bottom of the reactor is withdrawn from the gasifier by means of a moving grate. Ash drops into an ash lock hopper and subsequently is sent to disposal.

Steam and O_2 are introduced through the moving grate at the bottom of the gasifier to effect the gasification reaction. Excess steam is added to prevent clinker formation on the grate. As the steam and O_2 pass up through the bed of coal, 4 different reactions and temperature zones can be identified. They are, from bottom to top, carbon combustion at 1800°-2500° F (982°-1371° C), gasification at 1200°-1500° F (649°-816° C), devolatilization at 1000°-1200° F (538°-649° C), and drying at 700°-1000° F (317°-538° C). As the coal descends through the bed, some volatile matter in the coal is first driven off and the remaining carbon is gasified and combusted.

The crude product gas leaves from the top of the gasifier at temperatures of 700°-1000° F and passes through a series of scrubber coolers and heat recovery systems, where additional steam is generated. The wash waters and condensates from these processes would contain a small amount of particulate and a variety of organic compounds generally characterized as tars, oils and phenols. Depending on the point in the process where the condensate is removed, it would be sent to either a tar/liquor or oil/liquor separator. After the tar and oil have been separated from the wastewater, the wastewater streams are combined and sent to phenol and NH_3 recovery processes. The resulting wastewater can then be treated using appropriate physical, chemical or biological treatment processes and discharged or recycled to the process.

Cooled and cleaned gas leaving the final cooler is treated in an AGR system producing an intermediate pressure, medium-Btu product gas. Byproduct naphtha would be recovered from condensate collected in a cooling step prior to acid gas removal. Each of these byproducts (tars, oils, phenols, NH_3, and naphtha) would require careful handling to preclude adverse impacts on occupational health or environmental contamination. Some of these byproducts could be sold and others, such as the recovered organics, recycled to the gasifier.

Two unit operations unique to the Lurgi process that would require special attention are the crushing and screening of coal in preparation for gasification and the coal feed method. When sizing the coal for gasification, fines would be generated requiring appropriate control methods to prevent not only air pollution but, also, a loss in overall plant efficiency. Although a Lurgi using non-caking coals cannot gasify most of the fines, Lurgi gasifiers may be able to use a significant fraction of the fines from agglomerating eastern coals. Remaining fines would be burned in an auxiliary boiler to produce process steam and mechanical power.

The second process unit that would require close attention is the lock hopper method of feeding coal to the gasifier. Being at the top of the gasifier, the lock hopper comes into direct contact with the raw product gas when coal is fed to the gasifier bed. A portion of this raw product gas enters the coal lock hopper during feeding and then must be purged from the system when the lock hopper is depressurized and opened to add more feed coal. Without appropriate controls the purged gas from the lock hopper would be a source of emissions containing a number of organic compounds that may be harmful to the plant workers or the public.

2.3.2.5 British Gas Corporation/Lurgi Slagging[2]

The Lurgi slagging gasifier is an intermediate pressure, fixed-bed, slagging process being developed by the British Gas Corporation (BGC), Westfield, Scotland. Development of a slagging version of the Lurgi gasifier began in 1953 in Germany. A pilot slagging gasifier was purchased by the Ministry of Power and moved to England in 1955 where developmental work continued off and on until 1964 when work was indefinitely halted. In 1974, under the sponsorship of a number of U.S. companies, the BGC began modifying one Lurgi gasifier at the Westfield, Scotland, facility to operate under slagging conditions. BGC has successfully operated this one semicommercial scale gasifier, and it has been found that high-ash, high-moisture coals can present some operational problems to a slagging gasifier. Based on results of these tests, a 3800 TPD coal gasification plant is being designed using slagging Lurgi technology.

The slagging Lurgi requires sized coal (1/8 in - 1 1/2 in diameter), O_2 and steam. It requires about 0.52 lb of O_2 and 0.28-0.41 lb of steam per lb of coal to carry out the reaction. The gasifier operates at pressures ranging from 60-370 psig and utilizes a water jacket to produce steam by recovering heat escaping from the gasifier shell.

The slagging Lurgi operates very similar to the Lurgi dry-ash described in Section 2.3.2.4. Coal is introduced into the top of the gasifier from a lock hopper and moves downward. As the coal descends, some volatile matter in the coal is driven off and the remaining carbon is gasified and combusted. Steam and O_2 are mixed and fed through tuyeres (nozzles) in the gasifier wall near the base of the reaction chamber to effect the gasification reaction. The reaction bed uses a stirring arm to allow efficient processing of caking coals. Coal ash becomes molten at the bottom of the gasifier and is continuously removed from the system through the slag tap hole. Slag drops into a slag quench vessel and is then removed for disposal through a slag lock hopper at the base of the unit.

As steam and O_2 pass through the bed of coal, temperature stratification occurs as in the Lurgi dry-ash gasifier. The temperature in the coal combustion zone is 2300°-2500° F (1260-1371°C). The temperatures in the gasification, devolatilization and drying zone are estimated to be similar to those occurring in the Lurgi dry-ash gasifier.

The crude product gas leaves the top of the gasifier at an estimated temperature of 700°-800° F (317°-426°C) and passes through a series of gas cooling and cleaning processes. The wash water and condensate are treated to remove tars, oils, NH_3 and phenols as byproducts. The resultant wastewater is given appropriate physical, chemical or biological treatment to remove trace constituents and then is discharged to a receiving stream or recycled to the process.

The cooled and cleaned gas is treated in an AGR system to produce an intermediate pressure, medium-Btu product gas. Naphtha is recovered from the product gas stream as a byproduct prior to AGR. As with the Lurgi dry-ash gasifier, these byproducts would require careful handling to prevent adverse impacts on worker health and to avoid environmental contamination due to accidental spills. The recovered organics could be recycled to the gasifier, and the other byproducts sold.

The slagging Lurgi uses the same coal preparation and coal feeding methods as the Lurgi dry-ash and would therefore require close control to prevent significant releases to the environment. It would be necessary to burn any coal fines which cannot be gasified in an auxiliary boiler. The basic objective behind developing a slagging Lurgi is to supply the gasifier with only the steam required to gasify coal. With a Lurgi dry-ash gasifier, excess steam is added to prevent clinker formation on the ash removal grate. By reducing the steam input to the system, the combustion zone temperature rises above the ash fusion point, allowing removal of ash as a liquid slag. Furthermore, changing from non-clinkering to slagging conditions results in a five-fold reduction in steam requirements. This results in a higher thermal efficiency and a higher crude gas output per unit input of coal than those of the Lurgi dry-ash gasifier system.

2.3.3 Utility and Waste Characteristics of Gasifier Processes

As part of TVA's gasifier screening studies, a number of factors were evaluated to determine the relative environmental acceptability of each gasifier.

Selected parameters from conceptual design studies have been summarized in Table 2-7 to show a number of differences between the 5 gasifier systems. Because a consistent design basis was used (i.e., percentage of sulfur in coal, percentage of sulfur removal), there were no significant differences in certain parameters, such as tail gas emissions, and this data is not included in this table.

2.3.3.1 Utility Requirements

A number of factors were considered in evaluating the 5 selected gasifiers. One of the initial concerns was the utility requirements. As Table 2-7 shows, a 4-module plant using K-T technology requires the greatest amount of power to operate followed by Texaco, B&W, Lurgi dry-ash, and the slagging Lurgi. The larger power requirements for K-T results primarily from the need to compress the hot raw product gas prior to AGR. The other gasifiers are pressurized systems and do not require large amounts of additional gas compression at this point in the process.

Evaluating power requirements is complicated by the fact that these gasifiers can utilize waste heat recovery systems to generate fairly high quality steam. This steam can be used in the gasification and gas cleanup operations or used to drive large

TABLE 2-7

SUMMARY OF GASIFIER UTILITY
REQUIREMENTS AND MATERIAL BALANCES

4-MODULE PLANT

Evaluation Factors	K-T	Texaco	B&W	Lurgi dry ash	Lurgi Slagging
Power Consumption, MW	804	280	256	162	76
Coal Fines to be Burned In Auxiliary Boiler, TPD*	--	--	--	5,000-6,500	6,500
Makeup Water Requirements, gpm	20,100	19,600	16,000	31,000	15,000
Gasifier Slag, TPD	990	3,040	2,580	--	3,250
Gasifier Ash, TPD	3,070	--	860	3,250	--
Tars	--	--	--	(recycled to gasifier)	
Oils, B/D	--	--	--	1,620	1,830
Phenol, TPD	--	--	--	53	81
Ammonia, TPD	--	--	--	252	57
Naphtha, B/D	--	--	--	2,080	1,351

*The K-T, Texaco, and B&W gasification processes can utilize coal fines. The Lurgi processes require sized coal (see Section 2.3.2) and cannot utilize coal fines, which are generated in the coal sizing, in the gasification process. This lost energy needs to be recovered in an auxiliary boiler.

plant components such as gas compressors. There are a number of technical tradeoffs available as steam use is optimized. TVA initially considered burning additional coal to meet most of the process steam and mechanical drive requirements. Analysis of the environmental impacts of such a coal-fired boiler, especially the emissions to the air and the solid wastes, indicated that they could be significant unless reduced. Based on this analysis plus technical and economic considerations, TVA concluded that it was preferable to eliminate the auxiliary coal boiler where possible. Electric power from the TVA grid and limited use of clean product gas would be used where possible. The burning of product gas results in extremely low levels of emissions and was not viewed as a significant environmental concern.

Since the Lurgi processes would not be able to gasify all of the fines, economics and response efficiency require that they be burned at the plant. As shown in Table 2-7, as much as 25% of the total coal input may be in the form of fines which would need to be burned. The resulting emissions to the air and solid wastes could be significant unless reduced.

Makeup water requirements (Table 2-7) for the 5 gasification systems range in flow by a factor of approximately 2. Steam consumption in the gasifiers and water for gas cooling and cleaning account for more than 95% of the total plant water requirements. The total requirements for process water range from a low of about 15,000 gpm for the Lurgi slagging gasifier to a high of about 31,000 gpm for the Lurgi dry-ash gasifier.

Water requirements of a gasification plant can potentially impact water availability and the aquatic ecosystem. The Tennessee River has an abundant supply of water at either of the 2 sites, and availability is not a concern for the proposed facility. The major concern would be the potential impact of water withdrawn on various plant or animal populations existing in the river. Adult fish impinged on intake screens are normally injured or killed. Larval fish and fish food organisms entrained in the makeup water are assumed to be destroyed. Impacts could be minimized by reducing the makeup water requirements to the lowest practical level. From this standpoint the slagging Lurgi and B&W processes look most favorable, followed by the Texaco and K-T processes which have slightly higher water requirements, and the Lurgi dry-ash gasifiers which had the highest estimated water requirements. Impingement and entrainment are related to the location and design of the intake structure as well as the quantity of water withdrawn. It is, nevertheless, apparent that the smaller the water requirements are for a facility, the easier it would be to design an intake structure that avoids or minimizes adverse impacts on the aquatic ecosystem.

2.3.3.2 Solid Waste Characteristics

There are significant differences in the solids handling requirements for each of the gasifiers. The K-T gasifier has a high ash particulate carry over (approximately 65 to 75%) in the exit gas. Removal processes would result in either a liquid sludge or dry particulate matter, both of which present significant disposal problems. All of the other gasification systems remove most of the waste slag from the base of the unit with little ash particulate carry over in the exit gas.

Another difference in the gasifier solid waste results from the gasifiers operating at different temperatures. All, but the Lurgi dry-ash gasifier, operate at temperatures above the melting point of ash. This produces a glassy slag material. The Lurgi dry-ash process produces an ash that has not melted into a slag-like material.

The different process temperatures and operating conditions probably affect the leaching characteristics of the various waste material. TVA operates a number of coal-fired power plants with combustion temperatures in the same range as the high temperature gasifiers (2800°-3200°F). Results of leaching tests conducted on fly-ash, bottom ash (slag), or scrubber sludge samples from each of TVA's power plants indicate that fly ash is more susceptible to leaching than boiler slag (please refer to Appendix B for more information). With only a few exceptions, more contaminants were extracted from fly ash than boiler slag during leaching tests. This may be due to the process temperature and resultant chemical structure of the slag, or that fly ash simply had more surface area available for water contact than did bottom ash resulting in more leaching. This leads one to expect that from a solid waste disposal standpoint, it would be more desirable to utilize a high temperature process that produces a vitreous slag similar to power plant slag.

Recent studies have provided limited information on the leachability of ash or slag from different gasifiers using various coals[4,5,6] (please see Appendix B, Table B-9). In these studies, ash or slag samples were tested using the EPA Extraction Procedure (EP). Since the leachate concentrations for EPA EP toxicity criteria pollutants were below the limits, the solid wastes were not considered to be hazardous. Although the data were limited and the variations in detection limits for measuring pollutant concentrations sometimes prevented comparisons, the metal concentrations in the leachate from gasifier slag or ash generally were within the ranges of values reported for boiler slag at TVA power plants. For further discussion of these studies, please refer to Appendix B.

TVA is performing extensive characterizations of solid wastes from both preferred technologies (Texaco and K-T) using design coal (see Appendix B). Results of these studies would be used in selecting the disposal option from those outlined in Section 2.3.6.11.

2.3.3.3 Process Byproducts

An important consideration used to evaluate the relative environmental acceptability of each of these systems was byproduct production. The presence of unwanted byproduct tars, oils, phenols, NH_3, and naphtha was determined to be a significant disadvantage of the Lurgi systems. Systems producing numerous byproducts would require a more complex waste treatment system, as well as careful handling and disposition of the potentially hazardous byproducts. A process advantage of the high temperature (K-T, B&W, and Texaco gasification) systems is that they do not produce significant amounts of these byproducts. Other byproducts such as sulfur and industrial gases are produced by all of the processes and would be sold where possible. They are not expected to pose environmental concerns.

2.3.3.4 Wastewater Characteristics (Untreated)

In order to further evaluate the environmental characteristics of the gasifiers under consideration, available information on gasifier waste constituents was reviewed. It was found that untreated wastewater from systems which produced byproduct tars, oils, phenols, and NH_3 contained a number of organic constituents. Wastewater from high temperature processes that produced none of these byproducts in significant quantities contained essentially none of these organics. Process wastewater considered in this evaluation consisted of direct contact water used for raw product gas quenching, cooling, and cleaning; and ash/slag quenching. Tabular information for these wastewaters is given in Appendix B.

The K-T gasifier wastewater is generally high in suspended solids and NH_3, but contains no tars, oils, or phenols. The major pollutant is suspended solids which is to be expected from a system with approximately 65 to 75% ash carryover in the gas stream. There is an appreciable amount of NH_3 in the wastewater as well as smaller concentrations of cyanide, thiocyanate, and oxygen-demanding compounds. Hydrogen sulfide (H_2S) was not detected in wastewater indicating that most of it remains in the gas stream during cleaning and cooling.

No direct characterization of B&W wastewater is available due to limited recent development work. Estimates of wastewater characteristics, based on projected operating conditions, indicate high levels of NH_3, thiocyanate, and oxygen-demanding compounds. B&W slag quench water is expected to be similar to that of the K-T process. A very small amount of residual organics (tars to light organics such as acetic acid) may be found in the raw product gas leaving the gasifier. These organics could potentially contaminate gas cleaning or cooling water and thereby complicate treatment.

Limited data is available on the Texaco gasifier quench water blowdown characteristics. This gasifier is undergoing development work and has an incomplete environmental data base. Preoperational studies completed on TVA's pilot Texaco gasifier to date indicates the presence of a number of compounds in the gasifier blowdown including dissolved and suspended solids, NH_3, and organic compounds. Since most of the coal ash is expected to leave the gasifier as slag from the base of the unit, there is not expected to be a large amount of suspended solids in the gasifier quench water as compared to the K-T process. The level of organic constituents in the wastewater appears to be higher than that in the K-T wastewater.

There is a marked difference in wastewater organics content between the Lurgi dry-ash gasifier (lower temperature process) and the K-T, B&W, and Texaco systems. The Lurgi wastewater contains significantly higher amounts of fatty acids, phenol, pyridines, other organics and NH_3, but little if any suspended solids. This would require careful treatment of Lurgi gasifier wastewasters.

The Department of Energy has sponsored work to convert caking coals into pipeline quality gas. The British Gas Corporation's slagging Lurgi was used by the contractor, Conoco Inc., to conduct a technical support program for the design of the plant. Pertinent results of these tests indicate that the wastewater is similar to that of the dry-ash Lurgi. Suspended solids levels are not high, but there are large amounts of NH_3 and organics. Information given in Appendix B gives an indication of the myriad of organic compounds found in Lurgi gasifier wastewater.

2.3.3.5 Air Emission Characteristics

Gasifier air emissions are closely linked to the feed coal characteristics and operating conditions of the gasifier. Each gasifier would produce a slightly different product gas, and many of the constituents existing in the raw gas would condense or be captured in gas cooling and cleaning processes. Volatile organic material, volatile trace metals and particulate matter are expected to be removed during product gas quenching, cooling, and cleaning. It is unlikely that significant amounts, if any, of these constituents would ever leave the gasification system as an air emission. Some pollutants, however, are not removed from the raw product gas during a water scrubbing process. The major pollutant is sulfur in the form of H_2S. Other trace gas components include carbonyl sulfide (COS), carbon disulfide (CS_2), mercaptans (R-SH), NH_3, and hydrogen cyanide (HCN). AGR systems can remove most (90%) of each of the trace components. For evaluation purposes it was assumed that AGR systems would be capable of removing essentially all of these compounds from the raw product gas of each of the 5 gasifiers. Differences in gasifier emissions to a large extent have been reflected under the discussion on wastewater. Emissions to the air from the gasification process tail gas cleanup system would consist primarily of CO_2, N_2, and SO_2. With present gas treatment technology, it is possible to obtain an overall sulfur removal rate of 99.8% or higher. It is anticipated that there would be emissions of CO and methanol from the selected AGR system's CO_2 vents. More detailed discussions of potential emissions to the air are found in Chapter 4 and Appendix B.

In addition to the specific potential emission from a gasifier, each system would require a certain amount of process steam generation. Various characteristics of the gasification process would determine if an auxiliary boiler is needed to generate process steam and would therefore determine the level of any air emissions coming from the auxiliary boiler. As indicated previously, these emissions could be significant for the Lurgi processes where large quantities of coal fines must be burned.

2.3.4 Environmental Evaluation of Candidate Gasifiers

The potential for the 5 gasifiers under consideration to impact the environment have been evaluated in 5 basic areas given below:

- Solid Waste Disposal
- Wastewater Treatment
- Presence of Hazardous Compounds
- Water Requirements
- Coal Fines to be Burned

Each gasifier was evaluated according to its potential for environmental impact in each of the previous criteria. This evaluation was subsequently incorporated into an overall gasifier evaluation that included a number of technical and economic factors. The 5 criteria are discussed below.

Solid Waste Disposal - Solid waste disposal would be a major undertaking and was a concern raised in the public EIS scoping meeting. Solid waste must be in such a form or disposed of in such a manner so as to protect public health. Steps must be taken to protect ground water and to prevent public exposure to solid wastes that could be harmful. This was viewed as a major environmental consideration. Each gasifier was evaluated based on the anticipated nature of waste coal-ash originating from the gasification process. The temperature of the process and the point of solids removal from the gasifiers were major considerations in evaluating the solid wastes.

Wastewater treatment - Coal gasification process wastewaters are a primary concern from the standpoint of trace toxic or hazardous constituents. These trace constituents in wastewater are viewed as possible environmental contaminants that could impact the public or the aquatic environment. It would be necessary to properly treat wastewater to prevent adverse environmental impacts. Should the wastewater contain carcinogenic organic pollutants it would probably require complicated treatment procedures.

Presence of Hazardous Compounds - Certain process byproducts were viewed as having potentially significant impacts to workers and the environment. Systems producing a variety of byproducts which might be carcinogenic require more complicated waste treatment systems and careful handling to prevent occupational exposure. The production of hazardous compounds from coal conversion processes is an issue of national significance and concern.

Water Requirements - This was considered as it related to impacts on the aquatic ecosystem. The gasification reaction would consume water unlike a conventional coal-fired electric generating plant that does not consume water during coal combustion. The smaller the water requirement, the less entrainment and impingement impacts there would be on aquatic ecosystems. Smaller volumes of discharge water, given appropriate treatment, would also result in less potential impact to water quality.

Coal Fines to be Burned - Where feasible, TVA proposes that electric power from the TVA grid or clean product gas be used to provide for the mechanical drives and/or process steam over and above that recovered from the process. This would eliminate coal-fired auxiliary boilers. Certain processes, however, cannot gasify all of the coal fines. For economic and resource efficiency reasons, these would have to be burned. A coal-fired auxiliary boiler would result in gaseous and particulate air emissions, as well as solid wastes of which to be disposed. The wastes from the auxiliary boiler would relate directly to the amount of coal fines burned.

Each of the gasifiers was evaluated according to the criteria outlined above. The following material is a discussion of the gasifier environmental evaluations.

2.3.4.1 Solid Waste Disposal

Two basic factors were used to evaluate solid waste disposal--process temperatures and point of ash or slag withdrawal from the systems. It has been noted that fine fly ash particles are more susceptible to leaching than bottom ash or slag. It is not known whether this is related to the temperature at which the fly ash was formed or the greater ash surface area available for water contact. Available information nevertheless, indicates that a vitreous slag material produced at high temperatures is less susceptible to leaching and is preferred.

Each of the gasifier solid wastes present disposal problems in terms of protecting ground water. The wastes were rated based on the potential for leaching, possible ground water contamination, and ease of handling. Available information (see Appendix B) suggests that solid waste from the Texaco (assuming recycle of entrained fly ash), B&W, and the Lurgi processes display somewhat similar leaching characteristics using EPA's extraction procedure (EP). The leachate concentrations of EPA EP toxicity criteria pollutants are similar to those of TVA boiler slag and are below the EPA EP toxicity criteria. For these 4 gasifiers, essentially all of the ash leaves the gasifier as an ash or slag from the base of the unit. The K-T process is a high temperature system, but about 65 to 75% of the coal ash is entrained in the gas stream. This large amount of fly ash represents increased potential for leaching (assuming it displays characteristics similar to power plant fly ash) and presents disposal problems in either wet or dry form. If dry disposal were used, leaching problems would be reduced. Preliminary results of TVA's overseas test at an existing coal gasification plant indicate that wet ash collection would remove certain gases from the product gas stream which may cause the wet ash to be classified as hazardous. Dry collection would not pose this problem.

2.3.4.2 Wastewater Treatment

The Texaco, K-T, and B&W gasifiers were evaluated as presenting the least potential for adverse environmental effects. The Texaco and B&W gasifier may have slightly higher wastewater concentrations of organic compounds than the K-T process. This was not viewed as being a significant difference. The K-T wastewater would have large solids separation requirements and possibly higher levels of trace elements due to the carry over of fine particulate into the gas cooling stage. The Texaco process benefits from the potential capability to recycle wastewater through the gasifier as part of the coal slurry makeup water. The Lurgi dry-ash and slagger were considered to require more complex wastewater treatment systems in order to protect the environment. The gas cleaning and cooling water requires tar and oil separation steps, followed by phenol and NH_3 recovery. The resulting wastewater contains a variety of organic compounds some of which are considered hazardous.

2.3.4.3 Presence of Hazardous Compounds

One of the environmental concerns regarding the emerging coal conversion processes is the presence of hazardous compounds in the wastes. Gasification technology can be controlled to preclude the entrance of significant amounts of hazardous materials into the ambient environment. However, present technology offers alternate choices with substantially different risks.

The K-T, Texaco, and B&W processes are high temperature systems that do not produce large quantities of potentially hazardous byproducts or wastestreams that contain significant amounts of hazardous materials. Texaco and B&W were rated somewhat lower than K-T because available information suggests that they would probably contain small amounts of trace organic constituents in the wastewater. The Lurgi systems were viewed as presenting a relatively greater risk of environmental contamination. The large number of complex organic compounds present in wastes and byproducts of the Lurgi systems have a greater potential to adversely impact plant workers and the environment than wastes from other gasifiers. Should either of the Lurgi systems be selected, adequate procedures would need to be taken to prevent or contain accidental spills of byproducts. Furthermore, extensive worker health and safety administration practices would need to be implemented and enforced to avoid exposure to harmful substances.

2.3.4.4 Water Requirements

The gasifier water requirements were considered in order to determine which system presented the greatest potential risk for entrainment and impingement losses. The slagging Lurgi and B&W

gasifiers use the least amount of water and were viewed as essentially equivalent. The Texaco and K-T gasifiers used slightly more water than the B&W or slagging Lurgi. The Lurgi dry-ash gasifier used substantially more water than the other systems and was viewed as presenting the greatest potential for adverse environmental impacts due to plant makeup water withdrawal. With proper location and design of an intake structure, impacts on the aquatic environment could be reduced to insignificant levels for all technologies.

2.3.4.5 Coal Fines to be Burned

The gasification systems were evaluated from the standpoint of environmental impacts resulting from burning coal fines in an auxiliary boiler. The Lurgi dry-ash and slagging Lurgi required an auxiliary coal fines burn, while the K-T, Texaco, and B&W gasifiers did not. It follows that the Lurgi gasifiers would have a significant potential for impact on the environment due to the particulate and gaseous air emissions and solid waste from the auxiliary boiler. With proper plant design and optimization of steam use, impacts from the auxiliary boiler emissions would be minimized, but they still could constitute a major fraction of the air emissions from the plant.

2.3.4.6 Conclusions

From an environmental standpoint, the B&W, K-T, and Texaco systems are considered equally acceptable and are preferred over the others. The K-T gasifier suffers the drawback of having a large amount of fly ash for disposal. The Texaco process offers the potential advantage of wastewater recycle to the gasifier due to the method of feeding coal to the system. The Lurgi gasifiers generally presented the greater potential for environmental impacts because of the presence of hazardous compounds in the wastewaters, potentially contaminating the environment; higher utility requirements; and the need to burn coal fines. If either of the Lurgi systems were chosen for technical or economic reasons, they would require more complicated environmental controls. It is believed, however, that the risk of environmental contamination for all systems would be reduced to an acceptable level through the addition of suitable control technology.

2.3.5 Gasifier Technology Evaluation

As the project proceeded from the conceptual design phase to detailed design and large-scale coal testing, it was necessary to reduce the number of processes analyzed from 5 to 2 processes. To ensure a commercially viable demonstration, the 4-module plant would consist of no more than 2 processes. The final process choice for the first 2 modules depends on technical, environmental, and economic considerations.

A principal question is whether the gasifier would work reliably and cleanly once it has been constructed. This requires an assessment of the technical risks associated with the process and the level of effort needed to resolve them in a timely manner.

Such resolutions are best accomplished by testing coal representative of that which would be used in the proposed north Alabama coal gasification plant in an existing gasifier in an integrated plant at a level of 100 TPD of coal or larger. This limits gasifier scale-up for the commercial plant to about a factor of 10. (Each 5,000 TPD module would incorporate several gasifiers in parallel.) It also permits the collection of meaningful operational data, including key effluents.

The remainder of the section discusses the technical risks associated with each technology and the opportunities available for testing the design coal on a significant scale. The need to test eastern coal (dictated by the current design), permitting requirements, and the construction schedule is a significant factor in selecting a technology.

2.3.5.1 Koppers-Totzek

Since this is a commercially used technology, the primary risks are associated with applying the process to the specific design coals under technical, environmental, and economic constraints. Most of the experience overseas is with a 2-headed gasifier design, but economics suggest that a 4-headed design with higher throughput should be used for the proposed application. There has been limited experience in India with the 4-headed design which indicates that the 4-headed design has no process-related problems. Routine mechanical and electrical maintenance would be required as it is for the 2-headed design.

The design coal was tested at an existing K-T, 2-headed, commercial gasifier in Ptolemais, Greece, to confirm the design parameters for the proposed application. Effluents were sampled to support the design of appropriate environmental control systems. The results of these studies are presently being evaluated.

2.3.5.2 Texaco

Although Texaco has extensive commercial experience in gasifying heavy oils and other petroleum refining residuals, the Texaco process has never been used commercially to gasify coal. The risks are therefore concentrated in the subsystems involving coal preparation, gasification, and heat removal where coal slag is prevalent. Steps further downstream can be based on commercially available processes. Recovery of high temperature steam from the ash-laden raw product gas, scale-up of the gasifier by a factor of about 10 and preparation of a high concentration coal-water slurry using the design coal are among the most serious technical risks. Other risks involve the long-term reliability of instrumentation, controls, and materials.

Eastern U.S. coal has been tested at the 150 TPD Ruhrchemie plant in Oberhausen-Holten, Germany, in cooperation with the Electric Power Research Institute. It has a heat recovery system similar to that proposed for the north Alabama coal gasification plant. Effluent data collected during the test is now being analyzed and would be used to support the design of appropriate environmental control systems. TVA's recently completed 200 TPD ammonia-from-coal plant at Muscle Shoals will be operated in a water quench mode using a wide variety of coals, including those in the design range (Illinois No. 6 and Kentucky No. 9) for the proposed facility. To the extent practicable, data from this plant would be used to support the north Alabama plant design.

2.3.5.3 Babcock & Wilcox

The B&W gasifier was developed and tested on pilot and semi-commercial scale units in the 1950's, but the efforts were discontinued, and the facilities no longer exist. None of these units were operated under the pressure and capacity now being proposed. The new B&W gasifier design, however, is based on B&W's extensive pulverized coal technology base.

The list of technical risks reflect the fact that the proposed design is based on successful integration of many concepts some of which have not been commercially demonstrated. This includes special large-scale heat exchangers, dense phase coal feed, particulate removal, raw gas compression, and control systems.

With no existing facilities to test the design coal at a commercial or semi-commercial scale, it does not appear possible to overcome these risks in time to support the proposed project schedule.

2.3.5.4 Lurgi Dry-Ash

The conventional dry-ash Lurgi gasifier is in commercial use in the South African SASOL plant and elsewhere using noncaking coals. In the past, smaller size units in western Europe have operated commercially on weakly caking European coals and have successfully tested some U.S. caking coals. Based on this successful commercial experience, especially in South Africa, the dry-ash Lurgi is generally regarded as the most desirable process for noncaking coals when synthetic natural gas or fuel gas is desired.

The major technical risks associated with use of the dry-ash Lurgi in this proposed application involve the reliability of coal stirrers, particularly at the large size proposed to handle caking coals, and the recycle of fines, tars, and oils and disposal of other byproducts in an environmentally acceptable manner. While solutions to these problems have been proposed, they have not yet been proven in an integrated system at commercial or semi-commercial scale.

To rectify the situation, Lurgi has begun a program to modify one of the gasifer units at SASOL (South Africa) to test caking coals at a commercial scale. This unit should be available for testing in the summer of 1981.

2.3.5.5 British Gas Corporation/Lurgi Slagging

The slagging Lurgi has evolved from the conventional Lurgi and is now in advanced development by British Gas in Westfield, Scotland. A conventional Lurgi gasifier was modified to operate in the slagging mode at a rate of 300 TPD. Over a several-year test program, nearly 50,000 tons of coal have been gasified. A larger 600 to 700 TPD gasifier is being built by British Gas for operation in the fall of 1982.

The risks associated with this technology are essentially similar to those associated with operating the conventional Lurgi on eastern U.S. coals plus the risks associated with long-term, full-scale operation of the gasifier in a slagging mode.

It would be possible to test the design coals at the existing 6-ft slagging Lurgi test unit in Westfield, Scotland, but longer term semi-commercial operation would not be possible until late 1982.

2.3.5.6 Conclusions

Four gasifier technologies are at a state of technical readiness where they could be considered for this project; 2 entrained gasifiers--K-T and Texaco, and 2 fixed bed--Lurgi Dry-Ash and British Gas Slagging Lurgi.

The estimates of gas cost developed by 3 architect-engineering firms in their conceptual designs (available through the National Technical Information Service) indicate that some of the processes would produce lower cost gas than other processes. These cost differences, however, are well within the accuracy range of the estimates themselves. Technical problems, delays or other events which could affect the various gasifier designs differently could shift the economic balance.

Design and operational considerations suggest that it would be easier to build a gasification plant using either entrained bed or fixed bed gasifiers rather than a combination of entrained bed and fixed bed. The differing subsystems, such as waste and byproduct handling, would result in 2 plants on the same site if 1 of each were chosen (rather than a single integrated plant).

The fact that this proposed application would use eastern caking coals to produce a significant fraction of synthesis gas favors entrained gasifiers over fixed bed gasifiers. The conventional Lurgi is being used commercially on noncaking coals. It produces a combination of H_2, CO, and methane (CH_4) which is particularly useful if the ultimate product is SNG or fuel gas, but is a disadvantage for feedstock applications because CH_4 must be removed.

From an environmental point of view, as discussed in Section 2.3.4, entrained bed gasifiers, because of their higher operating temperatures, appear to have fewer inherent environmental problems. Technical solutions of the special environmental problems of fixed bed gasifiers have been identified but these have not been demonstrated yet in the U.S. on a commercial scale.

For these reasons, the 2 entrained technologies--K-T and Texaco--were selected as the preferred gasification processes to be evaluated in the final conceptual design and testing phase.

The K-T process appears to produce more costly gas than the Texaco process, primarily because it is an atmospheric pressure process. The market requires a high-pressure product, and it is more costly to pressurize the raw gas from a K-T gasifier than it is to pressurize the coal feedstock to a Texaco gasifier.

TVA, therefore, initiated final conceptual designs for the K-T and Texaco processes by C. F. Braun, an architect/engineer firm, and made arrangements for large-scale testing at K-T and Texaco gasifier installations in Europe. The Texaco test conducted with the cooperation of the Electric Power Research Institute at the Ruhrchemie plant in Oberhausen-Holten, Germany, was completed in November 1980. The K-T test was conducted at the Nitrogen Fertilizer Industries plant in Ptolomais, Greece in March and April 1981. The data from both tests are currently being analyzed. Process and environmental data were collected during these tests.

2.3.6 Description of Proposed Action

The preferred alternative is to construct the first 2 modules of the coal gasification plant at Murphy Hill using either Texaco or K-T gasification technology. As indicated previously, the plant would produce MBG composed primarily of H_2 and CO. This gas would initially have 2 basic applications--as feedstock to produce chemicals and liquid fuels and as feedstock to produce SNG. Figure 2-4 is a general site plan for the preferred alternative. The gasification plant and ancillary facilities have been placed as far away from the shoreline as practicable to eliminate or minimize visual and noise impacts to the public living opposite the plant site on the other side of the river.

The following is a general description of the basic plant components. Where appropriate, alternative locations or designs for certain plant components, such as the coal unloading facility and intake structure, are described and the preferred options are identified. To facilitate the reader's understanding of the proposed gasification facility as presently envisioned, we have provided 2 process flow diagrams, Figures 2-5 and 2-6, based on K-T and Texaco gasification technology, respectively.

2.3.6.1 Coal Receiving and Storage

Coal would probably be shipped from southern Illinois, western Kentucky, Tennessee, and/or Alabama, to the Murphy Hill site by barge and unloaded using conventional unloader technology. Three basically different barge docking and coal unloading facility locations were identified and studied. As indicated in the DEIS, one option (Option A) was to locate the facility in the inlet north of the site between the meteorological tower, ash pile, and dead coal storage area (see Figure 2-4, General Site Plan). Disadvantages of this location were cost, environmental implications involving

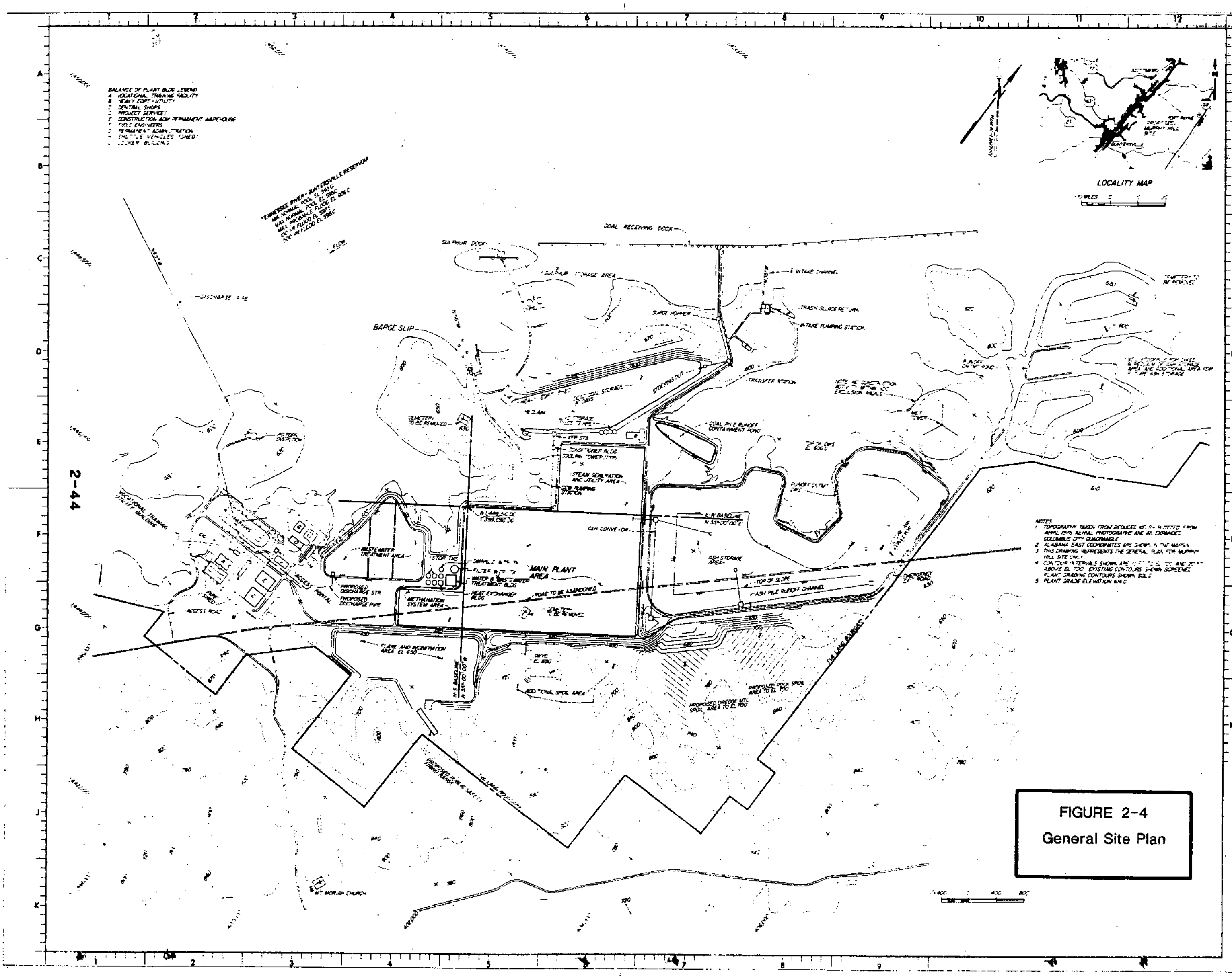
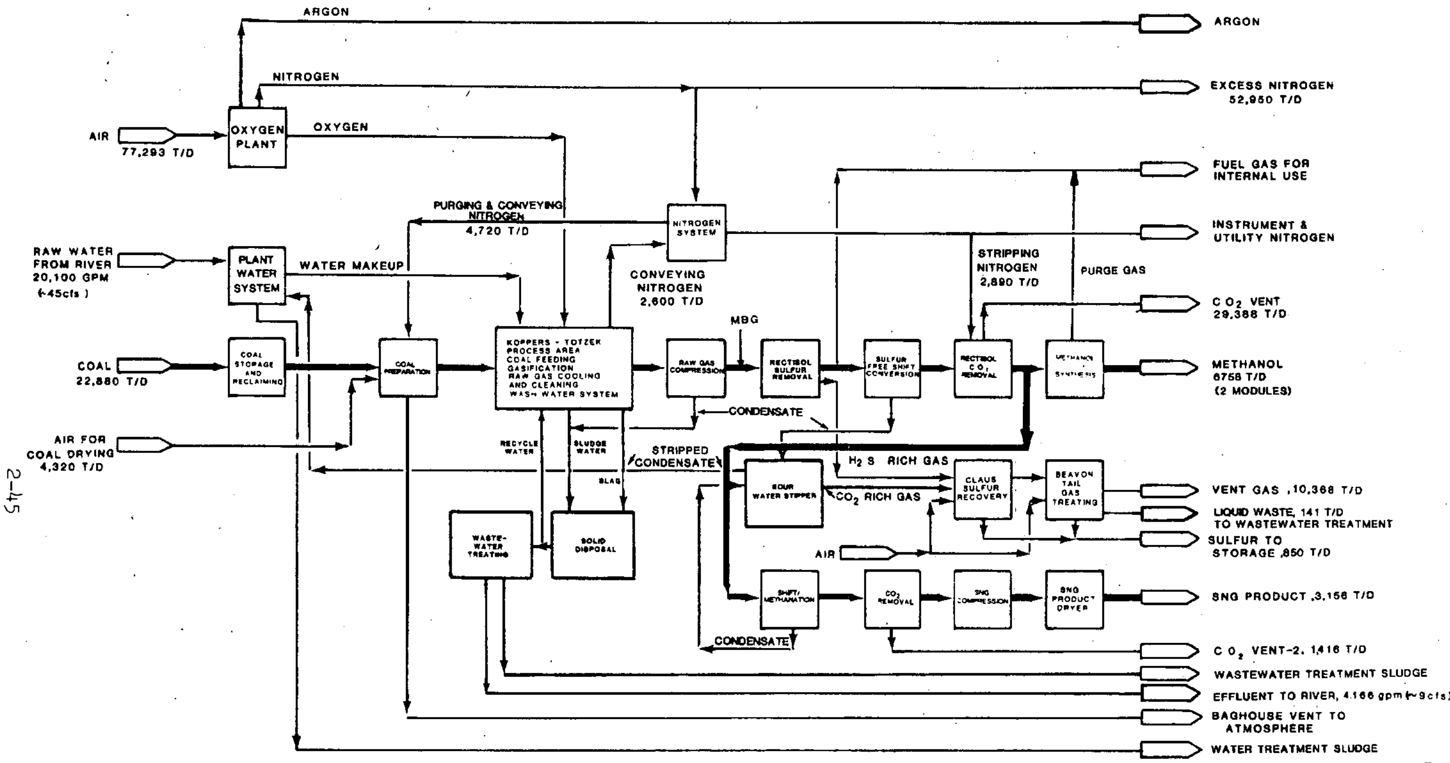


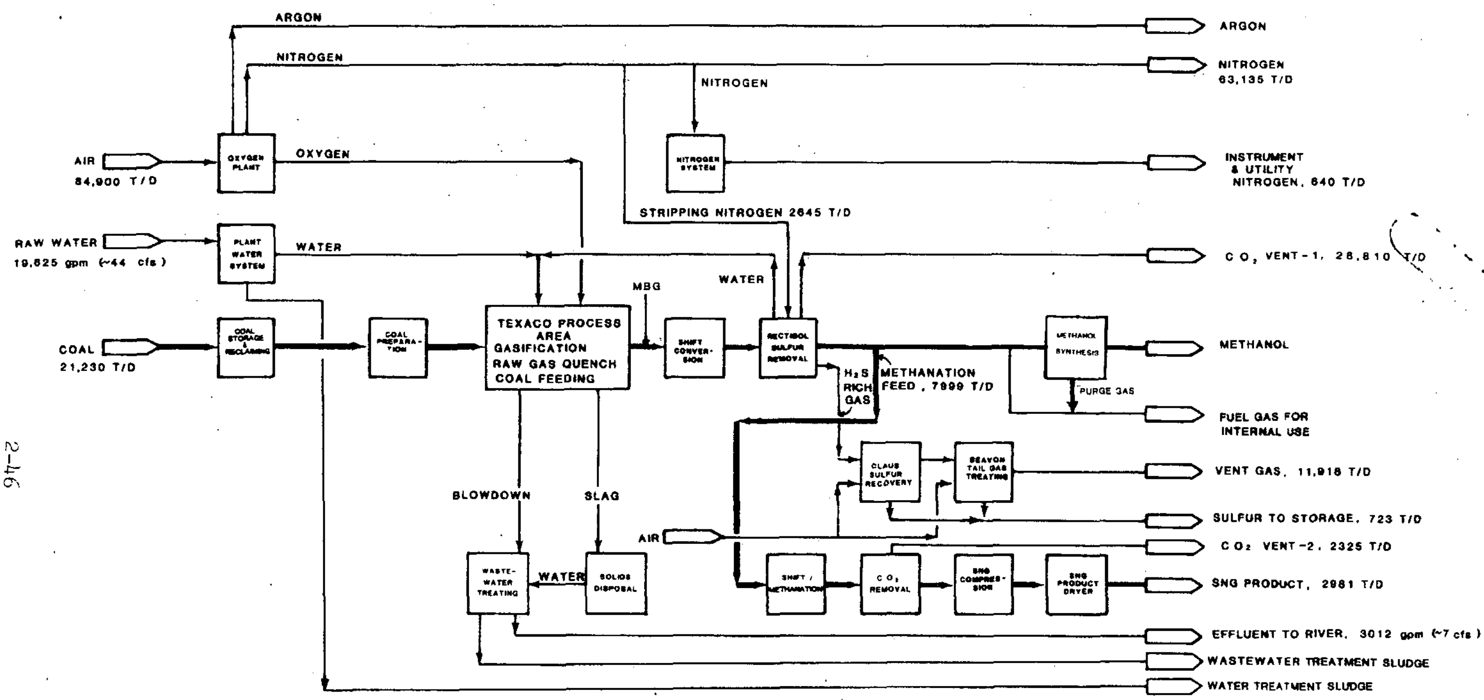
FIGURE 2-4

General Site Plan



TVA PROPOSED
COAL GASIFICATION PLANT
KOPPERS - TOTZEK PROCESS
FOUR MODULES
BLOCK FLOW DIAGRAM

FIGURE 2-5



TVA PROPOSED
COAL GASIFICATION PLANT
TEXACO PROCESS
FOUR MODULES
BLOCK FLOW DIAGRAM

FIGURE 2-6

extensive dredging in a productive overbank* area of Guntersville Lake, barge navigation difficulties, and engineering problems associated with coal unloading and handling equipment.

Another option (Option C) was to locate the facility approximately 2700 ft offshore at the secondary channel with a connecting tressel/causeway to the Murphy Hill site. Disadvantages of this location were the high initial cost, potential problems associated with lake flood protection, safety impacts to river traffic, and potential noise and visual impacts to residences on the opposite bank of the lake. The third and preferred option (Option B) is to locate the facility as shown in Figure 2-4 approximately 500 ft offshore with a connecting causeway. Locating the facility at this point (minimum 450 ft from 590 contour to inshore side of mooring cells) optimized the combined costs for channel dredging and coal handling equipment. Environmental effects of dredging and barge traffic on productive overbank areas were reduced by locating the facility away from the most productive areas to the extent practicable. Siltation records for Guntersville Lake indicate that lake siltation effects on the site area are minor. Maintenance dredging of the navigation channel under this option would therefore be minimal and localized with a possible frequency of once every 5 to 10 yr.

The barge docking and coal unloading facility would have the capability of mooring empty and loaded barges. A "barge puller" system would be used to aid in the coal unloading operations, minimizing tug boat use as much as possible. It is estimated that this facility would have an 80,000 to 120,000 cubic yard (yd^3) rock-filled causeway and 36 steel sheet pile cells comprised of 31,000 to 40,000 yd^3 of granular fill, 25,000 ± yd^3 of unclassified excavation, and 4,000 ± yd^3 of fill concrete. Two larger cells would be used to support the coal unloading structure. Dredging of the required navigation channel to an elevation of 580 ft would require approximately 234,000 ± yd^3 of excavation. Dredge spoil would be disposed of onsite (see Figure 2-4) in an environmentally acceptable manner. Dredging depths would vary from a minimum of no dredging in some areas to a maximum depth of approximately 10 ft. Overdredging to reduce maintenance dredging is not considered necessary due to the low siltation levels existing in Guntersville Lake. Construction of the coal dock would be a Section 10 and 404 regulated activity.

Options other than the solid rock-filled causeway were considered for connecting the coal unloading dock to the site, but for a number of reasons, the solid causeway was selected for use. It was determined that culverts or other openings in the causeway were not needed for flood control. The causeway, while displacing a small amount of natural biological habitat, provides new and additional substrate (rock fill) for aquatic organisms to utilize. Further, the causeway provided a solid foundation for constructing

*Overbank is generally defined as those areas of the lake which were not a part of the original Tennessee River streambed or its immediate floodplain.

the coal unloading equipment and for other uses during construction. It also proved to be the simplest to construct with the least costly method of connecting the coal dock to the site. A rock-filled causeway was also selected for use with the sulfur dock (see Section 2.3.6.18).

Coal received at the site would be transported by a covered conveyor system to the coal storage and reclamation area. A 90-day supply of coal would be stored onsite. The coal storage area would be designed and constructed to prevent coal pile runoff from contaminating ground water or surface water. This could be accomplished by using manmade contours to direct runoff into holding ponds or to the wastewater treatment area for treatment as appropriate.

2.3.6.2 Coal Preparation

Coal would be transported to live storage silos that would feed the coal preparation units. The K-T process requires dry, pulverized coal and would use surge hoppers, gravimetric feeders, mills, coal dryers, and pulverized coal storage hoppers equipped with bag filters and drives. The coal grinding operation would take place in an enclosed building. TVA is evaluating the possible use of mine mouth coal washing for this facility. Coal washing would significantly reduce the ash content in coal, easing solid waste disposal requirements. Some of the sulfur would also be removed. During the drying and grinding operation, coal dust would be emitted.

The Texaco process uses a wet grinding technique to pulverize coal. The pulverized coal is mixed with water to produce a coal/water mixture of the desired consistency for pumping to the gasifiers. Coal fines and significant quantities of dirty water streams recovered downstream of the gasification system are recycled to the slurry preparation.

2.3.6.3 Coal Gasification

The prepared coal is injected into the gasifier with the required amounts of O_2 and, in the case of K-T, steam. Details of the gasifier operation have been given in Section 2.3, "Gasification Technology Evaluation."

2.3.6.4 Gas Cleaning and Compression

Raw product gas flows from the K-T gasifier through water scrubbers and electrostatic precipitators to remove ash dust sufficiently to permit compression of the gas. Gas is then compressed from atmospheric pressure in the first of 4 compression stages. Between the first and second compression stages, catalytic reactors convert traces of nitrogen oxides (NO_X) and O_2 to nitrogen and water vapor. This treatment prevents the formation of solids in compressor stages 2, 3, and 4 as a result of reactions initiated under high pressure between O_2 and other gas components. The Texaco process differs in that the gasifier is pressurized and gas compression prior to AGR is not required.

2.3.6.5 Carbon Monoxide (CO) Shift Conversion

The CO shift conversion adjusts the H_2 to CO ratio of the gas to that necessary for either methanation or methanol synthesis. Steam is added to the MBG stream to provide the water required in the shift conversion step. Shift conversion may be accomplished prior to AGR, as shown for the Texaco process, Figure 2-6, or after AGR (K-T, Figure 2-5), the location depending on system integration studies. In the K-T process, shift conversion is carried out, followed by separate CO_2 removal steps. Shift conversion adjusts the H_2/CO ratio to meet the requirement for methanol production. Depending on the market requirements, a side stream of this shifted gas is piped to the second shift conversion process which is combined with the methanation reaction to produce SNG.

In the Texaco process, CO_2 removal is combined with the AGR step after the shift conversion step. Depending on market demands, a side stream of this shifted gas would be processed to produce SNG.

2.3.6.6 Acid Gas Removal (AGR)

The MBG, either shifted or unshifted, is processed in the AGR system. At the outset of the conceptual design study, a number of AGR processes were considered to be viable candidates for use in the proposed coal gasification plant. Of the many available, 5 were considered to be the more likely candidates-- Selexol, Rectisol, Sulfinol, Benefield, and Stretford. (The Stretford unit converts reduced sulfur compounds directly to elemental sulfur and does not require a Claus sulfur recovery plant.) As a result of conceptual design studies, the Rectisol and Selexol AGR systems appear to be the more favorable options. The Rectisol process appears to be the more favorable option for this facility for technical and economic reasons. Technically, the Rectisol process is commercially proven, having wide application in facilities throughout the world. This process is most suited to producing the desired products. Environmentally, the two processes are considered equivalent. Major sulfur emissions from the gasification plant do not arise from the AGR system, but rather from the sulfur recovery area. Treated MBG leaves the AGR system containing 1-5 ppm of sulfur. The CO_2 content of the MBG would depend on whether the MBG is shifted or unshifted and on which end products are to be produced.

An acid gas stream is produced by absorbing H_2S and CO_2 from the gas stream in solvent and then desorbing the absorbed H_2S and CO_2 in a stripping column. If nonselective absorption is used for AGR, then a single gas stream dilute in H_2S is produced during desorption. If selective absorption is used for AGR, then 2 gas streams are produced during desorption (a CO_2 stream clean enough to be vented to the atmosphere, and a stream relatively rich in H_2S). The stream containing H_2S is fed to a Claus plant in both the K-T and Texaco systems.

2.3.6.7 Sulfur Recovery

For both the K-T and Texaco processes, H_2S from the AGR system is converted to elemental sulfur using a Claus process unit. The Claus process is expected to obtain about 95% conversion to elemental sulfur. For low H_2S concentrations in the acid gas, the Claus plant requires supplemental fuel. Product gas or elemental sulfur may be burned for this purpose.

To limit sulfur emissions from the Sulfur Recovery area, an additional sulfur removal process is used to treat the tail gas. Tail gas treatment processes that were determined to be the most likely candidates were Beavon/Stretford, SCOT, and Wellman/Lord. As a result of conceptual design studies, the Beavon/Stretford tail gas treating unit was identified as the preferred option for the proposed facility because it was commercially proven and was capable of greater sulfur removal levels. Table 4-1 summarizes estimated emissions from the gasification plant. Overall sulfur recovery would meet sulfur recovery unit emission standards for sulfur compounds in treated tail gas similar to that required for petrochemical plants. Molten elemental sulfur produced in these units is recovered as a byproduct and stored prior to sale and transport off of the site. The facility would have a 30-day molten sulfur storage capacity.

2.3.6.8 Methanation

After the raw gas from either of the K-T or Texaco processes has been desulfurized and shifted, the gas would be sent to either the methanation or methanol synthesis areas, the amount depending on market demands for SNG and methanol feedstock.

The methanation step uses a catalyst in temperature controlled, fixed-bed reactors to convert shifted desulfurized gas to SNG. The SNG is delivered to a CO_2 removal area and then to the SNG product gas compression area. The methanation reactions are highly exothermic. Steam generated in these methanation reactions may be used for 2 purposes: first, for the previously discussed shift conversion, and, second, to supplement the total plant steam needs.

2.3.6.9 Product Gas Compression

Purified SNG from the K-T gasification plant methanation area undergoes final compression to a pressure of about 600 psig. The gas is then cooled, dried, and delivered to the battery limits of the plant.

2.3.6.10 Methanol Synthesis

Methanol syngas undergoes trace desulfurization to less than 0.1 ppm sulfur and then compression to the required methanol synthesis pressure. In methanol synthesis, CO_2, CO, and H_2 react under pressure and in the presence of an appropriate catalyst to produce methanol. Unreacted gas is separated and recycled to achieve more efficient conversion. A purge gas stream rich in combustible (H_2 and CO) is withdrawn from the recycle gas to prevent accumulation of inerts (CO_2 and N_2) and is used as fuel in the gasification plant.

Crude methanol undergoes distillation, resulting in the production of 1 gas stream and 3 liquid streams. The gas stream containing H_2, CO, CO_2, methane, methanol, and small quantities of low-boiling ethers, formates, ketones, aldehydes, and acetates is burned as a fuel gas. The liquid streams are (1) the refined methanol, (2) the heavy ends (ethanol and higher alcohols), and (3) a wastewater stream. The heavy ends are burned as a fuel oil. The wastewater stream may contain trace amounts of dimethyl ether, methyl formate, methanol, ethanol, and higher alcohols. This stream is very small compared to the total quantity of plant wastewater and would be treated in the wastewater treatment system. Both crude and refined methanol would be stored in tanks located within diked areas. Vapor emissions from these tanks would be controlled.

The amount of additional water makeup required and wastewater discharged by up to three methanol synthesis units (for a four-module plant) is not anticipated to be a significant increase over those values assessed in this EIS. However, if the increases were determined to be significant then the capacity and design of these methanol units and related modifications to water use facilities would be evaluated under TVA's NEPA procedures as part of its 26A review process as well as the Corps Section 10 and 404 permit review procedures.

2.3.6.11 Air Separation Plant

Oxygen required for gasification in both gasifiers is produced as 99.5% O_2 with an air separation plant. The gasification process requires approximately 4,400 TPD of O_2 for each 5,000 TPD gasification module. Principal components of the air separation plant are: air compression, low temperature air fractionation, and O_2 compression to slightly above atmospheric pressure for K-T gasifiers and approximately 1,000 psig for Texaco gasifiers.

Liquid O_2 storage and high pressure gaseous O_2 storage may be provided as backup supplies of O_2 during outage of the air separation plants. In addition, atmospheric pressure O_2 gas holders are provided as required.

The air separation plant also produces nitrogen which may be used as a conveying medium for pulverized coal for the K-T process and as inert gas for blanketing and instrument service.

2.3.6.12 Ash and Slag Handling

Table 2-7 in Section 2.3.3 summarized the tonage of ash and slag expected to be produced per day from the gasification plant. Depending on the coal, the ash content could range from 10% to 15% of the total coal or 2,000 to 3,000 TPD of ash being produced by a 4-module plant. Studies on coal ash at TVA's power plants indicate that the elements aluminum, iron, and silica comprise as much as 85% to 90% of the total ash. An additional 10% to 15% of the total ash is made up of calcium, magnesium, potassium, chloride, titanium, sulfur, and sodium. The remaining small percentage of ash is comprised of a number of trace elements including antimony, arsenic, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, and zinc. Reference 3 contains more detailed information on trace element concentrations in coal and ash.

Slag and ash disposal options were evaluated during this study. There are 3 basic disposal options: (1) wet collection and sluicing to a settling pond for final disposal, as is done at most of TVA's coal-fired power plants; (2) wet collection and sluicing to a settling pond, ash dewatering, and disposal in a "dry" form; and (3) dry collection and transport to the disposal area and dry disposal. The cost of constructing large disposal ponds at Courtland could be substantial due to the geological conditions of the area. Wet disposal of all the ash at Murphy Hill would require the acquisition of additional land. Consequently, it was determined that disposal of the ash and slag in a dry form is preferred. The actual collection and disposal process has not been determined yet.

A number of ash and slag engineering properties affect the feasibility of disposing of ash and slag in dry form. Among these engineering properties, the moisture content of and ability to remove water from the ash and slag is an essential concern if dewatering is required. If these properties are, unexpectedly, such that stacking ash and slag to the desired height is infeasible, additional land may eventually have to be acquired at the Murphy Hill site. Other options such as reducing the ash content of the coal used and sale of the slag would be considered. In any event, the acquisition of additional land for ash and slag disposal would be evaluated under applicable environmental review procedures. As part of its large-scale coal testing program, TVA has undertaken tests to determine the engineering properties of the ash and slag produced in K-T and Texaco gasifiers. Preliminary results indicate that because of difficulties in dewatering wet ash, it is preferable to mechanically separate the ash in dry form before stacking it as proposed. If the ash cannot be captured dry, wet disposal of the ash and slag during an interim period of operation will have to be considered, thereby providing additional time to refine the ash dewatering process. TVA is continuing its studies of the engineering properties of both wet and dry ash.

Continuing tests will also include an evaluation of the chemical composition of the waste ash and slag and the potential toxicity of runoff, effluents, and leachates. Preliminary results of TVA's overseas tests at existing coal gasification plants indicate that wet ash collection would remove certain gases from the product gas stream which may cause the wet ash to be classified as a hazardous waste. These potential problems are not expected to arise if the ash is collected dry. TVA is continuing its studies of the chemical properties of both wet and dry ash. Should the waste not be classified as "hazardous", disposal areas, nonetheless, would be designed such that ground water beyond the boundary of the waste disposal area would not be toxic to aquatic life and would meet applicable drinking water standards. One possible option would be the use of a liner in the disposal area to protect the ground water. Natural conditions at the site, such as soils, bedrock, topography, and groundwater flow patterns could be sufficient to protect the ground water. Investigation would continue to define further the foundation requirements. While the final disposal method has not been selected, the following is presented for information.

In the K-T gasifier, approximately 65 to 75% of the coal ash would be entrained with the raw gas and would flow through the waste heat boiler. At this point two options would be available. The first option, and the one used at most K-T gasifier installations, would be to route the ash entrained gas directly to the washer/cooler where most of the ash would be separated from the gas and slurried to the ash and slag handling area. The second option which has seen limited use in commercial installations, although considered practical by the gasifier manufacturer, would be to collect 80 to 90% of the entrained ash in dry form in a mechanical separator installed between the waste heat boiler and the washer/cooler. The remaining 10 to 20% of this entrained ash would pass through the mechanical separator and be removed from the raw product gas stream in the washer/cooler. The ash slurry from the washer/cooler could be either disposed of separately or mixed with the dry ash to form an essentially dry material for disposal. The remaining 25 - 35% of coal ash not entrained in the raw gas stream would leave the gasifier through a water bath at the bottom of the gasifier. This ash would be a granulated slag containing about 6% water.

Once the ash was collected dry from the raw gas stream, it would be stacked and compacted in the solid waste disposal area. If the ash were collected wet, it would be slurried from the ash and slag handling area to a series of settling ponds for further handling as required. Water from the waste would be collected; treated, if necessary; and reused or discharged. Please refer to sections 4.1.2.12 in Chapter 4 and 4.2.12 in Appendix G for additional discussion.

In the Texaco gasifier essentially all of the coal ash is ultimately converted to an inert slag. Some small percentage of the ash is removed in the wastewater treatment system. Slag is discharged from the gasifier, passed through screens, and then sent to the slag storage pile. Fines accumulated in the screens' sumps would be recycled to the coal pulverizers. Entrained fly ash would be recovered and recycled to the coal slurry feed. If recycle of the fines and fly ash is not feasible, it would be disposed of in the same manner as described for K-T fly ash.

The foundation work for final disposal of the ash and slag depends upon the engineering properties of the in situ soil and the characteristics of the ash and slag leachate. These variables would be defined before the final disposal plans are developed. Currently, TVA is evaluating a number of disposal alternatives which relate to foundation conditions at the preferred site. The following is a discussion of these options.

If the soil in the solid waste disposal area is found to be structurally capable of supporting the anticipated ash and slag loads, the waste ash and slag would be disposed of on the in situ soil or rock. Should TVA studies indicate that it is necessary to collect leachate, the disposal area would be constructed to contain, monitor, and treat leachate as required before discharge or reuse.

If the soil in the ash and slag disposal area is found to be incapable of bearing the anticipated ash and slag loads, the area would be stripped of in situ soil, and rock would serve as the foundation. Alternatively, the in situ soil would be left in place and a containment dike and its foundation appropriately developed to hold the in situ soil in place.

Should TVA's studies indicate that leachate collection was necessary and the soils were structually unsound, the disposal area would be stripped of in situ soil. The underlying rock would be examined to determine the potential for excessive leakage into ground water and corrective actions proposed. Provisions would be made for a drainage blanket and interceptor ditches if necessary. A liner would be provided between the drainage blanket and the disposal material. Provisions would be made to collect, contain, appropriately treat, and discharge the leachate. Alternatively, granular backfill material would be placed on top of the rock to a level above the ground water table. A liner would be constructed on the granular material to contain the leachate. Leachate would be monitored and treated as required.

2.3.6.13 Utility Area

The utility area includes the plant water systems, steam systems, instrument and general plant compressed gas supply equipment, and startup/shutdown utilities.

Plant Water System - The various types of water used in this facility are potable, demineralized, process, and cooling. Conceptually, the plant makeup water system would consist of a clarifier, filter, demineralizer, sludge thickener, and sludge dewatering filter. Process water would be treated with a combination of chemicals, clarified and filtered to remove objectionable suspended solids and color. Sludge from the clarifer would be thickened and dewatered. The recovered water would then be recycled to the head of the clarifier. Dewatered water treatment sludge is classified as a nonhazardous solid waste and is suitable for disposal by landfill. The demineralizer would provide water with low hardness, low silica, and low dissolved solids for use as boiler feed water makeup and possibly cooling tower makeup. Wastewater produced during regeneration of the demineralizer would be sent to the wastewater treatment area. A portion of the raw intake water may be treated by filtration and chlorination for use as potable water. However, initial plans call for groundwater as the source of potable water.

Plant Steam System - Either process is a net producer of steam. Steam is generated in the gasifier heat recovery systems, Claus plant, shift conversion plant, and methanation plant. A condensate header collects the condensate from the various users in the plant and returns it to a central flash drum. The condensate from the flash drum is pumped to deaerators with additional makeup water available from the demineralizer.

Plant Compressed Gas System - To the extent practicable, the plant compressed gas system would use nitrogen produced as a by-product in the air separation plants. In the K-T process, nitrogen is used to convey fine pulverized coal and for various nitrogen-purges. In both, the K-T and Texaco systems, nitrogen is used in place of air for pneumatic instruments and for utility needs. In the K-T process, CO_2 from the Rectisol system will be used for gasifier poke holes and raw compressor seals.

Startup/Shutdown Utilities - It is anticipated that during plant startups and shutdowns, a small boiler capable of operating on propane or natural gas would be available for use. It would provide steam as necessary for building heat, for piping and equipment heat tracing, and possibly gasifier startup.

2.3.6.14 Cooling Water System

Mechanical draft cooling towers provide cooling water for use in process heat exchangers, steam condensers, and other plant water cooled equipment. Blowdown from the cooling towers would be discharged along with other wastewaters to a holding pond and then discharged through a multiport diffuser located in the secondary channel of Guntersville Lake.

2.3.6.15 Flare System

Hydrocarbon discharges from pressure safety valves in the various units are piped into the flare header. During startup of the Texaco based gasification plant, the gas of varying composition is vented into the flare system until the plant is on stream. The flare system consists of a main flare header, a flare knockout (KO) drum with pump, and the flare stack with seal pot. In the case of K-T, each gasifier is equipped with a separate flare stack for use during startup. Please see Table B-15 in Appendix B for estimated emissions during initial plant startup. A K-T based gasification plant would also utilize a flare system for downstream equipment emergencies.

The flare KO drum is provided to remove liquid hydrocarbon and water which is discharged or condensed in the flare header. The liquid collected is pumped to the wastewater treatment system and the vapor is routed to the flare stack.

2.3.6.16 Wastewater Treatment

The FEIS assesses environmental impacts of the facility based on the best available engineering practices and experience. Where final wastewater characteristics are not yet available, a worst-case is assumed for the environmental impact analysis. The facility would utilize "Best Available Control Technology" (BACT) for these cases consistent with appropriate permitting regulations.

The final details of what would constitute BACT cannot be engineered until the various wastewater characterization and treatability studies (including toxicity analysis) are completed. Therefore, a wastewater analysis program has been developed and implemented for an NPDES permit. This program would obtain further data and information to define BACT and to ensure that effluents from the operational facility are, and would continue to be, environmentally acceptable.

TVA conducted preliminary evaluations of 3 different wastewater treatment/discharge options to determine relative cost differences. These 3 treatment options were based on conceptual design work completed for TVA by architectural-engineering firms. Option I assumed zero discharge of EPA-regulated liquid waste streams. Option II assumed that the cooling tower blowdown and runoff from the ash/slag disposal and coal storage areas were treated and discharged. Option II also assumed that there was no discharge from the gasification/gas cleanup portions of the plant. Option III assumed treatment and discharge of all waste streams.

Each option would itself produce either a treated effluent and/or residuals that can be managed in an environmentally acceptable manner. Since each option is believed to be environmentally acceptable, TVA determined that Option III was the most cost effective and is the basis for TVA's design efforts. More details of this study are given in Appendix B.

A number of wastewater treatment technologies, some of which are presented in Table B-16, are potentially applicable to coal gasification wastewaters. Additional wastewater treatment processes that are potentially available for application at the proposed coal gasification facility include powdered activated carbon addition to activated sludge, ozonolysis for dissolved organics removal, biological nitrification-denitrification for nitrogen removal, and mixed media filtration for suspended solids removal.

At the present time, TVA and its contractor are evaluating wastewater treatment systems for the proposed facility. The final system design would be completed after waste characterization and waste water treatability studies (including toxicity analyses) are completed. The following wastewater treatment system conceptual design is based on conceptual design efforts and represents our current thinking on a wastewater treatment process. In the K-T gasification system, water used to cool and clean the raw product gas from the gasifiers would be contaminated with small quantities of NH_3, H_2S, HCN, thiocyanates, chlorides, and solids. The solids would be removed and the water recycled to the process. The sludge would be transported to the ash disposal area. The ash transport wastewater would combine with the ash/slag pile runoff and with small quantities of contaminated runoff from the process area. The resulting stream would be treated with ferrous sulfate and lime, clarified, and filtered prior to NH_3 removal in an NH_3 stripper. The water from the NH_3 stripper would be neutralized and then would flow to a biological treatment system before final discharge.

In the Texaco gasification system, water used for cooling and cleaning the raw gas stream would be contaminated with small amounts of sulfide, cyanides, thiocyanates, formates, NH_3, and solids. The solids would be removed to disposal and the resultant wastewater would be treated with ferrous sulfate and lime, clarified, and filtered prior to NH_3 removal in an NH_3 stripper. The stripped water would be neutralized and then would flow to a biological treatment system before final discharge.

Other wastewaters from the facility include cooling tower blowdown, steam generation blowdown, treated sanitary effluent, and coal pile runoff. After meeting applicable NPDES requirements, appropriately treated wastewaters would be injected into the cooling tower blowdown line, which also would be monitored for NPDES requirements, and discharged into channel areas. All wastewater streams would be provided with appropriate holding capabilities such that treatment facility upsets would not result in adverse aquatic impacts. Upsets would be detected through the use of a continuous biological monitor (onsite) which monitors effluent quality after the confluence of cooling tower blowdown and process wastewaters. Flow diagrams of the conceptual wastewater treatment systems for both gasification processes are given in Appendix B.

TVA has collected wastewater samples from K-T and Texaco gasification processes and is conducting characterization and treatability studies (including bioassays) to confirm our assumptions regarding wastewater treatment. Appendix B contains a description of these wastewater studies and discussion of the use that will be made of the study results.

2.3.6.17 <u>Raw Water Intake System</u>

The raw water intake system would withdraw water from Guntersville Lake for use in the gasification process, as component cooling water, and in other miscellaneous service water system needs such as dust control. Six intake systems were evaluated before it was decided to utilize an open channel with fine mesh, vertical traveling screens (option 3). The 6 systems evaluated were:

1. 1300 ft ± intake piping, 0.5 mm opening vertical traveling screens;

2. 3600 ft ± intake piping, 3/8 in opening vertical traveling screens;

3. Open channel, 0.5 mm opening vertical traveling screens;

4. 1300 ft ± intake piping, 0.5 mm opening vertical traveling screens and 0.5 mm opening horizontal traveling screen;

5. Open channel, 0.5 mm opening vertical traveling screen and 0.5 mm opening horizontal traveling screen;

6. Intake system with 6 fixed screens (0.5 mm opening) with manual cleaning capability at shoreline.

The environmental assessments of these systems are provided in the responses to public comments in Appendix E, Sections J and M.

System Description

The intake system would be located at TRM 370.5 on the left bank of Guntersville Lake. The principal features of the intake system would be the pumping station and a riprapped open channel which would connect the pumping station and the lake.

The pumping station would have 2 openings. Each opening would have a 6 ft wide vertical traveling screen with 0.5 mm openings for fish mitigation purposes. In addition to the traveling screens, the system would contain the following major features:

1. four makeup pumps
2. two raw service water pumps
3. four makeup strainers
4. two screen backwash pumps
5. two raw service water strainers
6. one trash rack
7. system for safely returning impinged fish to lake

The total estimated dredging spoil material to be removed from the embayment area due to the intake's open channel construction would be approximately 22,000 ± yd^3. All dredging spoil material would be disposed of on land. The total estimated riprap to be used in the intake structure is 6,000 ± yd^3. Construction of the intake would be a Section 404 regulated activity.

System Operation

The condenser cooling water makeup flow would be supplied by the makeup pumps at the intake pumping station. The raw service pumps would be used to supply the water treatment plant water and miscellaneous raw water needs.

When the condenser cooling water system is operating at 3.0 cycles of concentration, the total inflow to the intake pumping station for all plant process needs, including simultaneous backwash of both vertical traveling screens and all strainers, would be approximately 50 cfs. Under this condition, the flow velocity in the intake open channel and at the vertical traveling screen would be less than 0.1 fps and 1.0 fps, respectively. The backwash flows from the vertical traveling screens and strainers would be discharged into a trash sluice and returned to the embayment as shown in Figure 2-4.

2.3.6.18 Wastewater Discharge System

The coal gasification plant would utilize a common discharge system to dispose of properly treated plant effluents into Guntersville Lake. A number of alternatives were evaluated before it was decided to utilize a 3250 ± ft discharge pipe that extended to the secondary river channel. The discharge pipe lengths assessed were 380 ± ft, 900 ± ft, 1700 ± ft, and 3250 ± ft. The specific environmental impacts of the various alternative discharges are provided in TVA's responses to public comments. (Please refer to Appendix E, Sections I, J, and M).

The discharge system would be located near TRM 369 on the left bank of Guntersville Lake. Condenser cooling water (CCW) blowdown would enter the discharge system from a branch in the pressurized CCW cold water conduit in the CCW pumping station. The blowdown flow from the CCW system would be regulated by valves. The blowdown flow from each cooling tower would be combined and monitored prior to entering a controlled closed conduit which would discharge to a retention basin and eventually through the discharge control structure. The effluents from the several other systems in the wastewater treatment area, after the desired treatment and monitoring has been completed, would also discharge to the retention basin and discharge control structure. The discharge flow from the discharge structure would also be regulated by a valve.

The discharge pipe would terminate in the secondary river channel with a multiport diffuser approximately 36 ± inches in diameter and 150 ft long. The top of the discharge pipe (submerged portion) would be below an elevation of 580 ft. The submerged discharge pipe and the multiport diffuser would be supported by a bed of crushed stone and held in place by a concrete anchoring system to prevent movement. The required navigational clearance would be maintained.

The total estimated dredging spoil material to be removed while constructing the submerged discharge pipe and multiport diffuser is approximately 35,000 yd^3. All dredging spoil material would be disposed of on land. Rock backfill requirements during construction of the submerged discharge pipes are approximately 25,000 yd^3.

The discharge system would provide for the discharge of the CCW blowdown (approximately 15 cfs at 3.0 cycles of concentration) and effluents from other systems in the wastewater treatment area. The CCW blowdown would be less if a higher cycle of concentration were used. The anticipated discharge flow may vary from 0 to 20 cfs during the normal operation. With a 150 ft long multiport diffuser located at the secondary channel, the discharge system would have an estimated dilution rate of 20.

Growth of clams, bacteria, algae, fungi, etc., in the CCW system would be controlled by appropriate chlorination treatment. Blowdown flow would be suspended from the unit being chlorinated until the chlorine residual dropped to a level acceptable for discharge in accordance with the terms of the NPDES permit.

An automatic continuous flow monitoring system would be provided to record the discharge flow rate and a continuous flow biomonitor would be used to detect any wastewater treatment malfunctions. A sampling facility would also be provided for routine monitoring needs in accordance with the NPDES permit. Construction of the discharge structure would be conducted in conformance with Section 404 and Section 10 permit requirements.

2.3.6.19 Barge Slip and Sulfur Dock

Construction and operation activities at the Murphy Hill site would require a barge slip facility, located at TRM 369±. The facility would consist of a rail barge unloading facility and a conventional barge unloading facility. The conventional facility would have a rock-filled grounding pad for the barge. A leaf span rail bridge and sheet-pile cells would be constructed for the rail facility. The barge slip would have a width of approximately 140 ft and require dredging to obtain a navigation channel bottom of maximum elevation 580 ft. The total estimated dredging quantity is 60,000 yd^3 which would be disposed of onsite in an environmentally acceptable manner. The estimated construction quantities for concrete and for riprap and crushed stone below elevation 595 ft are approximately 2000 yd^3 and 15,000 yd^3, respectively. After construction of the coal gasification plant, the barge slip would remain in place and be utilized as a permanent facility for operation and maintenance needs.

The gasification plant would require a sulfur dock to ship a major plant byproduct, sulfur. A total of 6 dock locations were evaluated before a location was selected. The dock would probably include a rock-filled causeway with 5 granular filled steel sheet pile cells, 4 mooring cells for empty and loaded barges, and 1 molten sulfur loader. It is estimated that the sulfur dock would require 6,000 to 8,000 yd^3 of granular fill, 4,000 ± yd^3 of unclassified excavation, 40,000 to 50,000 yd^3 of rock fill, and 750 to 900 yd^3 of fill concrete. Minor dredging amounting to approximately 2,000 yd^3 would be required to obtain elevation 580 ft in the area of the dock. Dredge material would be spoiled in the same manner and location as the other dredge spoil. Sulfur dock access will be via the coal receiving dock navigation channel.

It is likely that, should methanol be produced onsite and transported by barge, either the barge slip or sulfur dock would be utilized for loading methanol.

2.3.6.20 General Facilities

General facilities for the coal gasification plant include:

- Product, byproduct and chemical storage
- Power, lighting, and communications
- Roads and fences
- Fire protection system
- Sewage plant
- Interconnecting piping
- General buildings

The major product storage for the facility is methanol. Should it be decided to produce methanol at the proposed facility, storage capability would be provided as necessary. The major byproduct storage for the plant other than waste solids is elemental sulfur. Chemical storage includes water chemicals and solvents. The fire protection system is based on drawing water from the river for firefighting purposes.

It is anticipated that an electrical transmission line would be constructed to the site from the south side of the river. TVA has prepared plans to construct a substation on the Murphy Hill site with connections to the existing system south of the river. An Environmental Assessment (EA) for the proposed substation and connecting transmission lines was prepared in 1979 prior to initiation of this environmental study. Subsequently, it was decided to relocate the proposed substation to the edge of the Murphy Hill site (using a portion of the site and land offered for sale to TVA), thus leaving the site open for future development. At this location, only one transmission line corridor will be required, whereas the original location requires three transmission line corridors.

The property located on the southwest boundary of the plant site offered for sale to TVA has been investigated, and a supplement to the 1979 EA completed which concluded that use of the property for the substation would not result in any significant environmental impacts. This EA, as supplemented, is available to the public, and it evaluates in detail the potential impacts of the substation. The need for a substation in the area was identified in 1972, and the decision to proceed with the substation is independent of the decision to proceed with the proposed coal gasification facility.

TVA evaluated the potential for socioeconomic impacts resulting from the combined construction work forces of both the proposed coal gasification facility and the substation. Substation construction would occur from May 1983 to June 1985, with a peak construction work force of about 65 to 75 people during the middle third of the construction period. Construction of the coal gasification facility would begin in the fall of 1982, with site preparation to begin one year prior to this. During the time of peak employment at the substation construction site, construction employment at the gasification site would be increasing from an estimated 600 workers in early 1984 to 1300 workers in late 1984. Impacts from that level of employment at the gasification plant are not expected to be significant (please refer to sections 4.1.1.4 in Volume 1 and 4.1.4 in Volume 2 for additional information on socioeconomic impacts). Given the small increase in the total number of workers resulting from substation construction, the potential combined impacts would also be insignificant.

TVA is discussing several possible road improvements with State and local authorities. Road improvements being proposed for the Murphy Hill site vicinity would include widening and/or resurfacing of some roads and bridges. The State typically funds road improvements intended to promote industrial development. The following improvements have been identified.

Alabama State Highway 227 - Improvement of the pavement to a width of 24 ft and of the roadbed to a width of 40 ft along the 8-mi portion that extends from the intersection of Marshall County Road Number 50 to Five Points including widening the bridge at each of Minky, Short, and Town Creeks;

River Road -

a. Improvement of the pavement to a width of 22 ft and of the roadbed to a width of 34 ft along the 2.2-mi segment connecting the plant site to Five Points;

b. Maintenance of roadway during plant construction and resurfacing of existing pavement after completion of plant construction on the 2.6-mi portion between the plant site and South Sauty Creek;

c. Improvement of pavement to a width of 22 ft and of the roadbed to a width of 34 ft along the 11.4-mi section extending from South Sauty Creek to Alabama State Highway 35, as well as widening the bridges (34 ft roadways) at South Sauty Creek and Chisenhall Spring Branch;

Back Valley Road - Improvement of the pavement to a width of 22 ft and of the roadbed to a width of 34 ft on the 6.2-mi segment connecting Five Points to the intersection of River Road;

Mount Moriah Church Road - Improvement of the pavement to a width of 22 ft and of the roadbed to a width of 30 ft on the 1-mi portion extending from River Road at the plant site to the Back Valley Road;

Haygood Church-Sandridge Church Road - Improvement of the pavement to a width of 20 ft and of the roadbed to a width of 24 ft along the 0.75-mi segment that extends from River Road at Kirbytown to the Back Valley Road;

Preparation of plans and construction work to be performed would be in accordance with Alabama Highway Department specifications.

2.3.6.21 Medium-Btu Gas Pipeline

While the construction of a MBG pipeline is not proposed at this time, hypothetical routes have been sited and generally evaluated. The main pipeline trunk would extend across north Alabama on both the north and south sides of the Tennessee River. Figure 2-7 shows a possible MBG pipeline route. A more detailed description of the pipeline appears in Appendix C. In addition, possible pipeline routes for SNG were identified by major pipeline companies, and these are shown in Figure 2-7. The SNG pipelines would tie to existing natural gas lines.

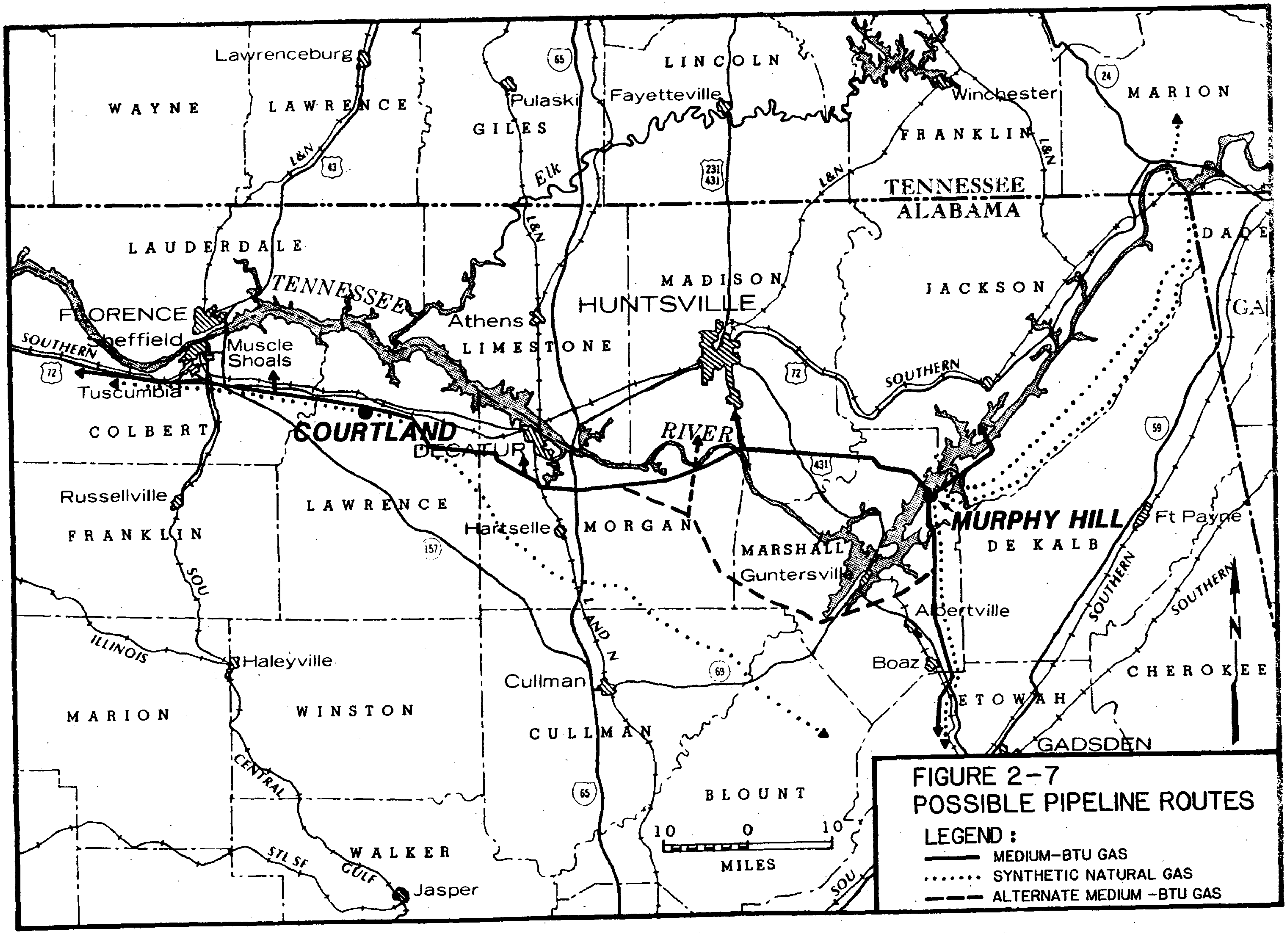


FIGURE 2-7
POSSIBLE PIPELINE ROUTES

The MBG pipeline route has been evaluated by a major pipeline company to ensure that potential construction constraints or environmentally sensitive areas were avoided. Before an MBG pipeline would be constructed, the route would undergo a more extensive evaluation and environmental review, possibly including Sections 10 and 404 review by the Corps. If the pipeline were to be constructed by a private entity, it may be necessary for TVA, in carrying out its responsibilities under Section 26a of the TVA Act and TVA's NEPA procedures, to conduct a detailed evaluation and environmental review.

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3. AFFECTED ENVIRONMENTS

This chapter summarizes the manmade and natural features of the alternate sites which would be affected by constructing and operating the proposed north Alabama coal gasification demonstration plant. More detailed discussions of the affected environments are provided in Appendix F, Volume 2, of the FEIS.

3.1 MURPHY HILL

3.1.1 Manmade Resources

This section addresses land uses, recreation and scenic resources, cultural resources, socioeconomic characteristics and existing river traffic. The Murphy Hill site, including adjacent TVA land, consists of approximately 1,400 acres and is located in northeast Marshall County, Alabama on the left bank of Guntersville Lake. Approximately three-quarters of the site is forested and the remainder is either pastureland or cultivated fields. About 30% of the land at the proposed site is classified as prime farmland. The general vicinity of the site within a 5 km (3 mi) radius is similarly characterized and has some low-density, single-family residential development including second homes. There are no residents present on this site. Development of this site does not conflict with local land use plans (for example, those of the Top of Alabama Regional Council of Governments), since recent county and regional land use plans indicate that the land is intended for industrial development.

No recreation facilities exist on the site, although two State Parks are located in the site vicinity. Recreation activities in the vicinity of the site are primarily lake-oriented. No unusual or unique scenic or natural features have been identified on the site nor in the site vicinity.

Cultural aspects of the site and the surrounding area were examined. No historic or important architectural resources are located on the site, although a log cabin, which might be eligible for listing in the National Register of Historic Places (NRHP), is located about 1 km (1/2 mi) from the site. An investigation of the only potentially significant archaeological locus on the site was made in 1974.

This site is remotely located from the region's population growth areas, with no urban centers in the immediate vicinity. Population centers in the area include: Arab, Guntersville, Albertville, and Boaz of Marshall County; Scottsboro and Stevenson of Jackson County; and Fort Payne and Rainsville of DeKalb County.

In the last 2 decades the economic trends for Jackson, Marshall, and DeKalb counties have tended toward decreased agricultural employment and increased manufacturing employment. The area has experienced limited industrial development, which includes the Monsanto plant, constructed about 10 years ago, approximately 8 km (5 mi) downstream from the site. However, this plant, which employed about 850 persons, was closed in February 1981. Monsanto's plans for either lease or sale of the facility are uncertain at this time.

There is a current shortage of available housing in DeKalb and Marshall counties. However, some housing vacancies can be expected in all 3 counties due to the decline in construction employees residing in the area when the nearby TVA Bellefonte Nuclear Plant nears completion in the next few years. The area is served by 5 school systems, all of which are operating near or beyond capacity. Currently, the water and sewer treatment facilities in this area without excess treatment capacity either have planned or have initiated improvements or expansions. All local governments have some full-time law enforcement personnel. Fire protection in the impact area consists of service by full-time and/or volunteer firemen. The 3-county area is serviced by 6 hospitals, 1 comprehensive mental health center (plus 4 satellite centers), 8 nursing homes, and 18 ambulance services. Jackson and DeKalb counties are designated as critical health manpower shortage areas.

Highway access to the Murphy Hill site is from a 2-lane paved county road known as River Road. There is no main highway leading directly to the relatively isolated site. River Road connects into a larger network of area roads leading to various communities.

If the plant were built at Murphy Hill, coal, some equipment and/or supplies would be transported on the Tennessee River to the site by barge due to the accessibility of the site from Guntersville Lake and the economics of barge transport. Traffic on the Tennessee River includes both recreational and commercial vessels. To allow travel throughout the waterway system, navigation locks are located at all mainstream dams. Based on unofficial estimates from the Corps of Engineers for 1980, the amount of commercial traffic through the locks at any one dam differed considerably (see Table 3.1.5-1 in Appendix F), ranging from 28 tows at Melton Hill Dam to 3,675 tows at Kentucky Dam. The number of recreational boats utilizing the locks at any one dam per year varied from 284 at Melton Hill Dam (232 recreational lockages) to 2,871 at Guntersville Dam (1,606 recreational lockages). The average total lockages annually (including double and triple lockages for commercial tows) at any one dam ranged between 282 (Melton Hill Dam) and 6,061 (Kentucky Dam). The average time for commercial lockages varied from 21 min (Fort Loudoun and Chickamauga Dams) to 55 min (Pickwick Dam) for single lockages; from 85 min (at Chickamauga Dam) to 157 min (Wilson Dam) for double lockages; and from 141 min (Chickamauga Dam) to 277 min (Wilson Dam) for triple lockages. The approximate percent utilization of the locks ranged between 78% (Kentucky Dam) and 2% (Melton Hill). The delay time for commercial vessels waiting for the lockage of other traffic averaged between 56 min at Guntersville Dam and 244 min at Kentucky Dam.

3.1.2 Natural Resources

This section describes a number of site characteristics including air quality, river flows, water quality, ground water, aquatic life, upland vegetation, wildlife, threatened or endangered species, waterfowl, floodplains, geology, noise, and radiological characteristics.

The air quality around the Murphy Hill site is generally considered to be good. The State of Alabama has designated the area surrounding the Murphy Hill site as being in attainment with the National Ambient Air Quality Standards. TVA has installed an air quality monitoring station adjacent to the site to develop site specific data to support air quality permit applications. This station monitors the particulate, nitrogen oxide, sulfur dioxide, carbon monoxide and ozone levels in the air. Preliminary data from this station are presented in Appendix F. Table 3-1 summarizes climatic information for the site.

River flow near the site is controlled by releases from Guntersville (TRM 349) and Nickajack (TRM 424.7) Dams. Because both dams are typically operated by TVA for production of power during times of peak demand, flow in the Guntersville Lake is rarely steady. Nickajack Dam has no flow about 8% of the time. However, these no flow periods rarely exceed 12 continuous hr. The 7 day, 10-year low flow is 11,000 cfs. The water surface elevation of Guntersville Lake varies between normal minimum pool elevation 593 ft and normal maximum pool elevation 595 ft. Maximum depths in Guntersville Lake in the vicinity range from 11 to 12 m (35 to 40 ft).

Water temperatures in Guntersville Lake approaching the Alabama maximum criterion of 30° C (86° F) and dissolved oxygen levels below the Alabama criterion of 5.0 mg/l have been observed during the summer months in the site vicinity. Recent data indicate that thermal stratification and dissolved oxygen deficits in the lower depths of the lake have resulted in the ambient water quality exceeding the Alabama criterion for dissolved oxygen in the stream reach below Guntersville Dam at certain times. Similar conditions were observed in stream reaches below most of TVA's mainstream lake dams. Conversely, dissolved oxygen concentrations in the surface layer of the lake water in the site vicinity were observed to exceed saturation due to photosynthetic activity.

The chemical quality of Guntersville Lake in the site vicinity is generally fair. Table 3-2 summarizes water quality data for a number of trace constituents. When compared with current national primary drinking water standards, data reveal that the water in Guntersville Lake is acceptable for human consumption. However, the water may require treatment for removal of some aesthetically undesirable constituents (secondary standards). Concentrations of mercury and nickel in the lake water sometimes exceed the recommended EPA criteria for protection of human health. Recommended

Table 3-1

CLIMATIC DATA SUMMARIES

	MURPHY HILL	COURTLAND
Temperature[1,2]: -		
Annual Average	15°C (60°F)	16°C (61°F)
Annual Average Maximum	22°C (72°F)	22°C (72°F)
Annual Average Minimum	9°C (49°F)	10°C (50°F)
Coldest Month (January):		
Average Maximum	10°C (53°F)	10°C (50°F)
Average Minimum	0°C (32°F)	-1°C (31°F)
Warmest Month (July):		
Average Maximum	32°C (90°F)	32°C (90°F)
Average Minimum	19°C (67°F)	21°C (70°F)
Growing Season[2]: (Days)	210	230
Precipitation[1,2]: -		
Annual Average	137 cm (54 in)	127 cm (50 in)
Wettest Month (March): Average	15 cm (6 in)	15 cm (6 in)
Driest Month (October): Average	8 cm (3 in)	7 cm (3 in)
Average Annual Snowfall	6 cm (3 in)	11 cm (4 in)
Humidity[3,4] and Fog[3,5]: -		
Annual Average Relative Humidity	70%	72%
Average Number of Days with Heavy Fog[a]	30	22
Radiation[4] and Sky Cover[4]: -		
Daily Solar Radiation (Langleys/Day):		
Annual Average	380	380
Maximum Monthly Average (June)	550	550
Minimum Monthly Average (December)	200	200
Daily Sky Cover (Sunrise to Sunset):		
Annual Average (In Tenths)	5.5	6.0
Severe Weather: -		
Thunderstorm Days/Year[3]:	58	58
Tornadoes[6,7]:		
Number Reported 1955-1967[b]	20	31
Probability of Occurrence[c]	0.0011	0.0017
Recurrence Interval (Years)	925	600
Hail 1.9 cm (0.75 in) or Greater[6]:		
Number of Occurrences 1955-1967[b]	14	7

References 1-7 are fo[illegible] of the chapter.

a. Heavy fog is defined by the National Weather Service as restricting visibility to 0.4 km (0.25 mi) or less.

b. Data given is for one degree latitude/longitude squares (about 10,180 km^2, 3930 mi^2), one that includes Murphy Hill and one that includes Courtland.

c. The probability of occurrence is the probability of a tornado striking a point, in any year, in a one degree latitude/longitude square.

Table 3-2 TVA Coal Gasification Project - Comparison of Water Quality Data in the Vicinity of the Murphy Hill Site (Guntersville Reservoir) with Various National Water Quality Criteria and Standards for Potentially Toxic Pollutants

							EPA Water Quality Criteria[e,f]			
							Fresh Water Aquatic Life		Human Health	
Parameter[a]	Minimum	Mean[b]	Maximum	Number of Samples	National Primary Drinking Water Standards[c]	National Secondary Drinking Water Standards[d]	24 hr. Average	Maximum	Recommended	Risk Level[g]
Ammonia	<10	50	280	110	--	--	--	20[h]	--	--
Arsenic	<5	<5	<5	30	50	--	--	440	0[i]	2x10^{-2}-2x10^{-4}
Barium	<100	<100	<100	30	1,000	--	--	--	--	--
Beryllium	<10	<10	<10	30	--	--	11[j]	--	0[i]	4x10^{-2}-4x10^{-4}
Cadmium	<1	<1	3	30	10	--	0.015[j]	1.8[j]	10	--
Chromium	<5	<5	7	30	50	--	100	--	--	--
Copper	<10	<14	50	30	--	1,000	5.6[j]	14[j]	--	--
Lead	<10	<15	45	30	50	--	1.2[j]	92[j]	50	--
Mercury	<0.2	<0.2	0.7	20	2	--	0.0006	0.002	0.14	--
Nickel	<50	<70	490	30	--	--	65[j]	1,250	13.4	--
Nitrate[k]	200	410	1,500	109	10,000	--	--	--	--	--
Phenols	<1	<1	2	30	--	--	1	--	3,500	--
Selenium	<2	<2	<2	30	10	--	35	260	10	--
Silver	<10	<10	<10	30	50	--	--	1.7[j]	50	--
Zinc	<10	<25	460	30	--	5,000	47	210[j]	--	--

Notes:

a. All units are in μg/liter.
b. In cases where the minimum detectable limit (MDL) was reported for 50 percent or more of the samples, the MDL was averaged as an MDL; i.e., <10 was averaged as <10. In cases where the majority of the samples exceeded the MDL, the MDL was averaged as an absolute value; i.e., <10 was averaged as 10.
c. Reference No. 8.
d. Reference No. 9.
e. Reference No. 10.
f. Reference No. 11.
g. Risk levels cited for suspected carcinogens correspond to incremental cancer risks of 10^{-7} to 10^{-5}; i.e., one additional case of cancer in populations ranging from 10 million to 100,000, respectively. (See reference No. 11 for further explanation).
h. Unionized; comparisons were made utilizing the table provided in reference No. 10.
i. Zero level results from EPA's assumption that no "safe" level of carcinogenic substances exists.
j. Criteria calculated for 60 mg/liter hardness.
k. Measured as nitrate plus nitrite nitrogen.

EPA criteria for the protection of aquatic life are also exceeded for certain parameters. Sediments in Guntersville Lake were found to contain certain metals in concentrations above the mean value found throughout the Tennessee Valley. Total surface water use is about 41,000 m^3/day (10.8 MGD) in the site vicinity.

Ground water availability at the Murphy Hill site is variable. In the flat portion of the site, the Chickamauga limestone underlying the site yields little water. The "Murphy Hill" part of the site area is underlain by more soluble limestone units of the lower Chickamauga limestone, yielding greater quantities of water. Southeast of the road the underlying rock exhibits solution cavities. Historical data from the formation shows the quality of the ground water to be good. There are no public ground water supplies within 10 km (6 mi) of the plant site.

The Tennessee River (lower Guntersville Lake) is characterized by extensive overbank areas ranging from 1 to 6 m in depth and a narrow channel which averages 13 m in depth. Extensive growth of submersed and floating plants occur on the overbank areas, providing additional substrate for fish food organisms and spawning areas, nursery areas, and cover for fishes. Phytoplankton (microscopic plants) populations are generally high, as is the autotrophic index (indicative of organic enrichment). Increases found in numbers and percentage composition of blue-green algae are potentially indicative of eutrophication and are potentially detrimental to water quality. Bottom invertebrates collected were generally tolerant of silt and low dissolved oxygen. Fish populations are similar to those found in other mainstream lakes with respect to species occurrence. The fisheries habitat adjacent to the Murphy Hill site can be characterized as being highly productive. Sport fishing is concentrated around the weed beds and is heaviest during the spring. Commercial fishing in the site vicinity consists mostly of part-time fishermen, with full-time fishermen passing through the area intermittently.

Two aquatic plant species listed by Freeman et al (1979)[12] as "endangered" (Elodea Canadeneis Michx.) or of "special concern" (Isoetes engelmanii A. Br.) and a cave crayfish species (Cambarus A. hamulatus), listed as a species of "special concern" (Boschung, 1976)[13], had been reported in the site vicinity. Investigations revealed that 1 of the plant species and the crayfish species occur on site, but any impacts are expected to be insignificant (see Chapter 4 and Appendices F and G for further discussions).

The vegetative cover of the Murphy Hill site is a diverse mosaic of forests and fields brought about by the wide range of soil and topographic conditions and by past and present land use. Approximately one-fourth of the site is nonforested with the remainder being woodland, Table 3-3. The nonforested area contains about 78% open or reverting fields, 21% cultivated fields, and 1% in roads and ponds. The woodland area consists of mixed

TABLE 3-3

PHOTO-INTERPRETED FOREST TYPE AND LAND USE
FOR MURPHY HILL SITE
FROM
1980 TVA PHOTOGRAPHY

Forest Type or Land Use	Total Acres from 1980 Photos	Area East of Road, New Photos Unavailable	Grand Total	% of Total Acres
Forest				
Pines	189.3	0.0	189.3	13.5
Hardwoods	309.4	0.0	309.4	22.2
Mixed	183.6	374.7	558.3	40.0
Total Forest	682.3	374.7	1057.0	75.7
Open	279.2	0.0	279.2	20.0
Reverting[1]	48.8	0.0	48.8	3.5
Water	0.9	0.0	0.9	0.1
Roads[2]	9.8	0.0	9.8	0.7
Total Acres	1021.0	374.7	1395.7	100.0
Fence Lines[3]				
Ft	14,180	0		
Acres	14.5	0.0		

1. Reverting fields and brushland.
2. Includes only State Highway, assuming a 50 ft ROW.
3. Includes fence rows, narrow strips along roads and lake margins. Acreage is included in Open Land totals.

hardwoods and pines. The habitat diversity is reflected by the presence of a variety of animals. A total of 200 species of terrestrial vertebrates were observed or collected during TVA investigations.

Two species of Federally endangered mammals, the gray bat (Myotis grisescens) and Indiana bat (Myotis sodalis), are known to utilize caves in northeastern Alabama; however, neither of these 2 species has been observed in any of the 3 caves located on or in close proximity to the Murphy Hill site. The closest cave which is known to be inhabited by either of these species is located approximately 11 air km (7 air mi) from the site. Both the Indiana and gray bat forage over streams, rivers, ponds, lakes, and adjacent riparian vegetation; and some bats may utilize lake and shoreline habitat on or adjacent to the Murphy Hill site.

The Bald Eagle (Haliaeetus leucocephalus), listed as Federally endangered, was identified by the U.S. Fish and Wildlife Service as occurring in the vicinity of the Murphy Hill site (see Appendix D). Guntersville Lake supports a wintering population of eagles and the 1979-80 mid-winter eagle survey recorded 15 Bald Eagles on this lake. Six of these eagles were observed within 8 air km (5 air mi) of the site and the others were within 16 air km (10 air mi) of the site.

The U.S. Fish and Wildlife Service identified 14 species of freshwater mussels which possibly inhabit the Tennessee River (i.e. Guntersville Lake) in the vicinity of the Murphy Hill site. TVA conducted a qualitative survey in August 1977, and a more extensive survey in 1980, to determine the distribution of molluscan species near the Murphy Hill site. No threatened or endangered species were found. No significant aggregations of mussels were found and the species collected are commonly found in other reaches of the Tennessee River.

All of the shorelines, shallow embayments, and inlets at the Murphy Hill site are classified as wetlands. In addition, a scrub class wetland of approximately 1 acre exists on the site near the location of the proposed coal storage area and 5 acres are located near the proposed soil stockpile. These wetlands at the Murphy Hill site and the shoreline of Guntersville Lake provide breeding habitat for wood duck. Large numbers of migrant wintering waterfowl populations are present on Guntersville Lake during the fall and winter migration periods. Guntersville Lake is especially noted for its large population of gadwall and widgeon. The lake may be important as a wintering habitat for these 2 species of waterfowl. Osprey were observed on and near the Murphy Hill site. A colony of nesting great blue herons exists 40 km (25 mi) upstream.

The Tennessee River 100-yr floodplain at the Murphy Hill site is the area lying below elevation 597.3 ft and the 500-yr flood elevation is 598 ft.

The Murphy Hill site is characterized by gently sloping soils on stream terraces of the Captina-Taft-Tupelo-Culbert soil association. The rocks across the Murphy Hill site are predominately limestones, but include shales, siltstones, cherts, and combined variations of these four lithologies. Bedrock at the site is generally shallow and, when sound and unweathered, is capable of supporting any of the intended loads. Soils range in thickness from 0 to about 18 m (60 ft), but over most of the site are thin, making borrow soils for storage pond dikes and liners (if needed) scarce. If onsite soils were unacceptable for construction needs, then material would be obtained from commercial sources or a borrow area. Such a borrow area would be reviewed in compliance with applicable regulations and procedures. The ability of the rock to support liners appears to vary over the site. Rock underlying the flat land between the road through the site and the foot of "Murphy Hill" does pass ground water, but no undermining of adequately placed liners should occur here. However, the area lying to the southeast of the road is susceptible to the continued formation of sinkholes, caves, and swallow holes, which could cause collapse or undermining of liners.

A baseline sound survey (see Table 3-4 and Figure 3-1) conducted by TVA during 1980 identified motor vehicle traffic, some airplane traffic, and river traffic as the major manmade noise sources now existing in the site vicinity. Depending upon the survey site, average nighttime levels varied between 40 and 53 dBA while average daytime levels varied between 43 and 58 dBA. Again depending upon the site, levels as high as 82 dBA were exceeded 0.1% of the time.

Results of radiological monitoring conducted by TVA at the Murphy Hill site show that direct radiation levels and concentrations of radioactivity in surface water, soil, and sediment appear to be typical of background levels in the Tennessee Valley region.

3.2 COURTLAND

3.2.1 Manmade Resources

This section addresses land uses, recreation and scenic resources, cultural resources, and socioeconomic characteristics of the Courtland site and the surrounding area. The Courtland site, a former Air Force base, is located in the north-central section of Lawrence County, Alabama, approximately 6 miles inland of Wheeler Lake. The 2,246 acre site is approximately 90% prime farmland. Currently, 1,556 acres are leased for cotton while the remainder of the site is either vacant or has abandoned air strips or buildings present. There are no residents other than a caretaker present on the site. The general vicinity of the site is characterized by cropland and pasture with some low-density residential development. This site has been considered for industrial development by local authorities during the last several years.

TABLE 3-4

BASELINE SOUND SURVEY DATA

Murphy Hill Site, December 1980

Measurement Location[2]	Average Sound Level, dBA			
	Day	Night	Day-Night	L(0.10)[1]
1	43	40	48	56
2	49	43	51	65
3	58	53	61	80
4	57	51	60	82
5	51	50	58	74
6	48	46	54	68

Courtland Air Base, December 1980

Measurement Location[3]	Average Sound Level, dBA			
	Day	Night	Day-Night	L(0.10)[1]
1	54	47	55	--
2	54	49	57	70
3	57	50	59	74
4	48	42	50	65

1. L(0.10) is the level which is exceeded 0.10% of the time.
2. For location of measurement sites, see Figure 3-1.
3. For location of measurement sites, see Figure 3-2.

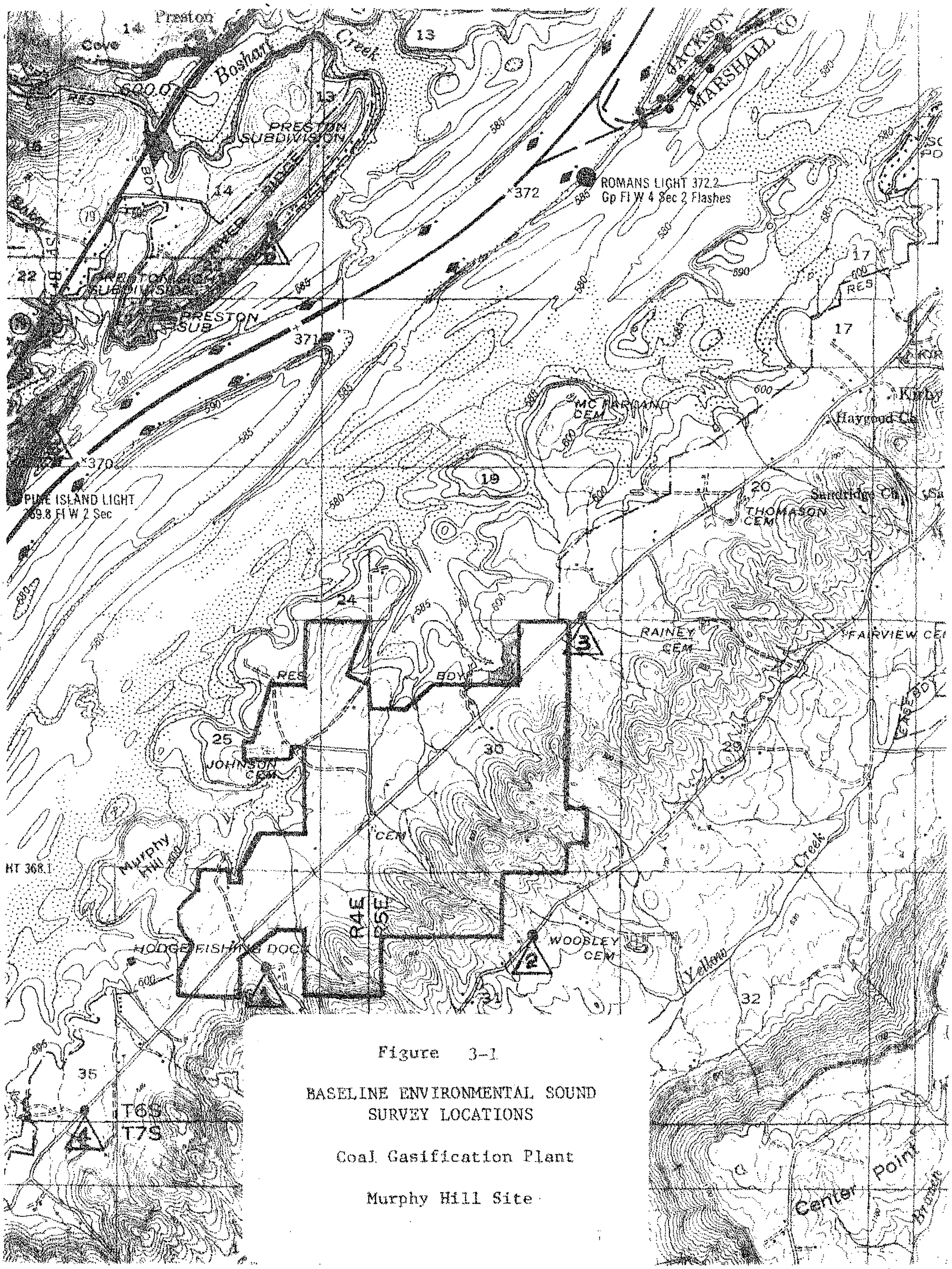

Figure 3-1

BASELINE ENVIRONMENTAL SOUND
SURVEY LOCATIONS

Coal Gasification Plant

Murphy Hill Site

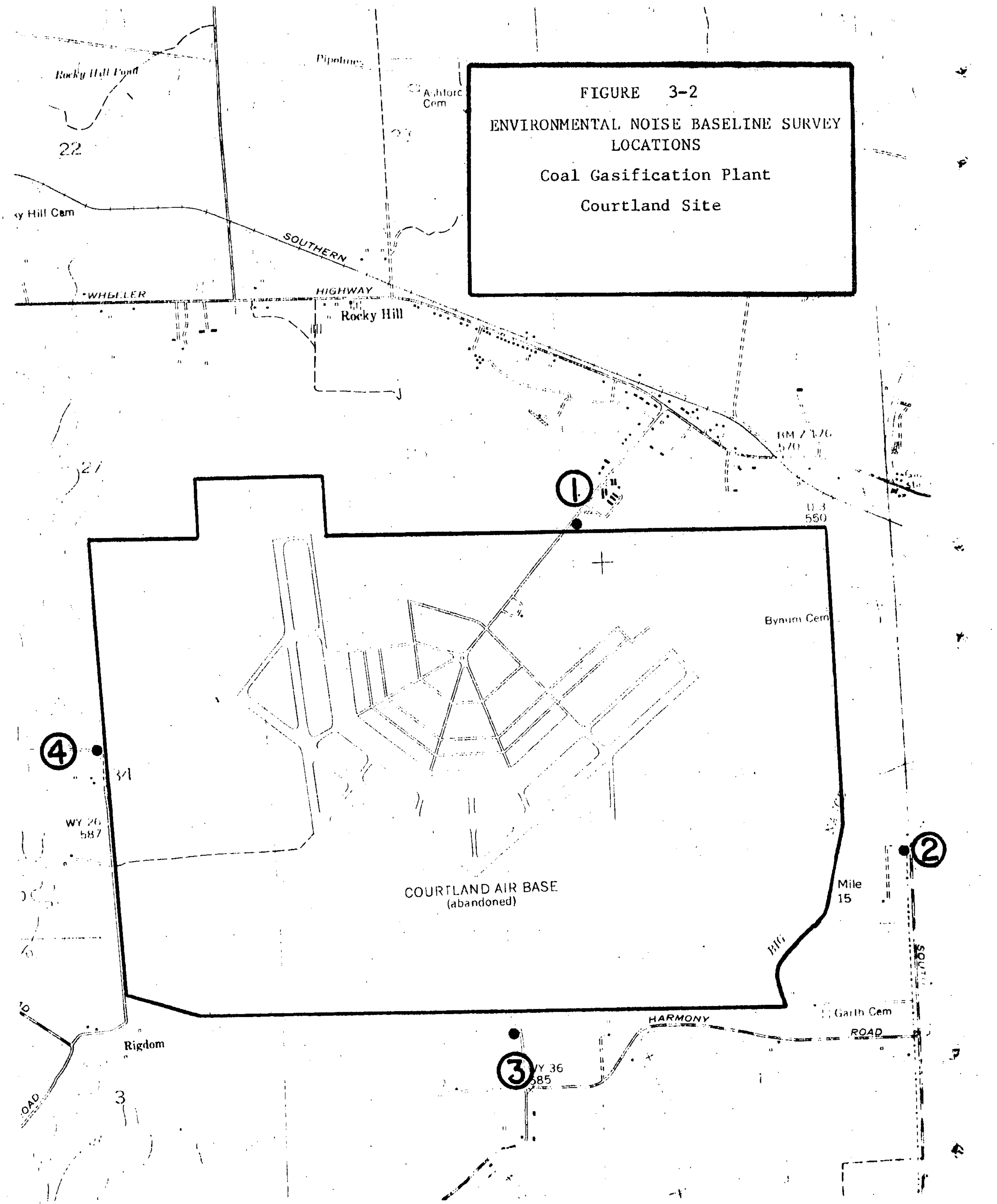

FIGURE 3-2

ENVIRONMENTAL NOISE BASELINE SURVEY LOCATIONS

Coal Gasification Plant

Courtland Site

No recreation facilities are present or are proposed on the site, although the site is sometimes used by hunting, auto racing, and model airplane flying enthusiasts. Generally, recreation activities in the study area are lake-oriented and are concentrated on Wilson and Wheeler Lakes, which are about 10 km (6 mi) from the site. No unique nor unusual scenic or natural features have been identified on the site. Some features that have been identified within 16 km (10 mi) of the site include: Town Creek and Big Nance Creek; a blowing spring; and several scattered sinkholes.

No historic or important architectural resources are located on the site; although, within the surrounding area, there are several structures (including the town of Courtland) which are potentially eligible for listing in the NRHP. Three potentially significant archaeological sites were located along Big Nance Creek adjacent to the site.

Except for Town Creek and Courtland, there are no other significant population concentrations in the immediate vicinity of the site. Population centers in the potential socioeconomic impact area include: Moulton, Town Creek, and Courtland in Lawrence County; Decatur in Morgan County; Sheffield, Tuscumbia, and Muscle Shoals in Colbert County; and Florence in Lauderdale County.

During the last 20 years, agricultural employment in the Lawrence, Morgan, Colbert, and Lauderdale county area has decreased significantly whereas manufacturing employment has increased substantially. There has been some limited industrial growth in the area including the Champion Paper Mill.

Currently, there is an adequate supply of housing in the study area. There are 9 school systems servicing these areas, and only 1 is operating near capacity, while the rest have some excess capacity. Generally, improvements or expansions either have been planned or have been initiated for water and sewer systems in the area currently without excess treatment capacity. Local governments in the study area have some full-time law enforcement personnel. Volunteer firemen service rural areas and the communities in Lawrence County, while full-time fire departments service communities in Morgan, Lauderdale, and Colbert County. The study area is serviced by 10 general hospitals, 1 mental health hospital, 14 nursing homes, and 9 ambulance services and rescue squads. Lawrence County is below acceptable guidelines for primary care physicians and dentists.

The Courtland site has direct highway access to US 72 Alternate (State Highway 20)--the main route between the Decatur and Quad-Cities (Florence, Muscle Shoals, Sheffield, and Tuscumbia) areas. The site located 10 km (6 mi) inland is currently not accessible by barge.

If the plant were built at Courtland, it is probable that some equipment and/or supplies (including coal) would be shipped to some point near the site by barge and then would be transported by truck, rail, or conveyor to the site, since the site is located about 6 mi inland from Wheeler Lake. The existing river traffic on the Tennessee River system and through the locks was described in Section 3.1.1 "Manmade Resources" for Murphy Hill.

3.2.2 Natural Resources

This section describes the same site characteristics as discussed for the Murphy Hill site. The air quality in the Courtland area is generally fair. The State of Alabama has designated the area as in attainment with the National Ambient Air Quality Standards. The site is approximately 35 km (22 mi) from the Sipsey River Wilderness Area, a Prevention of Significant Deterioration Class I area. Table 3-1 summarizes climatic information for the site.

River flow near the site is controlled by releases from Wheeler and Guntersville Dams. Because both dams are typically operated by TVA for production of power during times of peak demand, flow in the Wheeler Lake is rarely steady. Wheeler Dam has no flow about 10% of the time. These zero flow periods rarely exceed 20 continuous hr. The water surface elevation of Wheeler Lake is varied seasonally between normal minimum pool elevation, 550 ft, and normal maximum pool elevation, 556 ft. Maximum depths in Wheeler Lake near the Courtland site range between 16 and 18 m (53 and 60 ft). The 7-day, 10-year low flow is 12,000 cfs.

Temperature data obtained at a depth of 1.5 m (5 ft) revealed that the lake occasionally exceeded the Alabama criterion of 30^{o} C (86^{o} F). The lake exhibited weak thermal stratification during the summer months.

At the 1.5 m depth, the concentrations of dissolved oxygen were always observed to be 5.5 mg/l or greater. Concentrations were observed to exceed saturation levels up to 108%. Conversely, extremely low concentrations of dissolved oxygen have been observed near the bottom of the lake.

The bacteriological water quality of Wheeler Lake in the site vicinity is generally good; however, its chemical quality is only fair. Table 3-5 summarizes water quality data for a number of trace constituents. When compared with national primary drinking water standards, the data reveal that the water in Wheeler Lake is normally acceptable for human consumption. However, sporadic concentrations of lead and mercury were observed to be above the primary standards. The lake water may require treatment for removal of aesthetically undesirable constituents and disinfection (secondary standards). Concentrations of some trace contaminants (arsenic, beryllium, lead, mercury, and nickel) in certain areas of the lake sometimes exceed standards recommended by EPA for drinking water. Criteria proposed for the protection of aquatic life are also exceeded for certain parameters. Lake sediments in the site vicinity were found to contain high concentrations of

Table 3-5 TVA Coal Gasification Project - Comparison of Water Quality Data in the Vicinity of the Courtland Site (Wheeler Reservoir) with Various National Water Quality Criteria and Standards for Potentially Toxic Pollutants

Parameter[a]	Minimum	Mean[b]	Maximum	Number of Samples	National Primary Drinking Water Standards[c]	National Secondary Drinking Water Standards[d]	EPA Water Quality Criteria[e,f] Fresh Water Aquatic Life 24 hr. Average	Fresh Water Aquatic Life Maximum	Human Health Recommended	Human Health Risk Level[g]
Ammonia	<10	65	450	327	--	--	—	20[h]	—	—
Arsenic	<2	<4	15	188	50	--	--	440	0[i]	$2x10^{-2}$-$2x10^{-4}$
Barium	<100	<110	370	187	1,000	--	—	—	—	—
Beryllium	<10	<10	10	188	—	--	11[j]	—	0[i]	$4x10^{-2}$-$4x10^{-4}$
Cadmium	<1	<1	2	180	10	—	0.015[j]	1.8[j]	10	—
Chromium	<5	<7	50	195	50	—	100	—	—	—
Copper	<10	36	350	195	—	1,000	5.6[j]	14[j]	—	—
Lead	<10	<11	86	180	50	—	1.2[j]	92[j]	50	—
Mercury	<0.2	<0.3	12	186	2	—	0.0006	0.002	0.14	—
Nickel	<10	48	430	195	—	—	65[j]	1,250	13.4	—
Nitrate[k]	<10	350	1,700	222	10,000	--	--	--	--	—
Phenols	<1	<3	22	71	—	—	1	—	3,500	—
Selenium	<1	<1	<4	180	10	--	35	260	10	—
Silver	<10	<10	20	187	50	—	--	1.7[j]	50	—
Zinc	<10	30	250	203	—	5,000	47	210[j]	—	--

Notes:

a. All units are in µg/liter.
b. In cases where the minimum detectable limit (MDL) was reported for 50 percent or more of the samples, the MDL was averaged as an MDL; i.e., <10 was averaged as <10. In cases where the majority of the samples exceeded the MDL, the MDL was averaged as an absolute value; i.e., <10 was averaged as 10.
c. Reference No. 8.
d. Reference No. 9.
e. Reference No. 10.
f. Reference No. 11.
g. Risk levels cited for suspected carcinogens correspond to incremental cancer risks of 10^{-7} to 10^{-5}; i.e., one additional case of cancer in populations ranging from 10 million to 100,000, respectively. (See reference No. 11 for further explanation).
h. Unionized; comparisons were made utilizing the table provided in reference No. 10.
i. Zero level results from EPA's assumption that no "safe" level of carcinogenic substances exists.
j. Criteria calculated for 60 mg/liter hardness.
k. Measured as nitrate plus nitrite nitrogen.

certain metals. In the site vicinity, total surface water withdrawn for public and industrial water use is about 10.9 million m^3 (2.8 billion gal) per day.

Ground water availability at the Courtland site is good. The ground water occurs in fractures and crevices in the limestone, some of which have been solutionally enlarged by circulating ground water. Limited historical data from geological formations similar to those occurring at the site show the quality of the ground water to be fair. Within 32 km (20 mi) of the site, 2 industries, 22 small public water supplies, and numerous private water supplies obtain potable water from the Tuscumbia Limestone and Fort Payne chert. These formations underlie the Courtland site.

Aquatic habitats within the site vicinity include the Tennessee River (lower Wheeler Lake), Spring Creek embayment, and Big Nance Creek. Fish, zooplankton (primarily microscopic animals), and macroinvertebrate communities in Wheeler Lake appear to be representative of populations found in most other TVA mainstream lakes. Recent sampling of the phytoplankton (microscopic plants, primarily) has indicated an increase in the number and percentage composition of blue-green algae, increases which are potentially detrimental to water quality and potentially indicative of eutrophication. Major fish spawning and nursery areas in the site vicinity are the Spring Creek embayment area (approximately 6.5 km (4 mi) from the site on Wheeler Lake) and the lower reaches of Big Nance Creek (which meanders along the southeastern site boundary and flows into the Tennessee River immediately below Wheeler Dam). Both of these latter areas support an excellent sport fishery.

An aquatic snail species, Leptoxis (Anculosa) praerosa, ("mainstream river snail") categorized as "in danger of becoming extinct if present trends continue" and a fish species, Hemitremia flammea (Flame chub), categorized as a "species of special concern" (Boschung, 1976)[13] have been collected in lower Big Nance Creek. Mitigation prescribed would eliminate significant impacts to these species. (See Chapter 4 and Appendices F and G for additional discussion.)

The predominant terrestrial habitat type occurring at the Courtland site is agricultural land which is annually row cropped for production of soybeans and cotton. This open, agricultural land is bordered by overgrown fence rows on the south and west. These fence rows are composed primarily of plum, hackberry, mock orange, and blackberry. Big Nance Creek and its associated bottomland hardwood forest, serve as the eastern boundary of the site. The northern site border, once occupied by buildings, is now dominated by thickets of eastern red cedar, hackberry, honeysuckle, and blackberry. A total of approximately 245 species of amphibians, reptiles, birds, and mammals could utilize the site.

Past uses and a lack of suitable habitat in the Courtland site likely preclude the presence of any threatened or endangered aquatic plant species. Neither the Indiana bat (Myotis sodalis) or gray bat (Myotis grisescens) are known to inhabit caves in Lawrence County, Alabama. The closest cave which is known to be inhabited by either of these 2 species is located in Lauderdale County, approximately 13.5 air km (8.5 air mi) north-northeast of the Courtland site. Due to the small amount of stream (i.e. over water) and riparian habitat on the Courtland site, and its distance from the nearest cave known to support either of these endangered species, it appears unlikely that these bats would utilize the site area during foraging activites.

The red-cockaded woodpecker (Picoides borealis), listed as Federally endangered, was identified by the U.S. Fish and Wildlife Service as occurring in the Courtland area (see Appendix D). The nearest known population of red-cockaded woodpeckers is in William B. Bankhead National Forest approximately 40 air km (25 air mi) south of the Courtland site. During site visits, conducted by TVA from December of 1976 through May of 1980, no old growth pine stands suitable for the red-cockaded woodpecker were observed on or in the immediate vicinity of the Courtland site.

Streams near the Courtland site provide breeding habitat for wood ducks. Wood ducks, mallards, and black ducks were the main waterfowl species observed on Big Nance Creek adjacent to the Courtland site. Open water expanses in mid-lake of Wheeler and Wilson are significant resting and feeding areas for migratory and wintering waterfowl. Flocks of migratory shorebirds and wading birds find favorable habitat in shallow water areas and mudflats in the upper reaches of Spring Creek embayment.

The Courtland site is above the Tennessee River 500-yr floodplain. The Big Nance Creek 100-yr and 500-yr floodplains comprise only a small percentage of the Courtland site.

The Courtland site is characterized by deep, well-drained terrace soils of mainly Dewey-Decatur series. The site is completely underlain by Tuscumbia Limestone. When sound and unweathered, the bedrock would be capable of supporting any of the intended loads. The overburden thickness at the site, based on drilling, ranges from about 2 m (7 ft) to about 15 m (50 ft) and averaged about 8 m (27 ft). While the overburden soils would appear to be of sufficient thickness to support waste disposal liners, the ability of the underlying rock to support the soils is in question.

The baseline noise survey (see Table 3-4 and Figure 3-2) conducted by TVA during 1980 identified motor vehicle traffic, airplane traffic, and farm machinery as the major manmade noise sources now existing in the community. Depending upon the survey site, average nighttime levels varied between 42 and 50 dBA while average daytime levels varied between 48 and 57 dBA. Again depending upon the site, levels as high as 74 dBA were exceeded 0.1% of the time.

Results of radiological monitoring conducted by TVA at the Courtland site show that direct radiation levels and concentrations of radioactivity in surface water, soil, and sediment appear to be typical of background levels in the Tennessee Valley region.

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4. Climatic Atlas of the United States, U.S. Department of Commerce Environmental Science Services Administration, Environmental Data Service, Asheville, North Carolina, 1968.

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7. Thom, H.C.S., Tornado Probabilities, Monthly Weather Review, Vol. 91, Nos. 10-12, pp. 730-736.

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9. USEPA, "National Secondary Drinking Water Regulations," 44 Fed Reg. 42, 195. July 19, 1979.

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4. ENVIRONMENTAL CONSEQUENCES

This chapter presents the potential environmental consequences of constructing and operating the proposed north Alabama coal gasification demonstration plant at the preferred site, Murphy Hill, or the alternate site, Courtland. Socioeconomic impacts have been reassessed based on initially constructing only 2 modules of the proposed facility with the capability to expand to 4 modules at a later date. The estimated peak construction work force under the revised schedule is approximately 50% of that of the initial 4-module schedule, resulting in substantial reductions in impacts. Potential environmental impacts are presented for a number of categories under each site. The environmental assessments were based on constructing 4 modules. Since the present thinking is to construct 2 modules at this time, with the capability of expanding to 4 modules at a later date, this assessment envelopes or provides an upper bound on potential environmental impacts for the entire facility. More detailed discussions of the environmental consequences of constructing and operating the plant are provided in Appendix G, Volume 2, of the FEIS.

4.1 MURPHY HILL

4.1.1. Manmade Resources

4.1.1.1 Land Use

The entire Murphy Hill site would be utilized for the gasification plant and related facilities, resulting in the removal of the small amount of prime farmland (about 30% or 360 acres of the site) from possible future production. Based upon available information and the emission levels expected, agricultural operations elsewhere in the site vicinity are not expected to be detrimentally impacted.

A concern raised during the scoping process was the potential impact of the plant on land values in the general vicinity. To determine possible impacts on land values, a TVA consultant examined the historical record of changes in values at other TVA plant sites within the north Alabama area (Bellefonte, Widows Creek, and Browns Ferry). Where large industrial facilities were sited in the area, the impacts these facilities had were also examined. These industries included the Monsanto Plant and the Revere Copper and Brass plant in the Murphy Hill area and the Champion Paper mill near the Courtland site.

Land value reflects a wide variety of factors including national economic trends, site accessibility, development potential, development constraints (e.g., floodplains, topography, soil condition), and availability of utilities. These factors, as well as the timing and desire of buyers, determine whether land may be sold for a given price at a specified time. The historical records establish, in general, that neither the siting of nuclear plants nor large industries in the north Alabama area caused land values to decrease.

In fact, land values, as reflected by tax assessments and land sales, increased. However, no conclusion may be drawn that the increase was directly related to the plant siting. Inflation, improvements to the land, and a number of other factors may have caused the value to increase.

Based on this analysis, the siting of a coal gasification facility at Murphy Hill may be expected to change the character of land use development within the vicinity of the plant site. However, land values are not expected to decrease as a direct result of the plant siting.

4.1.1.2 Recreation and Scenic Resources

The impact of plant construction and operation on recreation activities is expected to consist primarily of the visual effects from the plant and of barge traffic.

The existing aesthetic character of this section of Guntersville Lake and the shoreline would be altered; however, the area does not provide a unique or highly unusual setting. Some plant facilities would be visible from the right lake bank. However, the topography of the ridge on the northwest portion of the site, existing trees, and the long distance across the lake should minimize the visual impact. The physical presence of barge tows and in particular the yard tug would impact the recreational use of the lake at the site. The barge unloading facility would generate noise during the construction phase but should create minimal impact during the operational phase. Please refer to Section 4.1.1.5 below for additional information on barging impacts.

No other potential impacts on scenic or natural features have been identified in the study area.

4.1.1.3 Cultural Resources

There are no structures of historical or architectural significance present on the site. It is expected that the proposed plant will have no effect on a nearby log cabin. The archaeological locus on the Murphy Hill site was studied intensively in 1974. The Alabama State Historic Preservation Officer (SHPO) has concurred with TVA's "no significant impact" determination for the proposed coal gasification plant (see Appendix D). It has also been determined that the proposed highway improvement activities will have no impact on any known archaeological or historical resources.

4.1.1.4 Socioeconomic Impacts

Construction of modules 1 and 2 of the coal gasification plant would require approximately 6 yr and could utilize up to about 3,600 workers at peak. A large number of these workers are expected to move into the 3-county area. The presence of such a temporary population influx may create the potential for a serious strain on various community facilities and services.

Significant negative impacts are not expected during the operating period of at least 20 yr from either the 800-person workforce needed to operate the first 2 modules or from the 1,400 person workforce needed to operate the plant if all 4 modules are built. The number of inmovers should be insignificant and dispersed throughout the 3-county area. The coal gasification facility is expected to induce some amount of new industrial development by the late 1980's. TVA will act within its planning and technical assistance capability to promote secondary development in an environmentally acceptable manner. (Please refer to Section 4.5 for additional discussion of potential environmental impacts of secondary development.) The additional capacity in services and facilities required to accommodate the temporary construction force should be adequate for any inmoving operational workers. There would, of course, be beneficial socioeconomic effects associated with the project. Employment would increase in the area, and additional personal income should be realized. Spending levels in the Murphy Hill area should increase.

As a result of the proposed private ownership of the north Alabama coal gasification plant and the reduction of associated socioeconomic impacts, TVA does not anticipate implementing the socioeconomic mitigation program discussed in the DEIS. The relationship of the project to local governments would be similar to that of other private industrial developments. The plant would be subject to taxation by Marshall County which would provide significant amount of revenues to pay for expansion of local services and facilities if necessary. Temporary financing arrangements might be necessary in certain cases to account for any possible time lag between the occurrence of impacts and the receipt of tax revenues. Also, any tax exemption granted to the private entity would be taken into account in choosing among various methods of granting assistance. With respect to DeKalb and Jackson Counties, accommodating the growth from plant construction would be accomplished in a fashion similar to that of other private industry, which could include seeking industry assistance.

It is important to emphasize that, with the current plans to construct a 2-module facility initially, the degree of adverse impacts expected is significantly less than that discussed in the DEIS. This is due to the revised estimated population influx which is now about 40% of the earlier estimate that had been based on constructing 4 modules with a peak work force of 6,800. The peak workforce estimate for a 2-module plant is 3,600. Thus, under any form of ownership, the scope of potential socioeconomic impacts would be greatly reduced.

TVA would be responsible for any impacts that might occur from its direct involvement in construction (site preparation phase). However, since virtually no inmovers are expected during that time, no impacts are expected.

It is possible that the increase in local employment related to construction and operation of the coal gasification plant could help offset the negative impacts of a permanent closing of the Monsanto facility. However, because of uncertainties over both the future utilization of the Monsanto facility and the transferability of skills to the coal gasification project, no definitive conclusions can be made on the potential for offsetting the negative impacts of Monsanto's closing.

During the peak year of construction, it is estimated that approximately 30% of the work force (1,080 workers) should move into the area with about 760 of them bringing their families for a total influx of about 2,750 people. These inmovers are expected to be well distributed in the area, with Scottsboro receiving about 35% of the people, and Guntersville, Albertsville, and Boaz each receiving about 20%.

There should be a slight compounding of the current housing shortages in DeKalb and Marshall Counties possibly resulting in the development of mobile home parks. The decline in the construction force at Bellefonte should increase housing vacancies in Jackson County. New permanent residents in the area are expected to eventually occupy housing built for and occupied by temporary construction inmovers.

The influx of school-age children into the 3-county impact area is expected to result in temporary shortages in capacity for all school systems. Additional classrooms, buses, and personnel would probably be required to maintain existing service levels.

No significant impacts are expected on water and sewer treatment facilities.

The population influx is not expected to cause significant adverse impacts on the services regularly provided by local governments, including fire and police protection. Some additional temporary stress could be expected on existing community recreation service levels. Such impacts would be incremental and not require large expenditures in a short period of time.

There are expected to be insignificant impacts on institutional medical care and emergency health services. However, inmovers should further strain the shortage of health professionals in DeKalb and Jackson Counties. In addition, some additional demands would be placed on currently overutilized public health services.

Construction of the plant at Murphy Hill would result in adverse impacts on local traffic. Heavy traffic congestion is expected on State Route 227 especially in Lake Guntersville State Park during peak project commuter hours. The DEIS indicated several possibilities for reducing traffic impacts including developing an employee transportation system, flexing the shift change time to avoid peak-hour traffic times, and upgrading local roads. Despite the reduction in the estimated work force, traffic congestion will still be a problem and implementation of those measures would still be appropriate. The details and extent of this road upgrading is presently being discussed with the Alabama Highway Department. The State typically funds road improvements intended to promote industrial development (e.g., State Route 227 from State Route 75 to the Monsanto plant).

4.1.1.5 Navigation Impacts

The amount of river traffic that would be associated with constructing the proposed 2-module facility is expected to be approximately 5 tows/month. In addition, it is estimated that sulfur shipment by barge would require one tow every 15 days. However, the greatest impact on river traffic is expected to result from barging activities associated with transporting coal to the site during plant operations.

The potential operational impacts of transporting coal to the site by barge were based on the assumption that the proposed facility would consist of 4 gasification modules processing 20,000 TPD of coal. The amount of coal required weekly by the 2-module facility would be approximately one-half of that estimated below. Therefore, the barging requirements of initial 2-module facility also would be reduced by about 50%.

Since the coal sources, their geographical location, and the barge transportation details (number of tows, size of tows, and size of barges) have not been determined, potential navigational impacts were evaluated by conservatively assuming that all of the coal would be obtained from distant hypothetical sources in southern Illinois and transported up the Tennessee River to the site. Tows would be expected to pass through the locks at Kentucky, Pickwick, Wilson, Wheeler, and Guntersville Dams en route to the site. It was further assumed that about 6 tows, consisting of 16 jumbo barges per tow, would be needed weekly to meet the coal requirements of the 4-module facility. The same number of similar tows would be required weekly to return empty barges to the coal loading site. Due to the size of these tows, a double lockage would be required at each of the main locks en route to the site.

The 4-module plant barge docking and coal unloading facility would eventually have the capability of mooring and storing 24 empty and 24 full barges, although the 2-module plant would probably not require as large a barge storage capability. It is anticipated that both a barge puller system and a yard tug would be utilized during coal unloading operations. Coal unloading would be expected to occur 16 hr/day on Monday through Friday, although it is conceivable that operational constraints would require unloading on weekends. Instead of utilizing a separate fleeting site, return tows would be assembled from empty barges at the plant barge docking area.

The additional barge traffic would not be expected to adversely impact commercial navigation along the Tennessee River. However, there would, of course, be increases in the amount of river traffic passing through the locks at Kentucky to Guntersville Dams. (Please see Table 4.1.5-1 in Appendix G). The percentage increases for each parameter would vary between the dams. Increases in the number of tows, commercial lockages, and total lockages at each dam (Kentucky to Guntersville) would range from 17% to 73%, 22% to 96%, and 21% to 45%, respectively, over existing river traffic levels. The average delay time for tows awaiting lockage would probably be negligible at Pickwick Dam where a new lock is being completed, whereas it could approach 12 hours at Kentucky Dam if no mitigative measures were taken. Based on the estimated increases in percent utilization of each dam, the additional river traffic would be well within the capacity of all dams, excluding Kentucky Dam. The percent utilization at Kentucky Dam would approach 95%, if no mitigative measures were taken such as directing part of the river traffic along an alternate route. Traffic originating on the Ohio River could enter the Cumberland River through the lock at Barkley Dam, and then travel along the Tennessee-Cumberland Canal to Kentucky Lake on the Tennessee River, thus bypassing Kentucky Dam. If a second lock were found feasible and were built at Kentucky Dam, the expected river traffic levels at Kentucky Dam could also be minimized. Barge requirements for a two-module facility would not be expected to adversely impact the capacity of Kentucky Dam.

As indicated, this analysis conservatively assumes that all of the coal used at the plant would come from Illinois. In actuality, some of the coal may come from western Kentucky, possibly bypassing Kentucky Dam, or from east Tennessee and other areas upriver from the proposed plant, or from local Alabama sources, all of which would lower the number of lockages and percent utilization of the downstream locks.

Significant impacts to recreational use of the Tennessee River are not expected, since commercial navigation would be confined to the deeper, marked channels and recreational boats often travel the entire surface of the river. However, as indicated in the DEIS, some impact on recreational use of Guntersville Lake within the immediate site vicinity would be expected, if the Murphy Hill site were selected.

4.1.2 Natural Resources

4.1.2.1 Air Quality

A summary of estimated potential emissions based on a number of general assumptions is given in Table 4-1. During construction, the primary emissions to the air would consist of fugitive dust due to building and road construction activities. Emission levels would vary depending on the specific operation and activity level. An average emission level was conservatively estimated as approximately 1.2 tons of total particulate matter (PM) per acre

TABLE 4-1

SUMMARY OF ESTIMATED POTENTIAL EMISSIONS TO THE AIR DURING CONSTRUCTION AND OPERATION OF THE PROPOSED COAL GASIFICATION PLANT (4 MODULES)

Emission	Source	Estimated Emission Rate
Fugitive Dust	Initial Construction Activities	1.2 tons/acre/ month[a]
Sulfur Dioxide	Gasification Plant Auxiliary Boiler	3.5 tons/day[b] .01 tons/day[c]
Suspended Particulate Matter	Plant Operation	0.3 tons/day[d]
Carbon Monoxide	Gasification Plant Auxiliary Boiler	8.7 tons/day[e] 0.2 tons/day[f]
Nitrogen Oxides	Auxiliary Boiler	2.0 tons/day[g]
Methanol	Gasification Plant	16.8 tons/day[h]

a. Temporary uncontrolled particulate emissions during initial construction activities.

b. Based on processing 20,000 TPD of 4.3% sulfur coal, 99.8% removal efficiency.

c. Based on combustion of product gas with 1 ppmv COS/H_2S.

d. Sources of these controlled emissions include coal unloading, coal storage, coal crushing, and cooling tower drift.

e. Acid gas removal system CO_2 vents. Based on processing 20,000 TPD of coal.

f. Assumed same rate of CO release with product gas combustion as with methane (natural gas) combustion (17 lb per 10^9 Btu).

g. Based on new source performance standard of 0.2 lb per 10^6 Btu heat input for this fuel type.

h. Acid gas removal system CO_2 vents. Based on processing 20,000 TPD of coal. TVA is considering the use of a control device to recover methanol for reuse.

per month. These levels would be temporary and could be reduced by about one-half by using an effective watering program. In addition, much of the dust is expected to settle within site boundaries.

Additional emission sources during the construction phase may include exhausts of construction equipment, open burning of natural waste materials and construction wood wastes, and operation of an onsite concrete batch plant. Emission controls on the batch plant and other mitigative actions, as required by State of Alabama regulations, would be implemented for these relatively short-term activities.

Air quality impacts from plant operations were estimated from available information and/or conservative assumptions, because the final design of the facility has not been selected. The major emission sources are expected to be coal transportation, handling, and gasification, and combustion of MBG or other low-sulfur fuels for minor utility needs during plant operation.

One principal emission during facility operations is sulfur dioxide (SO_2), which has an expected emission rate of 3.5 TPD or less from coal gasification under normal operating circumstances (20,000 TPD of 4.3% sulfur coal, assuming at least 99.8% removal). These emission levels are not expected to cause either the National Ambient Air Quality Standards* (NAAQS) or the PSD increments to be exceeded. No other major SO_2 sources were found in the potential impact area of the proposed facility.

Considerable quantities of PM emissions (as high as approximately 0.3 TPD) may result from coal handling and preparation. Utilizing favorable design options, the best available control technology, and other feasible mitigation measures would reduce these emissions. Since no other major PM sources and no PM increment consumers were found in the vicinity of the Murphy Hill site, the full PSD Class II increments are expected to be available.

Using control efficiencies typically required for coal handling components of such facilities and conservative air quality modeling, TVA's analysis showed that about 35% of the 24-hr PSD Class II increment and about 13% of the annual PSD Class II increment would be consumed near the site boundary. The highest

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*Primary and secondary NAAQS have been established by the EPA. Primary NAAQS "define levels of air quality which the EPA Administrator judges are necessary, with an adequate margin of safety, to protect the public health" (40 CFR Part 50.2). Secondary NAAQS "define levels of air quality which the EPA Administrator judges necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant" (40 CFR Part 50.2).

PM levels resulting from plant operation would be about 9% of the 24-hr secondary NAAQS and 4% of the annual secondary NAAQS.

Carbon monoxide (CO) would be emitted from product gas combustion and from the product gas cleanup system CO_2 vents. The estimated emission rate of 17,800 lb/day is expected to result in ambient levels, including background, considerably below the CO NAAQS.

Nitrogen oxides (NO_x) would also be emitted as a result of product gas combustion. Since the final boiler design has not been determined, a boiler just capable of meeting new source performance standards for this fuel type was assumed. These calculated levels resulted in ambient NO_x levels much below the NO_x NAAQS.

Potential emissions of methanol, a volatile organic compound, are shown in Tables 4-1, B-11, and B-12. Recovery of methanol is being considered for reducing these emissions. No significant amount of ozone (O_3) or O_3 precursors other than methanol (e.g., hydrocarbons, or other volatile organic coumpounds) would be expected to be released during plant operations. Methanol emissions and potential ambient impacts would be further evaluated in a PSD permit application to the State of Alabama. If methanol emissions are judged not to have a significant effect on ozone levels, no significant air quality impacts are expected from these constituents during plant operations.

The possible impacts from several other potential emissions were examined. Although considerable quantities of argon and nitrogen may be emitted during plant operation, these emissions are not expected to result in adverse air quality impacts. Other emissions (e.g., HCN, NH_3, reduced sulfur compounds, polycyclic organic matter, toxic trace metals, and other trace elements) are not expected to be produced in sufficient quantities to cause significant air quality effects.

In summary, a number of normal plant operation emissions to the air were evaluated, such as SO_2, PM, NO_x, CO and O_3. TVA has determined that none of these should cause NAAQS or applicable PSD increments to be exceeded if required mitigation measures are taken.

A preliminary analysis of possible impacts resulting from flaring of product gas during startup or emergency shutdown operations was performed in order to assess the need for mitigation measures. This preliminary analysis indicated that due to SO_2 emissions from the flare during initial plant startup, there may be a potential for ambient SO_2 concentrations to exceed the 3-hr and 24-hr NAAQS and PSD increments. A more complete analysis, using actual design information, would be conducted during the PSD permit application process. If mitigative actions were required, they may include design changes, low-sulfur coal, and/or startup restrictions during unfavorable meteorological conditions.

4.1.2.2 Surface Water

Availability

For purposes of evaluation, the maximum intake flow of the facility was assumed to be 50 cfs. Various discharge alternatives were considered; however, subsequent design information indicated that the facility could utilize a discharge of approximately 20 cfs. The consumptive water requirement of the facility would then be approximately 30 cfs. This water consumption requirement is not a significant portion (about 0.27%) of the average 7-day, 10-yr low flow (11,000 cfs) near the site and would have insignificant impacts on water availability. The average river flow is about 38,000 cfs.

Impacts on Water Quality

Wastewater discharges from the facility during construction will be regulated by the effluent limitations in the construction National Pollutant Discharge Elimination System (NPDES) permit. Construction of the facility would be in conformance with a site specific Erosion and Sediment Control Plan specifying "Best Management Practices" for the control of erosion and sedimentation due to storm water runoff from disturbed areas. A Spill Prevention Control and Countermeasures (SPCC) plan would be developed for construction to ensure that accidental spills of oil, hazardous substances, and hazardous wastes do not pose a significant environmental threat.

During plant operations, wastewaters to be discharged directly to the lake would receive treatment via Best Available Control Technologies. Inadvertent spills would be controlled as specified in the operational SPCC plan. The application of these control measures, along with the other operational commitments made in the FEIS, would ensure that the environmental impacts associated with these effluents would be appropriately minimized.

The potential toxicity, carcinogenicity, or mutagenicity of the various major wastewater streams (both untreated and treated) and treatment byproducts is not well documented. EPA is now developing a synthetic fuel regulatory strategy for all processes. A program would be developed and implemented as required under NPDES regulations, which would prevent or minimize the potential for the discharge of toxic or hazardous pollutants. EPA and the State of Alabama would be involved in the development of this program. In addition, the current draft NPDES construction permit requires further studies to assess plant-induced impacts, and thereby verify the adequacy of the wastewater treatment facilities.

Other potential impacts to water quality involve discharges of conventional pollutants. The operational NPDES permit that would be issued by the Alabama Water Improvement Commission would establish limitations on the discharge concentrations of these pollutants consistent with applicable regulatory provisions.

Based upon conditions under which dredging activity would take place and mitigative actions identified by TVA, the proposed dredging operations should have a minimal and acceptable impact on the water use and water quality resources of Guntersville Lake in the site vicinity (for additional information, see Appendix E, Section J, "Aquatic Ecology and Fisheries, Comment 5). Turbidity is not expected to be a problem. The Corps will evaluate this activity in the context of reviewing a Section 10 and 404 permit application for the water use facilities.

The effect of the assumed 20 cfs discharge on the thermal regime of the lake near the Murphy Hill site would be negligible. Rapid mixing (dilution of approximately 20) in an extremely small percentage (about 2%) of the total lake cross-section (about 109,300 ft^2) could be expected with a multiport discharge. A mixing zone of about 130,000 ft^3 would be sufficient. A velocity survey was conducted in May 1980 in Guntersville Lake near the Murphy Hill site. The test results indicated that thermal and chemical discharge impacts could be greatly reduced by locating the discharge in either the main or secondary channel.

The lower reach of Guntersville Lake is highly productive and is approaching its waste assimilative capacity. Development of the proposed coal gasification facility could potentially cause increases in the oxygen-demanding waste load and nutrient enrichment in the lower reaches of this lake. TVA is presently conducting assimilative capacity investigations to determine the quantity of oxygen-demanding wastes which the lake could assimilate while maintaining compliance with the State standards. The State of Alabama would utilize the results of these investigations in their NPDES permitting process for the proposed facility. As large a portion as practicable of the available assimilative capacity would be reserved for future development.

4.1.2.3 Ground Water

Ground water at the Murphy Hill site may be used for potable water. Protection measures would be taken as needed to prevent the contamination of ground water below areas utilized to control accidental spills of hazardous chemicals and substances. Similar measures would be provided for areas utilized for temporary storage of hazardous wastes (see Section 4.1.2.12 of the text).

4.1.2.4 Aquatic Ecology and Fisheries

Impacts and Mitigative Action Generic to Both Sites

Dredging and construction of water use facilities (including fill activities) would cause some mortality among less mobile organisms (fish food organisms, larval fish, and small fish) but the mortality would be restricted to the general area of activity, and recolonization or reinvasion normally occurs unless additional stress is exerted. More mobile organisms (adult fish, etc.) would leave the area during construction activity (and barging activities). For additional discussion, see TVA responses to comments 1, 4, and 6 of Section J, Appendix E.

Potential operational impacts (in addition to the barging) include entrainment and impingement of organisms resulting from the intake of raw water, plant noise (sport fishing impact), and the release of liquid effluents.

See Section 4.2.4, Appendix G, for a discussion of regulatory responsibilities related to instream construction activities and evaluation of effects on aquatic organisms.

TVA does not anticipate significant effluent-related operational impacts from the more routine conventional pollutants. Assimilative capacity studies are being conducted to determine the quantity of oxygen-demanding wastes which Guntersville Lake can assimilate while maintaining State standards. Thermal discharges would not cause water quality standards to be exceeded beyond a defined mixing zone, and discharges of organic matter would be reduced through use of appropriate wastewater treatment. TVA is currently conducting screening studies to determine whether or not effluents released by the proposed facility would enhance productivity. If adverse productivity levels are indicated, appropriate treatment to reduce nutrient impact would be installed.

Other less conventional effluent components are process dependent, and specific waste stream characterization is not available at this time. Appropriate waste characterization studies and wastewater treatability studies (including bioassays) are being undertaken to support the wastewater treatment plant design and permit applications, and wastewater discharges would be treated to avoid adverse toxic impacts to aquatic life. For further information, see the response to comment 3 under "J. Aquatic Ecology and Fisheries", Appendix E.

Process wastewaters would be recycled as much as practicable and treated effluent residuals would be discharged into channel areas as opposed to release in overbank areas. Because of the plant location, its commercial-scale size, and the fact that coal gasification is a new technology in the U.S. with no Federal pollution control standards, the draft NPDES permit for construction requires appropriate instream and onsite investigations during plant operation to evaluate potential toxicity and the stability of Guntersville Lake in the site vicinity. This monitoring would detect any impacts, and they would be mitigated as appropriate. Portions of the monitoring plans would be terminated as results demonstrate that it is appropriate to do so.

In the unlikely event of an accidental spill of chemical substances, the extent of harm to aquatic organisms would be dependent upon the nature and volume of the spilled material, as well as the nature and expediency of cleanup procedures. A comprehensive SPCC plan would be developed to control accidental spills in accordance with Federal regulations and TVA specifications.

Site-Specific Impacts and Mitigative Actions

Due to the productive nature of the site overbank areas, their fishery values, and the concentrations of metals and organic matter in the materials which must be dredged and disposed (for additional information, see Appendix E, Section J, "Aquatic Ecology and Fisheries", response to comment 5), instream construction and barging impacts would be minimized as follows: most barge channel and turnaround areas would be located in the deeper portions of the overbank as specified, avoiding productive areas to the extent practicable; dredging activities would not be conducted during fish spawning seasons (March to August) if practicable, and impacts minimized to the extent practicable; disturbed or potentially erodible shoreline areas would be riprapped to minimize turbidity and siltation; and to the extent practicable, barge traffic on the overbank areas would be controlled in such a way as to minimize impacts. Construction of the proposed facility would also create some site runoff, carrying suspended solids which potentially could adversely impact the lake. Consequently, all stormwater runoff during construction and from curbed process plant areas during operation would be appropriately treated prior to discharge, and nonpoint runoff would be controlled in conformance with best management practices.

Depending on ultimate raw water intake requirements, an unmitigated intake structure could produce undesirable impacts at this site. Subsequent to issuance of the DEIS, TVA biologists evaluated 6 potential intake designs and selected the design which is expected to provide the most practicable protection for the fish community at this site. For further explanation of the water-use facilities' locations and designs, refer to the response to questions 1 and 2 under "J. Aquatic Ecology and Fisheries" in Appendix E.

While 1 onsite population of the aquatic plant _Isoetes engelmanii_ A. Br. (a quillwort) would be displaced, shoreline populations of _I. engelmanii_, and an onsite population of _Cambarus_ (_A._) _hamulatus_ (a cave crayfish), are not expected to be impacted by construction and operation of the proposed facility. In any event, the survival of these species in adjacent areas of Guntersville Lake and Marshall County, respectively, would not be jeopardized (see Appendix F, Section 3.2.4 for additional information).

TVA anticipates that mitigation and design measures described above and in other sections of this document will reduce aquatic impacts to acceptable levels.

4.1.2.5 Upland Vegetation and Wildlife

Plant construction of the proposed coal gasification facility would result in clearing or alteration of approximately 450 acres of wildlife habitat of moderate quality and 950 acres of above-average upland wildlife habitat. Some species tolerant of disturbance would continue to inhabit the area, albeit in reduced numbers. While some organisms such as the birds and larger mammals would vacate the site during construction or disturbance, many smaller mammals would be unable to move with sufficient alacrity to avoid being destroyed. Although destruction of habitat and displacement of species would occur, the wildlife habitat would be enhanced to the extent practicable by protecting, preserving, and managing existing wildlife and waterfowl management areas on Guntersville Lake.

4.1.2.6 Threatened or Endangered Species

A request was submitted to the Regional Office of the U.S. Fish and Wildlife Service on February 14, 1980, for the names of those species either Federally listed or proposed for listing as endangered or threatened which might occur in the vicinity of the Murphy Hill or Courtland sites. Subsequently, a letter was received from this agency which indicated that 18 species of terrestrial or aquatic animals have distributional ranges which include the 2 alternative sites (see Appendix D). The following information represents TVA's biological assessment concerning possible impact to the 18 species in question and is designed to meet the requirements of Section 7c of the Endangered Species Act of 1973 as amended.

Construction and Operation

An inventory of the Murphy Hill site has been conducted and no resident populations of Federally listed endangered or threatened species were found. Construction and operation of a coal gasification facility at the Murphy Hill site may result in minor losses of shoreline or riparian habitat which may be occasionally utilized by either the gray or Indiana bat. Additionally, disturbance or destruction of riparian vegetation could potentially cause some impact to migrant or wintering bald eagles. Secondary impacts to eagles resulting from riparian habitat degradation may occur due to an anticipated decline in waterfowl use of the area. The present level of waterfowl use is thought to have an influence on raptor use of the site. However, considering the abundance of this type of habitat along the Tennessee River in northern Alabama, this loss would not jeopardize the continued existence of these 3 species, or adversely impact their critical habitat or inhibit opportunities for their recovery at the regional or national level.

Mitigation

Disturbance of shoreline and riparian habitat adjacent to Guntersville Lake would be minimized by utilizing the preferred docking options and by not locating other plant structures in the riparian zone. Where shoreline vegetation removal is necessary, such as during construction of waterway facilities, the resultant impacts would be mitigated by restoring, to the extent practicable, a wooded buffer zone along the lakeshore at the site to provide roosting and perching sites for bald eagles. Undertaking these mitigation measures would also ensure that impacts to potential foraging habitat for gray or Indiana bat are minimized.

Conclusion

Based on available information and undertaking the mitigation described above, TVA has determined a "no effect" situation exists regarding potential impacts to Federally listed endangered or threatened species.

4.1.2.7 Wetlands and Wetlands Wildlife

All of the shoreline, shallow embayments, and inlets that surround the site are classified as wetlands and these areas support very high numbers of waterfowl, fish, and wetlands wildlife. Plant construction and operation activities that alter or destroy riparian vegetation could have a significant impact on wetlands wildlife. The overbank area is important to waterfowl and other wetland wildlife and would be avoided to the extent practicable.

Construction of barge slips, terminals, and intake/discharge structures are the principal waterway activities likely to impact shoreline wetlands if the Murphy Hill site is selected. In addition, bridge construction and field activities associated with the proposed highway improvement project would also impact wetlands. Construction-related activities would directly impact 15 acres of wetlands out of a total of 260 acres of wetlands at the Murphy Hill site. However, there would be no practicable alternative to constructing such facilities in the wetlands. The selection of the preferred alternatives for the barge terminal and the intake/discharge system, as described in Chapter 2, and by locating other plant structures outside of the wetlands would minimize direct impacts to wetlands to the extent practicable and, therefore, would comply with the concepts and policies of Executive Order No. 11990 and TVA's implementing procedures.

The remaining wetlands at the site would not be directly affected by the project activities. However, waterfowl species and resident wood ducks that utilize these wetlands would be displaced by construction activities and increased barge traffic. To determine the amount and duration of impacts to these populations from construction- and operational-related activities, a waterfowl and wetland wildlife monitoring study would be conducted if practicable. These studies would also ascertain the capability of surrounding areas to support waterfowl populations that might be displaced during construction.

4.1.2.8 Floodplains

The project's present plant layout sites all structures, except for the sulfur dock, the coal barge terminal conveyor support structures, and other water use facilities above the TVA structure profile elevation (which is higher than the 100-yr floodplain). There is no practicable alternative to locating these latter structures on the floodplain and the effect on flood retention is minimal. Thus locating a facility at Murphy Hill would comply with the concept and policies of Executive Order No. 11988 and TVA's implementing procedures.

4.1.2.9 Geology and Soils

Depending on the location of waste disposal areas, varied requirements would be necessary to maintain the integrity of the disposal area. Field and laboratory soil investigations would determine the capacity of the soil to carry the ash and slag load. Should the soil be able to carry the required load, liners, if required, would most likely be constructed on the in situ soil. Should the soil be unable to carry the required load, any required liner would be founded on the top of rock or upon a selected engineering material having suitable structural integrity. If onsite materials are unacceptable for the construction of the liner, then material would be obtained from commercial sources or a borrow area. Use of such a borrow area would be reviewed in accordance with applicable regulations or procedures. The general area to the southeast of the road either contains or is susceptible to the formation of sinkholes, swallow holes, and caves that could cause the breaching of a liner if one were required for solid waste. The preliminary plant layout for the Murphy Hill site avoids this area.

Depending on the type of foundations proposed for the various structures, their proposed loads, their location onsite with respect to depth to rock and depth to sound rock, either rock supported mat, caisson, pile, soil supported mat, or soil supported footing foundations can be used.

No coal or petroleum is being extracted from the site. No other types of economic minerals exist on the site. Some coal is mined in an area east of the Murphy Hill site atop Sand Mountain.

4.1.2.10 Environmental Noise

TVA monitoring of construction noise at other large construction projects shows that daily levels at plant boundaries average 50 to 60 dBA with an occasional hourly average as high as 75 dBA. Murphy Hill would have similar construction noise levels at the site boundary but when extrapolated to a 1-mi radius, the levels should be 20 dBA lower. This compares favorably with the baseline levels shown on Table 3-4.

The major operational noise generators in the plant would be:

Pressure Reduction Valves - Without controls, noise from valves with sonic pressure ratios could reach 130 dBA measured at 10 ft, and from both an environmental and an occupational standpoint, special care would be taken to ensure the installation of quiet valves and blowdown mufflers where needed. The valve noise must be controlled to 90 dBA in the immediate vicinity to meet occupational noise requirements. The process noise level would then be below a Federally recommended average value of 65 dBA at the plant boundary.

Air Separation Compressors - Preliminary design plans for the air separation plant call for high-powered compressors which could generate as much as 130-dBA casing noise, as well as 130-dBA air inlet noise. These compressors would be designed for noise control, which may include housing or mufflers as necessary. Again, the noise must be controlled to 90 dBA for occupational health purposes and would meet the recommended 65-dBA average at the plant boundary.

Barges and Coal Handling - Barge unloading noise measured across the river (400 ft) from a similar type of unloader showed an average sound level of 66 dBA with 80 dBA exceeded 0.01% of the time. When the 80-dBA value is extrapolated to the 6,000-ft width of Guntersville Lake, the barge unloading and coal-handling noise should be no more than 60 dBA at either Pine or Preston Island residential sites. It is expected that the facility would be operated 5 days a week, approximately 16 hr/day. The coal needed for operation of the 4-module coal gasification plant would require an average of 5 to 6 additional tows per week with each tow consisting of 15 to 17 barges carrying 1,500 tons per barge. The same number of tows would be needed weekly to return empty barges to the coal loading site. Since the coal requirements of a 2-module facility would be about one-half of that estimated above the barging requirement for the facility would be similarly reduced (please see Section 4.1.1.5). The barges could travel during any day of the week. Noise from passage of the additional tows would increase the baseline average noise on shore by less than 2 dBA; however, the operation of the yard tug would be essentially continuous during coal unloading operations and may be intrusive. If such becomes the case, special muffling and engine enclosures may be necessary.

Other Sources - Transformers, cooling towers, ventilating fans, etc., should require no special treatment in order to meet the recommended average value of 65-dBA at the site boundary. Flares, depending on their location and method of operation, may need special treatment to meet the 65-dBA value at the site boundary. However, if operational noise surveys show a need to reduce the level of any noise source in order to attain the recommended average 65-dBA criterion, it is expected that additional measures would be initiated by the consortium.

4.1.2.11 Radiological Impacts

Radiological impacts from the proposed gasification plant at Murphy Hill are expected to be small.

The following major sources of potential radiological emissions to the atmosphere were identified for the generic coal gasification facility: (1) coal stockpile and associated coal handling operations, (2) barge unloading, (3) cooling tower, and (4) coal crushing and preparation. In addition, a minor source of radiological emissions to the atmosphere is expected to be the ash/slag disposal area. Radioactive releases were assumed to be either particulates or radon-222 gas and its short-lived decay products. Radiation dose pathways considered included inhalation of airborne radioactivity; ingestion of beef, vegetables, and milk containing radioactivity; and external irradiation.

At distances greater than about 1,000 m (3,280 ft) from the coal gasification facility, total radiation doses to the worst-case individual from atmospheric releases should be below the U.S. EPA dose criteria for the uranium fuel cycle and the U.S. Nuclear Regulatory Commission (NRC) dose criteria for light-water reactors used here as guidelines only. Doses are also small compared to background (an average of 140 mrem/yr in the Tennessee Valley region). Maximum ground-level radionuclide concentrations in air are several orders of magnitude below the Federal regulatory limits (10 CFR Part 20) for the general public.

Potential radiological impacts on water quality from operation of the coal gasification facility at Murphy Hill are predicted to be small. Doses to an individual from ingestion of water and fish are below EPA and NRC dose criteria. Estimated concentrations of radioactivity in water are well below 10 CFR 20 nonoccupational water concentration limits used here as guidelines for limits on exposure of members of the public.

4.1.2.12 Solid Waste Disposal

A number of nonprocess solid wastes would require disposal. The portion of domestic-type solid waste which is not salvaged as a recoverable resource would be disposed of in a State-approved disposal facility. Marshall County has presently available 6 sanitary landfills, some with expected lives of up to 10 yr, capable of accepting some or all of the domestic wastes from the proposed coal gasification facility at Murphy Hill. It is anticipated that the quantity of these wastes would have minimal impact on these facilities.

Construction, demolition, and degreasing wastes would be salvaged where possible. If salvage is not practicable, the materials would be buried onsite in an unclassified fill (in an environmentally acceptable manner) or offsite in a State-approved sanitary landfill. Hazardous and/or problem wastes would be either sold for reprocessing, recycle, or recovery if possible. All hazardous construction wastes would be disposed of off site in accordance with existing applicable State and Federal regulations. Temporary storage of hazardous wastes would be managed to prevent ground water contamination from accidental spills.

Process wastes requiring handling or disposal include gasification ash and slag, sulfur, wastewater treatment sludge, and catalysts. Elemental sulfur would be stored pending sale. Wastewater treatment sludges would be dewatered and, depending on feasibility, either disposed of by firing into the gasifier or in a State-approved disposal facility. Catalysts would be returned to the supplier or sold for recycle or recovery whenever possible. Otherwise, they would be disposed of in an approved offsite hazardous waste landfill.

It was originally planned to collect ash from the gas washer/cooler in slurry form and to mechanically dewater it prior to dry disposal (see Section 2.3.6.9 of the DEIS). Preliminary results of TVA's overseas tests at existing coal gasification plants have indicated that because of difficulties in dewatering wet ash, it is preferable to mechanically separate the ash in dry form before stacking it as proposed. Dry mechanical separation would eliminate the need to dewater the ash, and dry disposal, as proposed in the DEIS, would remain TVA's preferred disposal method. If the ash cannot be captured dry, wet disposal of the ash and slag during an interim period of operation will have to be considered. TVA is continuing its studies of the engineering properties of both wet and dry ash.

At Murphy Hill, the ash and slag disposal facility as presently envisioned would occupy approximately 200 acres with a depth of about 45 m (150 ft). The disposal area would be located in the flat area southeast of "Murphy Hill" (see Figure 2-4). It should be noted that the solid waste disposal facility at Murphy Hill has been located at the best location possible for either site, on land between "Murphy Hill" and the presently existing road bisecting the site. By locating the solid waste disposal facility in this area, the Murphy Hill site evaluation changed substantially from its initial rating which did not consider disposing of solid waste in this area. The disposal area is planned to accept the ash and slag in a dry state. It is possible that sufficient area would exist on the site to dispose of all of the dry ash and slag which would be produced over the 20 year plant lifetime from a 4-module plant. However, if it is found that engineering properties of either the waste or the proposed solid waste disposal area would preclude stacking the waste to these depths, then other options, including coal washing, ash reuse, or offsite disposal, would be investigated. In the event that additional land were needed, the proposed use of the land would be reviewed in accordance with applicable environmental regulations and/or TVA procedures. Under the present 2-module approach the amount of ash and slag produced would be reduced by about 50%.

The disposal area would be diked to retain rainfall runoff and reclaimed (recontoured and revegetated) progressively in sections after each section is filled. Drainage and diversion ditches would be provided to channel rainfall runoff away from the disposal areas.

If the wet disposal method were utilized, it would be necessary to construct diked ponds. This disposal method would result in an increased potential for environmental contamination (e.g., leachate transport due to an increased hydraulic head on the foundation, dike failure, etc.) and therefore would necessitate a more complex dike/foundation design. However, the disposal of materials in conventional surface impoundments is a well established technology. The construction of these ponds, including the use of an impervious lining, if necessary, to protect the groundwater, would be in accordance with all applicable Federal and State requirements and approvals. Surface discharges from the ponds, if any, would be made in accordance with applicable NPDES permit requirements.

The potential impact of contaminating ground water by leachate from process wastes could be compounded if the waste ash and slag were determined to be hazardous. Preliminary results of TVA's overseas tests at existing coal gasification plants indicate that wet ash collection would remove certain gases from the product gas stream which may cause the wet ash to be classified as hazardous. However, current information indicates that the ash, if collected dry, and slag would not be classified as hazardous. TVA is continuing its studies of the chemical properties of both wet and dry ash.

The ash and slag disposal area would be subject to geological and soils testing to determine control measures required to prevent ground water contamination that would result in ground water exceeding water quality standards for drinking water supplies at the disposal area boundary. Baseline water quality data would be gathered and a thorough investigation of the existing hydrogeological characteristics of the site would be performed. Ground water monitoring programs, as required by the State, would be developed to determine any impacts of solid waste disposal. Although not anticipated, if any contamination is detected, appropriate mitigative action would be taken to alleviate the impact. The disposal area would be designed and operated in accordance with applicable State and Federal regulations. If liners are required, they would be designed utilizing onsite materials if possible. Other sources of liner materials are addressed in Section 4.1.2.9.

4.2 COURTLAND

4.2.1 Manmade Resources

4.2.1.1 Land Use

Construction of the plant at the Courtland site, would utilize at least half (over 1,000 acres) of the site and would remove a large amount of prime farmland (which comprises 90% or 1980 acres of the site) from potential future production. Should a conveyor system be used to transport the coal from the river to the site, a conveyor route would need to be purchased or an easement obtained. This could impact an additional 150 acres of land. Based upon available information and the emission levels expected, agricultural operations are not expected to be detrimentally impacted from plant emissions. As in the Murphy Hill alternative, potential impacts to land values were studied. The historical records of changes in values establish, in general, that no decrease should result from siting the plant at Courtland.

4.2.1.2 Recreation and Scenic Resources

There are no significant impacts on recreation activities expected in the site vicinity. Only temporary and minor disturbances of scenic qualities on Big Nance Creek would possibly occur during plant construction. No other potential effects on scenic or natural features other than those from barge traffic (which were addressed in Section 4.1.1.5), are expected in the site vicinity. Visual impacts are not a major concern. Views of the site are limited, and tree plantings and architectural details would minimize the visual impact of the plant.

Potential noise impacts are discussed in Section 4.2.2.10.

The community recreation facilities in the area, excluding Lawrence County, should be adequate to handle any temporary inmover impacts.

4.2.1.3 Cultural Resources

No structures eligible for listing in the NRHP are located on the site. Impacts on cultural resources are not expected. If the plant is located at Courtland, an archaeological survey would be conducted, prior to site utilization, to test for subsurface sites and evaluate 3 potentially significant sites along Big Nance Creek. Any necessary mitigative actions would be coordinated with State and Federal officials.

4.2.1.4 Socioeconomic Impacts

The scope of the assessment of socioeconomic impacts and strategies for mitigation discussed for Murphy Hill also applies to Courtland. No significant impacts are expected to result from plant operation. In comparison to Murphy Hill, lower inmover estimates were identified for the Courtland area primarily because of better access to Decatur and the Quad Cities. During the peak year of construction, it was estimated that 25% of the work force (900 workers) would move into the area with about 630 of them bringing their families. These inmovers are expected to locate primarily in the Decatur and Quad Cities areas.

The greatest demand for housing would be in the Decatur area. There should be adequate availability of housing for inmovers in communities in the study area.

The school systems in the study area, excluding Lawrence County, should have adequate capacity to accommodate the project-related influx of school children. Some additional classrooms and buses would be required in Lawrence County to maintain existing service levels.

There are no significant adverse impacts on water and sewer treatment facilities expected for communities in the study area. Similar to Murphy Hill, any impacts on fire and police protection in the area would be insignificant and incremental in nature. The same potential exists for substantial property tax revenue for

Lawrence County as was discussed for Marshall County in the Murphy Hill area.

No significant impacts on institutional and emergency medical care are expected. Acceptable levels of health professionals should be maintained in the area with the exception of Lawrence County. However, some additional demands will be placed on current overutilized public health services.

Traffic impacts should be most significant on that 2-lane portion of U.S. 72 directly in front of the plant and through Courtland. Plant commuter traffic would cause the 2-lane portion of U.S. 72 to approach capacity during peak project use.

4.2.1.5 Navigation Impacts

As in the case of Murphy Hill, if this site were selected, most of the potential navigation impacts would be expected to occur downriver from the plant site. If the plant were located at Courtland, the coal would likely be shipped by barge to a point on Wheeler Lake near the site and then transported by a conveyor system to the site. Since Wheeler Lake is located directly downstream from Guntersville Dam on the Tennessee River, potential impacts would be similar to those discussed for Murphy Hill in Section 4.1.1.5 Navigation Impacts, excluding those impacts to river traffic at or above Guntersville Dam locks.

4.2.2 Natural Resources

4.2.2.1 Air Quality

Emissions to the air and onsite emissions sources during plant construction and operation are expected to be similar at both sites (see Table 4-1). There are some major SO_2 emission sources located in the Courtland site vicinity or affecting the area potentially impacted by the proposed facility. Among these sources are a large paper mill and a chemical plant. Some factors which can influence the extent of the combined effects of emissions from various sources include the distance between sources, the relative frequency and direction of wind, and other meteorological conditions.

In the areas near the site of the proposed facility, the combined effects of the major SO_2 emission sources are not expected to cause violations of the NAAQS or PSD Class II increments, based on preliminary air quality modeling. However, the Sipsey River Wilderness area, which is a PSD Class I area, will be impacted by plant operation and other sources are already consuming portions of the available SO_2 air quality increment in this area. If the Courtland site were selected, more extensive air quality modeling would be used to fully assess the combined impacts of the plant and other major SO_2 sources on the Wilderness area when plant design is complete.

Several sources of suspended particulate matter (PM) emissions are located in the vicinity of the site facilities or areas potentially impacted by the proposed plant. Because of distance from these sources to the Class I area, emission heights and rates, and meteorological conditions, the combined air quality impacts of PM emissions are not expected to cause violations of NAAQS or PSD increments in these areas, including the Sipsey River Wilderness area where there are Class I increment restrictions.

As in the case of the Murphy Hill site, other potential emissions, such as carbon monoxide, hydrocarbons, ozone, nitrogen oxides, nitrogen, argon, hydrogen cyanide, reduced sulfur compounds, ammonia, polycyclic organic matter, toxic trace metals, and other trace elements, are not expected to cause violations of NAAQS or other applicable regulations in the Courtland area.

4.2.2.2 <u>Surface Waters</u>

<u>Availability</u>

For purposes of evaluation, the maximum intake flow of the facility was assumed to be 50 cfs. Various discharge alternatives were considered; however, subsequent design information indicated that the facility could utilize a discharge of approximately 20 cfs. The water consumptive requirement of 30 cfs is not a significant portion (about 0.25%) of the 7-day, 10-yr low flow (12,000 cfs) near the site and would have insignificant impacts on water availability. The average river flow near the site is about 48,000 cfs.

<u>Impacts on Water Quality</u>

Surface discharges from the facility during construction and operation would be regulated as specified for the Murphy Hill site.

At Courtland, potential impact to water quality could result from instream dredging for a barge facility and intake/discharge structures. The major concerns are the effects of dredging on the physical water quality and the physiochemical equilibria of the sediments. Turbidity is not anticipated to be a problem. If turbidity levels exceed the standard after reasonable mixing, mitigative measures could be implemented such as installation of silt screens. A permit for this activity can only be granted if evidence indicates that toxic metals released by dredging will not result in unreasonable harm to the environment.

The effect of a 20 cfs discharge on the thermal regime of the lake near the Courtland site is negligible. Rapid mixing (dilution of approximately 20) in an extremely small percentage (about 1%) of the cross-section (about 230,000 ft^2) could be expected with a multiport discharge. A mixing zone of about 130,000 ft^3 would be sufficient. The discharge should be situated about 1,500 ft from the left bank of Wheeler Lake to assure adequate dilution.

The lower reaches of Wheeler Lake are highly productive and are approaching their limits for assimilation of oxygen-demanding wastes. Increases in waste load could aggravate conditions existing in the lower reaches of the lake. Studies similar to those that would be required for the Murphy Hill site would be conducted if the Courtland site were selected.

Construction of the facility would be in conformance with a site-specific Erosion and Sediment Control Plan specifying "Best Management Practices" for the control of erosion and sedimentation due to storm water runoff from disturbed areas. All point source discharges during construction would potentially have to be routed to Big Nance Creek until the discharge pipe to the lake is complete. Due to the small size and biological sensitivity of Big Nance Creek, effluent limitations and corresponding treatment requirements for construction discharges could be stringent. A SPCC plan would be developed to ensure that accidental spills of oil, hazardous substances, and hazardous wastes are controlled so as not to pose a significant environmental threat.

4.2.2.3 Ground Water

The Courtland site offers some limited potential for the use of ground water for low-volume plant needs. If the Courtland site were selected and it were decided to use ground water, appropriate test pumping would be conducted to evaluate the effects of withdrawal. Ground water quality will be protected as described in Section 4.1.2.3.

4.2.2.4 Aquatic Ecology and Fisheries

Site-Specific Impacts and Mitigative Actions

(See Murphy Hill section for a discussion of generic impacts and mitigation.)

Potential construction-related impacts include increases in surface water runoff, carrying suspended solids which could adversely impact Big Nance Creek or sensitive habitats in Wheeler and Wilson Lakes. Consequently, all stormwater runoff during construction and operation would be appropriately handled and/or treated prior to discharge using best engineering practices.

Due to the relatively small size and biological nature of Big Nance Creek and the Spring Creek embayment, potential impacts would be minimized as follows: crossings sites on Big Nance Creek for lake access would be carefully selected, and instream water use facilities (barge docks, intake, discharge) would not be located in, or in the immediate vicinity of, Spring Creek Embayment. The more desirable lake areas for these instream water use facilities appear to be downstream from Spring Creek. With lake-based water use facilities located as prescribed above, estimated entrainment, impingement, and sport fishing impacts (noise, barging) would not be significant (based on low intake volume estimates). Location of the discharge structures in the channel of Wheeler Lake, and noise mitigation, would further reduce the impacts.

Impacts to populations of the flame chub or the mainstream river snail in Big Nance Creek would be insignificant due to mitigation prescribed above. (For additional information, see discussion of "species of special concern" in Appendix F, Section 3.2.4B).

4.2.2.5 Upland Vegetation and Wildlife

The development of the proposed coal gasification facility at Courtland would result in clearing or alteration of terrestrial habitat. Some species tolerant of disturbance would continue to inhabit the area, however, in reduced numbers. Most mobile organisms such as birds and larger mammals would vacate the site during construction or disturbance. Less mobile organisms would be destroyed onsite as the land is cleared and prepared for construction.

4.2.2.6 Threatened or Endangered Species

Construction and Operation

Inventories of the Courtland site area have been conducted, and no Federally listed endangered or threatened species (see Appendix D) were found. Development of the proposed facility at the Courtland site would not jeopardize the continued existence of any known population of Federally listed endangered or threatened species or result in the modification or destruction of any habitats considered critical to the survival of such species.

Conclusion

Based on the available information, TVA has determined a "no effect" situation exists regarding potential impacts to Federally listed endangered or threatened species.

4.2.2.7 Wetlands and Wetlands Wildlife

Plant construction and operation could cause a reduction in wood duck production on portions of Big Nance Creek immediately adjacent to the Courtland Site. These impacts could be reduced and would be temporary if the facility was designed and constructed to avoid, to the extent possible, removing or damaging wetlands and riparian habitat along Big Nance Creek. Water use facilities and the coal conveyor system would be located to avoid existing wetlands, to the extent practicable, thus complying with the policies and concepts of Executive Order 11990 and TVA's implementing procedures. Estimated waterfowl and wetlands wildlife losses would be expected to be minimal and should not result in significant impacts on lake populations.

4.2.2.8 Floodplains

No permanent structures, other than water use facilities for which there is no practicable alternative, would be sited within the 100-yr (1% chance) floodplain for the Tennessee River or Big Nance Creek. There is a possibility that support structures for coal conveyors and water use facilities may have to be constructed in the Big Nance Creek 100-yr floodplain. To the extent practicable, siting these structures in the 100-yr floodplain would be avoided. In any event, structures would have minimal impact on flood retention capacity. Thus, locating a facility at Courtland would comply with the concepts and policies of Executive Order 11988 and TVA's implementing procedures.

4.2.2.9 Geology and Soils

Due to the karst nature of the Courtland site terrain, problems could develop in maintaining the integrity of waste disposal areas. Excavation of overburden and treatment of the rock beneath the disposal areas would be a significant expense and would have a questionable guarantee of success. Liners, if needed, would be designed utilizing onsite materials, if possible. Other sources of liner materials are addressed in Section 4.1.2.9.

Site grading would be less of an impact at Courtland. Since significant variations exist in depths to rock and depths to sound rock, and the overburden is generally more than 25 ft deep, use of caissons or piles would be extensive.

No coal or petroleum is being extracted from the site, and no other types of economic minerals exist on the site.

4.2.2.10 Environmental Noise

The construction and operational noise sources and levels will be similar to those described for Murphy Hill. Transport of coal to the site could result in noise impacts. Similar methods to those described for Murphy Hill would be used to monitor and to mitigate excessive construction and operational noise emissions from the plant.

4.2.2.11 Radiological Impacts

Potential radiological impacts on air and water quality were assessed for a coal gasification facility at Courtland.

Based on conservative assumptions, the total body dose to the worst-case individual living near the coal gasification plant may exceed the NRC dose guideline used here for comparison purposes. Maximum ground-level radionuclide concentrations in air in offsite areas should be much lower than 10 CFR 20 air concentration limits.

Radiological impacts on water quality from operation of the coal gasification facility at Courtland are predicted to be small.

Doses to an individual are below EPA and NRC dose criteria. Estimated concentrations of radioactivity in water are well below Federal regulatory nonoccupational water concentration limits (10 CFR Part 20) used here as guidelines.

Total doses to an individual due to all sources of radiological emissions at the coal gasification facility at Courtland are predicted to be less than background (an average of 140 mrem/yr in the Tennessee Valley region). The calculated dose at Courtland is higher than that for Murphy Hill because of differing meteorological conditions.

4.2.2.12 Solid Waste Disposal

The general material included in the Murphy Hill discussion concerning the types of solid waste generated by a coal gasification facility would also apply for the Courtland site in order to accommodate construction-related waste. Specific aspects pertaining to the Courtland site are discussed below.

Lawrence County has only one approved sanitary landfill at the present time. The expected life of this facility is 2 years. A disposal facility may have to be developed in the county during the first year of gasifier construction at the Courtland site. The amount of waste which is estimated to be generated on a daily basis would have minimal effect on any facility developed assuming a facility is developed.

The general material included in the Murphy Hill discussion concerning the characteristics and disposal options of ash and slag would also apply to the Courtland site. The proposed slag and ash disposal facility at Courtland as presently evaluated would occupy approximately 200 acres with a depth of approximately 45 m (150 ft). The facility would be planned to handle the slag or ash dry. Dry disposal is the preferred alternative for solid waste disposal at Courtland because of geologic and economic considerations.

Maintaining the integrity of the slag and ash disposal area foundation or liner, if needed, at Courtland would be difficult due to geological considerations. Courtland is located in an extremely active karst terrain. This could result in leaks from the disposal area into the ground water. Refer to Section 2.3.6 for more discussion on solid waste disposal.

4.3 Public Health and Safety

An engineering firm, working under a TVA contract, performed a preliminary study to assess the public health and safety impacts of accidents which could occur at the proposed coal gasification plant or along a product gas pipeline. This evaluation involved the identification of possible accidents and the evaluation of their effects under very adverse circumstances. Since little design information was available, extremely conservative assumptions were employed in the estimation of the impacts of the hypothetical events. The preliminary study concluded that all of the accidents identified have low probabilities of occurrence and that their expected impacts are less severe than the maximum ones discussed below and in Section 4.3 of Volume 2.

Among the hypothetical accidents identified in the preliminary study, the release of product gas presented the greatest potential for impacting the public. Under the most adverse conditions assumed, lethal concentrations of CO were predicted in a narrow region extending 5 km (3.1 mi) from a pipeline break. There exists also a concomitant danger of fire and explosion at points near the pipeline break. Lethal concentrations of NH_3 and H_2S were predicted in narrow downwind regions extending 0.8 km (0.5 mi) and 1.3 km (0.8 mi), respectively, from a hypothetical accident site at the plant.

A more detailed evaluation based upon more reasonable assumptions was performed to determine the risk of harmful public exposures to CO following a large release of MBG from a product gas pipeline. This more refined analysis indicated that the risk of significant CO exposure would exist only inside a relatively small region within approximately 1.4 km (0.9 mi) from the point of release. In addition, a second report prepared under a TVA contract determined that in areas of the world where coal gas containing less than 30% CO has been transmitted at low pressures for decades (e.g., Great Britain), the risk associated with potential gas leaks from transmission pipelines is perceived as minimum unless residences are in very close proximity. The report concluded that the local hazard from fire and explosion is likely to be more of a concern than that from release of toxic gases and that current normal "best practice" as applied to natural gas pipelines would probably be adequate for handling medium-Btu gas safely. Additional margins of safety could be provided by using pressure-reducing stations near end users, automatic shutoff valves, and thicker wall pipelines. The present 2-module concept envisions that the product gas would be shifted and converted into SNG and methanol within the process plant itself. Product gas containing significant quantities of CO would not be piped outside the plant under this concept. If the plant is later expanded to 4 modules, such pipelines may be required, however.

Low temperature coal gasification processes typically produce organic residues (tars, oils, and phenols). These undesirable byproducts are known to contain hazardous and toxic chemical compounds. Occupational exposures to these substances have resulted in increased incidences of diseases including dermatoses and cancer. Raising the temperature of the conversion process converts the hazardous tars, oils, and phenols to useful fuel gas. This both lowers occupational hazard and increases plant efficiency. This is one reason that TVA prefers the high-temperature process technologies.

Various process streams and wastes will contain other hazardous or toxic substances including reduced sulfur compounds, SO_2, traces of heavy metals, and organics. Plans to control these substances to safe and acceptable levels are discussed in various sections of this document. Measures to assure protection of public health would include:

1. Acid gas and tail gas cleanup systems to remove H_2S, COS, SO_2, and other trace constituents.
2. Water scrubbing of gas stream to remove particulates, trace metals, trace organics, phenols (should any be present), and soluble salts.
3. Recycling of process streams to the extent practicable.
4. Selection of wastewater treatment processes to prevent the release of pollutants in hazardous or toxic amounts.
5. Approved sanitary landfilling of certain wastes.
6. Onsite disposal of process slag and ash with ground water monitoring.

Before the coal gas plant becomes operational, results of studies conducted at the TVA Ammonia-From-Coal Plant, which uses a Texaco gasifier, and other evaluations would be available for use to confirm that the measures planned to protect the public, the environment, and the plant workers were adequate.

Development of an occupational health and safety program would help ensure compliance with all applicable regulations and adherence to desirable practices.

4.4 Pipeline Construction

4.4.1 Possible Pipeline Location

Although not now a part of the 2-module project being proposed, TVA identified a hypothetical route for a MBG pipeline serving the north Alabama area (please refer to Section 2.3.6.21). Figure 2-7 shows the possible location of this line. This does not represent the exact location of the pipeline, but a possible route which appears feasible from an engineering and environmental standpoint should one be needed to transport product gas from subsequent modules.

The pipeline would originate at the preferred site, Murphy Hill, and cross the Tennessee River. The MBG pipeline would run to a point south of Huntsville, Alabama, and again cross the Tennessee River. The pipeline would then run in a westward direction to the Florence, Alabama, area. Feeder lines would tap off at appropriate locations along this main trunk line. A more detailed description of the pipeline is given in Appendix C.

4.4.2 Effects of Pipeline Construction

The pipeline would probably be constructed on a right-of-way acquired by easement. Most uses of the right-of-way by the property owner would be allowed. A large portion of the land along the proposed pipeline route is agricultural, and the depth at which the pipeline would be buried would allow continued agricultural use of the right-of-way. No direct impacts to existing structures either on or off of the right-of-way would be anticipated. The right-of-way would be maintained during the life of the pipeline in such a way as to prevent the growth of large trees.

If construction of a pipeline is undertaken, the pipeline route would be evaluated to determine the presence of threatened or endangered species and rare or sensitive habitats. In addition, the route would be surveyed to determine the presence of possible historical or archaeological resources. If any conflicts were identified, the route would be reevaluated or appropriate mitigative measures taken.

The construction of the pipeline would result in clearing vegetation along the right-of-way. However, long-term impacts to agricultural and cleared areas could be minimal. The effect on forested areas would be greater than that on agricultural lands. Areas cleared for the pipeline would be seeded, if practicable, in species conducive to wildlife enhancement, and in any event measures would be taken to control erosion. The loss of this land habitat would result in animals relocating in adjacent areas or in the loss of animals should the adjacent habitat areas not be capable of supporting the additional animals. Clearings through forested areas would produce an "edge effect". Generally, these edge areas are important as food and shelter for many animals including the cottontail rabbit, whitetail deer, and a variety of song birds.

Impacts to aquatic communities due to instream activities or turbidity and silt loads, as a result of runoff from cleared areas, would be temporary. Where a pipeline crosses a river or other streams, removal of riparian vegetation would be minimized to the extent practicable, and disturbed areas would be stabilized as soon as possible. Dredging would be used to dig a pipeline trench in the river or stream bed. This trench would probably be refilled to the original level and bottom dwelling aquatic plants and animals would repopulate the area. Pipeline installation may require Sections 10 and 404 permit reviews by the Corps and Section 26a review by TVA. Construction plans would be evaluated as required by TVA's NEPA procedures and further mitigation would be stipulated as necessary.

Air emissions or noise associated with constructing the pipeline would be expected to be temporary and minimal. Marketable trees would be sold, and the debris remaining from clearing activities would be disposed of in accordance with applicable guidelines and ordinances.

The results of this preliminary assessment indicate that the possible pipeline routes would probably not encounter any unusual environmental problem as a result of gas pipeline development. These routes were reviewed by a major pipeline company and no significant environmental or engineering problems were identified. Should the pipeline be constructed, and more detailed future assessments identify a particular environmental conflict, it would not be expected to be of such a magnitude that mitigation could not be achieved by rerouting the pipeline or taking special construction precautions.

4.5 Potential Impacts of Methanol Transportation

Depending on the quantities, markets, and economics, methanol produced at the plant could be shipped from the site by truck, rail, barge, pipeline, or a combination of the above. Until detailed marketing arrangements are established, it is not feasible to assess the environmental impacts in detail. If the entire output from one module (5000 tons of coal per day) were shipped by a single mode, it would require approximately 130 trucks per day, 50 rail cars per day, or 1 to 3 barges per day. Shipment of this entire quantity of methanol by truck would not be feasible. Shipment by barge could require an additional transport of approximately 7 to 16 barges per week from the facility. This would result in an increase of about 7 to 17% in the level of barge traffic estimated for coal shipment (please refer to Section 4.1.1.5 for additional discussion on barging impacts). Although no rail line currently serves the site or is planned, it may be feasible to pipe the methanol to a nearby rail head or use rail barges. Rail barging would require between 2 to 5 barges per day with associated increases in barging levels above that estimated for coal transportation. Please refer to Section 4.4 above for an assessment of possible pipeline routes from the proposed facility.

Methanol is a common industrial chemical used in the organic synthesis of other chemicals, as a solvent in paints, and in a number of other products. Methanol is also known as methyl alcohol, carbinol, wood alcohol, or wood spirits. It is similar to gasoline, and both are currently transported by the above four means. Due to their flammable nature, safety precautions must be followed. The requirements for the safe transport of methanol by any of the means discussed above are addressed in the Code of Federal Regulations, Title 46 - Shipping, and Title 49 - Transportation. Protecting the public safety during transportation of the product methanol would be required by law in accordance with the appropriate transportation or shipping regulations. In the event of a methanol transportation accident, the most serious hazard posed to the public would be ignition or explosion of the methanol. The probability of a methanol fire or explosion is less than that for gasoline cargoes, since the flashpoint, ignition temperature and lower flammable limit of methanol are all much higher than those for gasoline. Further, since the number of Btu's/lb of methanol is less than one half that for gasoline, any fire or explosion involving methanol should be less severe than those involving gasoline. TVA does not anticipate that the shipment of product methanol by any of the transportation means discussed above would pose any unique public safety problems, inasmuch as large quantities of methanol and gasoline are routinely transported today.

As the methanol markets are further defined, the possible transportation routes would be selected considering the potential environmental impacts noted above. It is likely that more than one transportation mode would be used to transport methanol; but this depends on the market location, the quantities to be shipped, and the overall economics.

4.6 Potential Environmental Consequences of Secondary Development

The availability of the product gas and chemical feedstocks which would be produced by the proposed coal gasification facility may result in secondary development with associated environmental consequences. Such development could be in the form of new or existing industries which choose to locate in the north Alabama area or expand existing operations, respectively. It is impossible to specify in detail what the consequences of secondary development would be and where such development would occur, because it is not known at this time which industries, new or existing, may choose to use the product gas. Secondary development would, in general, be beyond the project's control. However, TVA normally acts within its planning and technical assistance capabilities to avoid adverse impacts and promote development in an environmentally acceptable fashion.

Depending on the industry, air and water quality and solid waste impacts may be associated with secondary development. Such impacts would, to a substantial extent, be minimized because of the various air and water quality and solid waste disposal requirements imposed under the air and water quality and solid waste disposal regulatory requirements of the EPA, Corps, and the State of Alabama. These regulatory requirements would also affect the degree to which an area could be developed by industry. Cumulative impacts on air and water quality could serve to limit industrial development unless appropriate mitigation was employed. While it is not anticipated, the possibility exists that clean MBG from the first 2 modules could be used as an industrial fuel gas. Air and water quality and solid waste disposal impacts may actually be improved if an existing industry were to choose to utilize the product gas instead of a more polluting fuel which may be in use at the industry.

New industrial development may also have land use impacts such as habitat and prime farmland losses, floodplain and wetlands impacts, noise impacts, species impacts, cultural resources impacts, and recreation and scenic resources impacts. Again, whether such impacts would occur depends primarily upon where a new industry may choose to locate and that industry's environmental policies. To a lesser extent than air, water, and solid waste impacts, those impacts could be minimized by applicable State and local requirements such as zoning and floodplain regulations.

As stated in Section 4.1.4 of Appendix G, both beneficial and adverse socioeconomic consequences would also be associated with secondary development. Beneficial socioeconomic consequences would be in the nature of additional employment opportunities offered by new industries or the expansion of existing industries and the rise in personal income and spending associated with such opportunities. Adverse socioeconomic consequences would be in the nature of possible demands on existing community services and possible strain on housing and transportation networks. Adverse consequences would depend upon where a new industry chose to locate or the location of any existing industry which chooses to expand. Regardless, adverse socioeconomic impacts are not expected to be significant from the scale of secondary development that is considered feasible.

4.7 Unavoidable Adverse Impacts

Many of the potential adverse impacts which might occur could be significantly reduced or eliminated through mitigative measures. This section discusses those impacts which may or would be unavoidable.

The development of a coal gasification plant at Courtland would remove a large amount of prime farmland from potential future production. A small amount of prime farmland would also be lost at Murphy Hill.

An adverse impact could occur at Murphy Hill on neighboring recreational and residential land uses. Extensive areas would be required at either site for the disposal of ash and slag resulting in a potential visual impact.

Significant traffic congestion in peak plant commuter hours during the construction period would impair access to and utilization of Lake Guntersville State Park adjacent to the Murphy Hill site. At Courtland, a significantly lesser degree of traffic congestion may occur on U.S. 72 during peak plant commuter hours.

Effluents released to the air, water, and land would be increased. However, the rate of emission would be in compliance with applicable regulatory requirements and would be held to levels which would not harm the public or the environment. Portions of the PSD air quality increment would be made unavailable near either site.

Construction of water use facilities and dredging would cause some mortality among immobile organisms in the general area of activity. Localized temporary increases in certain pollutants would result from dredging activity.

Increases in barge traffic would occur.

The development of the proposed coal gasification facility would result in the clearing or alteration of terrestrial habitat. Some terrestrial fauna would continue to inhabit the area but in reduced numbers. During construction, mobile organisms would vacate the site while less mobile organisms would be destroyed.

Plant construction and operation at the Murphy Hill site would impact waterfowl and wetlands wildlife. Transmission lines and high structures associated with the plant could cause strike mortalities at either site.

Gas pipeline construction would require obtaining a right-of-way, resulting in the clearing of vegetation and limitations on future use of the property. Where streams are crossed by the pipeline, some temporary disturbance would occur. As stated previously, undertaking the construction of a product gas pipeline is not proposed at this time.

4.8 Relationships Between Local Short-Term Uses and Long-Term Productivity

Construction and operation of the proposed coal gasification plant would essentially remove the selected site from consideration for any action other than those supporting the coal gasification plant for at least 20 yr (the plant life). The entire facility, including coal handling and storage, gasification, gas cleanup, wastewater treatment and ultimate solid waste disposal would utilize most of the land at either site. Most areas not supporting a specific plant unit would not be suitable for non-plant uses due to their close proximity to plant facilities. It is conceivable that certain land areas on the perimeter of each site might be used to support public recreation facilities such as a picnic area or boat ramps.

Present uses of both sites are limited to agricultural production activities. Practically speaking, these activities would be eliminated, certainly, for the life of the plant and probably for some number of years beyond this. Large areas of each site would be reclaimed solid waste disposal areas that would probably not be suitable or desirable for human habitation or agricultural uses. These solid waste disposal areas would be revegetated (if possible) and probably be reinhabited by wildlife. Upon retirement, plant equipment would be salvaged, if possible, for use at other facilities. Other structures would be sold as scrap or the entire site sold to another industry.

Construction at either site would result in altering the site's short-term uses from one of agriculture activities to industrial activities. The aesthetic and wildlife characteristics of the sites would be altered in the short-term. A site's long-term uses would probably be altered to preclude its possible use for residential, recreational, or agricultural uses. A majority of the site, more than likely, would be permanently dedicated to industrial activities unless it were determined in the future that the facility should be retired and dismantled. It is difficult to project how the site could be utilized 20 yr from now should it not continue as an industrial site. Two possible options are to (1) use the site as a wildlife management area or (2) develop appropriate areas of the site for public recreational uses. Industrial use of either site does not preclude its long-term use as a wildlife habitat. Further, if the plant were retired and dismantled, the aesthetic characteristics of the site could be altered to a more natural environment.

The objective of this project is to develop a working, viable, commercial technology that converts relatively high-sulfur coal to MBG and serve the north Alabama area. This gas can be used as a feedstock in chemical synthesis processes, synthesized into methanol and other liquid fuels, methanated to produce SNG or used as an industrial energy source. Should this technology develop, it would probably increase the use of coal in the long-term, but immediate short-term uses should not be significantly affected.

4.9 Irreversible and Irretrievable Commitments of Resources

The existing land use would be altered for the life of the project. The existing wildlife and wildlife habitat would be lost or reduced. The ecosystem could eventually evolve and recover although possibly to a different type of system. Agricultural use would essentially be lost over a large portion of the site. A small amount of prime farmland (which constitutes about 30% of the 1,400-acre site) would be lost if the plant were constructed at the Murphy Hill site. Since at least 1,000 acres and probably the entire site would be lost for future agricultural production if the plant were built at Courtland, a large amount of prime farmland (which comprises about 90% of the 2,246-acre site) would be affected. Recreational use would be lost for the life of the project, except possibly along the perimeter of the site area. The natural topography and flow patterns would be altered.

Fuel, construction materials, and manpower would be irretrievably committed in construction and operation of the facility. Approximately 10,000 TPD of coal would be consumed in the gasification process initially, with the possibility of this increasing to 20,000 TPD in the future. Water consumed in the gasification process would be irretrievably lost to its original use.

5. LIST OF PERMITS AND APPROVALS THAT MAY BE REQUIRED

Air Quality Permits

New Source Construction Permits (PSD Permits)

Operating Permits (temporary & permanent)

Corps of Engineers Sections 404 and 10 Permits

401 State Certification

National Pollutant Discharge Elimination System Permit

Public (Non-Community) Water Supply Approval

Waste Disposal Permit and Approvals

FAA Form 7460-1, Notice of Proposed Construction or Alteration

90-Day Premanufacturing Notification to EPA (TOSCA)

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7. EIS DISTRIBUTION LIST

FEDERAL AGENCIES

Advisory Council on Historic Preservation
Community Action Office
Community Services Administration
Council on Environmental Quality
Department of Agriculture
Department of Commerce
Department of Defense
Department of Energy
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of Labor
Department of State
Department of the Army, Corps of Engineers
Department of the Interior
Department of the Treasury
Department of Transportation
Environmental Protection Agency
General Services Administration
Interstate Commerce Commission
National Aeronautics & Space Administration
National Capitol Planning Commission
Water Resources Council

STATE AND REGIONAL AGENCIES

Alabama Air Pollution Control Commission
Alabama Cooperative Extension Service
Alabama Department of Agriculture and Industries
Alabama Department of Conservation and Natural Resources
Alabama Division of Solid Waste
Alabama Forestry Commission
Alabama Health Department
Alabama Highway Department
Alabama Office of State Planning and Federal Programs
Alabama Soil and Water Conservation Committee
Alabama Water Improvement Commission
Appalachian Regional Commission
Geological Survey of Alabama
Illinois Institute of Natural Resources
Kentucky Department of Energy
Kentucky Department for Natural Resources and Environmental Protection
Michigan Department of Natural Resources
Montana Department of Natural Resources and Conservation
North Central Council of Local Governments
Northwest Council of Local Governments
Ohio River Basin Commission
Ohio River Valley Water Sanitation Commission
Southeast Tennessee Development District
Top of Alabama Regional Council of Governments

GOVERNOR

James, Forrest, Jr., Hon.

STATE LEGISLATORS

Adams, H. H. "Bill", Hon.
Albright, Ray, Hon.
Albright, Robert E., Hon.
Bowling, W. C., Hon.
Brakefield, Carl C., Hon.
Britnell, Charlie, Hon.
Carter, Tommy, Hon
Cheat, Kenneth Earl, Hon.
Cobb, Wayne, Hon.
Coburn, Tom C., Hon.
Cooley, Steve, Hon.
Denton, Bobby, Hon.
Drinkard, William H., Hon.
Ford, Joe, Hon.
Gilmer, Charles. T., Hon.
Goodwin, J. W. "Joe", Hon.
Greer, Lynn, Hon.
Gregg, Richard, Hon.
Hall, Albert, Hon.
Hall, Robert B. "Bob", Hon.
Harvey, Bob, Hon.
Keener, Larry H., Hon.
Kelley, Phillip B., Hon.
LeMaster, James, Hon.
Letson, S. R. "Sam", Hon.
Martin, Charles B., Hon.
McDonald, Albert, Hon.
Mitchem, Hinton, Hon.
Patton, Robert E., Hon.
Rains, T. Euclid, Sr., Hon.
Riddick, Frank H., Hon.
Roberts, Tommy Ed, Hon.
Shavers, Cecil, Hon.
Smith, Bill, Hon.
Smith, James P., Hon.
Smith, Martha Jo, Hon.
St. John, Finis, Hon.
Starkey, Nelson R., Jr., Hon.
Stout, J. David, Hon.

LOCAL OFFICIALS

Albertville City Council
Alexander, H. A., Hon., Mayor of the City of Moulton
Allen, J. Hollie, Hon., Vice Mayor, City of Florence
Beard, John L., Hon., Probate
Brown, James F., Mr., Marshall County Comission
Burns, John D., Hon., Mayor of Russellville
Byars, Jimmy, Hon., Probate and Judge, Chairman of Franklin County Commission
Chitwood, Dorris S., Ms., Lawrence County Education Association
Clark, Bently, Mr., Councilman, Guntersville City Council
Coffey, Roy, Hon., Mayor of Courtland
Couch, Charles, Hon., Mayor of Union Grove
Crawford, Lonnie, Mr., Councilman, Scottsboro City Council
Cryar, Buford L., Hon., Mayor of Albertville
Davis, LaMonte, Hon., Mayor of Arab
Decatur City Council
Etowah County Commission
Fendley, Jack, Hon., Mayor of Oneonta
Fleming, Thornton, Mr., Chairman, Morgan County Commission
Florence City Commission
Fossett, J. D., Mr., Marshall County Commission
Graham, Jerry G., Mr., Lawrence County Commission
Grass, Melvin E., Hon., Circuit Judge
Green, Frank J., Mr., Blount County Commission
Guntersville City Council
Handcock, John, Mr., Councilman, Scottsboro City Council
Hembree, R. L., Hon., Mayor of Guntersville
Hubbard, Ronald, Mr., Councilman, Guntersville City Council
Jetton, William D., Hon., Circuit Judge
Johnson, Clark E., Jr., Hon., Circuit Judge
Lamb, Jerry, Mr., Lawrence County Commission
Long, John D., Hon., Mayor of Hartselle
Martin, Jimmie Dee, Mr., Lawrence County Board of Education
Matthews, Bob, Hon., Mayor, City of Section
McCollum, Mack V., Mr., DeKalb County Commission
Moon, Gordon Ray, Mr., Councilman, Guntersville City Council
Moulton City Council
Oneonta City Council
Owens, Roy W., Hon., Mayor of Scottsboro
Poe, Michael, Mr., Chattanooga Air Pollution Control Bureau
Proctor, Richard I., Mr., Lawrence County Commission
Randolph, Wallace T., Mr., Councilman, Guntersville City Council
Sebring, Lawrence, Mr., Jackson County Commission
Shelton, Delbert, Mr., Councilman, Scottsboro City Council
Smalley, Rex, Mr., Sherrif, Marshall County
Snider, Jack, Mr., Marshall County Commission
Sorter, Sue, Ms., Councilwoman, Guntersville City Council
Stewart, John M., Mr., Councilman, Scottsboro City Council
Sutton, J. D., Mr., Marshall County Commission
Tubbs, Ray, Mr., Councilman, Scottsboro City Council
Wright, Charles, Mr., Marshall County Comission

LIBRARIES

Alabama A&M University
Alabama Department of Archives and History Library
Alabama Public Library Service
Ben West Library
Callaway County Public Library
Chattanooga-Hamilton County Bicentennial Library
Cullman County Public Library
Dixie Regional Library
Donelson Branch Library
Fayette County Public Library
Green Hills Branch Library
Guntersville Public Library
Hoskins Library
Huntsville-Madison County Public Library
Knoxville-Knox County Public Library
Lee County Library
Memphis-Shelby County Public Library
Murray State University Library
Muscle Shoals Regional Library
North Alabama Cooperative Library System
Paducah Public Library
Purchase Regional Library
Scottsboro Public Library
Tennessee State Library and Archives
Tennessee Valley Authority Technical Library
Union County Library
University of Alabama In Huntsville Library
West Knoxville Branch Library
Wheeler Basin Regional Library

FEDERAL INTEREST GROUPS

American Farm Bureau Federation
American Lung Association
American Petroleum Institute
Association of State and Territorial Health Officials
Atomic Industrial Forum
Bass Anglers Sportmans Society
Bolton Institute, Inc.
Chamber of Commerce of the United States of America
Electric Power Research Institute
Environmental Action Foundation, Inc.
Environmental Action, Inc.
Environmental Defense Fund, Inc.
Environmental Policy Center
Envirosouth, Inc.
National Audobon Society
National Coal Association
National Environmental Health Association
National Parks and Conservation Association
National Synfuels Association
National Wildlife Federation
Natural Resources Defense Council, Inc.
Oil, Chemical, and Atomic Workers International Union
Sierra Club
The Conservation Foundation
United Mine Workers of America International Union

STATE AND REGIONAL INTEREST GROUPS

Alabama Association of Soil and Water Conservation District Supervisors
Alabama Bass Chapter Federation
Alabama Environmental Quality Association
Alabama Ornithological Society
Alabama Wildlife Federation
California Energy Resources and Development Commission
North Alabama Building and Trade Council
North Alabama Industrial Development Association
Tennessee Citizens for Wilderness Planning
Tennessee Toxics Program
Tennessee River Valley Association
The Alabama Conservancy
Wildlife Society, Alabama Chapter

LOCAL INTEREST GROUPS

Arab Chamber of Commerce
Carpenter, Millwrights, and Piledrivers Local Union Number 1371
Courtland Industrial Development Board
Decatur Chamber of Commerce
Decatur Industrial Development Association
Florence Area Chamber of Commerce
Fort Payne Chamber of Commerce
Gadsden Painters Local Union Number 651
Gadsden Plumbers and Steamfitters Local Union Number 498
Greater Kingsport Area Chamber of Commerce
Guntersville Industrial Development Board
Laborers Local Union Number 1333
Lake Guntersville Chamber of Commerce
Marshall County Council on Aging
Moulton Lions Club
Moulton-Lawrence County Chamber of Commerce
Russellville Industrial Development Board
Scottsboro-Jackson County Chamber of Commerce
Town Creek Booster's Club
Town Creek Industrial Development Board
Wakefield Community, Inc.

Interested Citizens

Abney, Ginger, Ms.
Abney, Johnny, Mr. & Mrs.
Abney, Johnny, Mr. & Mrs.
Abney, Pamela, Dr.
Abney, Pat, Mr. & Mrs.
Adams, A. G. Mrs.
Adams, A. G., Mr.
Adams, Alfred G., Jr., Mr.
Adams, Fancher, Mr. & Mrs.
Addington, V. G., Mr.
Adkins, W. R.
Agney, Allen, Mr.
Aiken, Dotty, Ms.
Albert, James, Mr.
Alexander, Mrs.
Allen, William, Mr.
Allred, Sylvester, Mr.
Alred, Fay, Ms.
Anderson, John, Mr. & Mrs.
Anderton, Wayne, Mr.
Arnold, Fred, Mr. & Mrs.
Arnold, Myrtle, Ms.
Arrick, Donna, Ms.
Articole, Bill, Mr.
Ashley, Charles, Mr.
Ashworth, Emmit O., Mr.
Atchley, Shirley, Ms.
Atchley, Theo, Mr.
Atchley, Troy, Mr. & Mrs.
Ayers, Asher, Mr. & Mrs.
Babin, Fred, Mr.
Bailey, Kelly Bell, Mr.
Bain, Bea, Ms.
Bain, J. M., Mr.
Bain, Simp, Mr. & Mrs.
Baird, Charles, Mr.
Baker, Clyde, Mrs.
Baldwin, Ray, Mr.
Ballentine, Earle, Mr.
Balton, Mr.
Bannister, Clarence, Mr.
Barfield, Beth, Ms.
Barlow, Tom, Mr.
Barnard, Don, Mr.
Barron, Lowell R., Mr.
Barron, Michael, Mr.
Barrow, J. D.
Bartlett, Robert V., Mr.
Bass, Lois, Ms.
Bates, Albert, Mr.
Bates, Cheryl, Ms.
Bates, James A., Mr. & Mrs.
Bates, Tom, Mr. & Mrs.
Batson, Roger, Mr.
Batson, Walter, Jr., Mr.
Baugh, James R., Mr.
Beakes, Bobbie, Ms.
Beck, Noel, Ms.
Beckner, Kevin, Mr.
Beckner, Muriel, Ms.
Beckner, Robert, Mr.
Bell, Thomas R., Mr.
Bena, Clarence A., Mr.
Bendix, Selina, Dr.
Benefield, Kaye, Ms.
Benner, Robert I., Mr.
Bentley, Charles R., Mrs.
Bentley, Doris, Ms.
Bentley, Philip, Mr. & Mrs.
Berry, Pam, Ms.
Berryman, Anna, Ms.
Bevel, Donna L., Ms.
Bevel, Travis Neal, Mr.
Bevill, Cora, Ms.
Bevill, Grove, Mr.
Bevill, James E., Mr.
Billings, Edward R., Mr.
Blackburn, Douglas, Mrs.
Blackwell, Margaret, Ms.
Blackwell, Wendell, Mr.
Blain, Rex B., Mr.
Blake, William, Mr.
Bodkin, C. J., Mr.
Booker, Washington, III, Mr.
Bottesini, M. N., Mr.
Box, Tom, Mr.
Boyd, Elise S., Ms.
Bradly, Carol, Ms.
Bragg, Joe, Mr.
Bragg, Leonard E., Sr.
Brandon, Charles, Mr.
Brantingham, Shirley A., Mr.
Breland, C., Mr.
Breland, Gail, Ms.
Breland, John, Mr.
Brewster, Ann Maples, Ms.
Brick, Steve, Mr.
Bridges, Howard, Mr.

Brookshire, J. B., Mr. & Mrs.
Brown, Bill, Mr. & Mrs.
Brown, Jesse G., Mr.
Brown, John W., Mr.
Brown, Mattie R., Ms.
Brown, Rex B., Mr.
Bruck, Dave, Mr.
Bryant, Ronald, Mr.
Burden, L. L., Mrs.
Burgess, Howard, Mr. & Mrs.
Burgess, Hugh, Mr.
Burgess, Trudy, Ms.
Burke, J. Brad, Mr.
Burns, Rowland E., Dr.
Burton, B. H.
Butts, John T., Mr.
Bynum, Fannie Rickie, Ms.
Bynum, Royce M., Mr.
Cain, E.
Cain, R. E., Mrs.
Caldwell, Dorris, Ms.
Calhoun, Dan, Mr.
Calhoun, Gloria, Ms.
Callahan, Clyde, Mr.
Campbell, Billy, Mr. & Mrs.
Campbell, David, Mr.
Campbell, Jerry L., Mr.
Campbell, Mainerd G., Mr.
Campbell, Thomas, Mr.
Cannon, H. B.
Carden, William C., Mr.
Carr, Bruce, Mr.
Carroll, Jesse J., Jr., Mr.
Carruthers, W. B., Mr.
Cartee, Ann, Ms.
Carter, Clayton, Mr.
Casey, Donald P., Mr.
Castaldi, Frank J., Dr.
Chambers, R. P.
Chambers, Tom, Mr.
Chamblis, Carroll
Chandler, Orman, Mr.
Chapin, Garnet, Mr.
Chavez, Christy, Ms.
Cheng, Daniel, Mr.
Christopher, Jay S., Mr.
Cisco, Beatrice, Ms.
Cisco, Ed, Mr.
Civitarese, Kathleen, Ms.
Clark, Aaron, Mr.
Clay, Greg, Mr.
Clay, Sherman, Mr. & Mrs.
Clements, Veda, Ms.
Click, Les, Mr.
Clifford, Jerry, Mr.
Clinton, Ken, Mr.
Coker, William F., Mr.
Cole, Mary J., Ms.
Cole, W. M., Mr.
Collins, Chester L., Mr.
Collins, D. C., Mr.
Collins, Willard, Mr.
Conley, R. L.
Conner, Ed, Mr.
Conner, Ellis, Mr.
Conner, Johnny, Mr. & Mrs.
Conner, Libby, Ms.
Conner, Polly, Ms.
Conner, Ricky, Mr. & Mrs.
Conner, Sharon, Ms.
Cook, Betty, Ms.
Cooley, Dwight, Mr.
Cooper, Judy, Ms.
Cornelius Ross L., Mr.
Cornelius, David A., Mr.
Cornelius, Jerry W., Mr.
Councill, R. J.
Couch, Charles, Mr.
Cowart, Walter, Mr.
Crawford, J. D., Mr.
Croft, Johnny, Mr.
Crosslin, Vickie, Ms.
Culbert, Emma, Ms.
Culbert, Joe D., Mr. & Mrs.
Culbert, Mary, Ms.
Cuneo, Richard T., Mr.
Cunningham, R. C., Mr. & Mrs.
Curry, Glenn, Mr.
Daley, Cameron H., Mr.
Dalins, Ilmars
Dasch, Jacqueline, Ms.
Davidson, Dalmus, Mr.
Davidson, Diane, Ms.
Davis, John, Mr.
Davis, Juanita, Mrs.
Davis, Marsha, Ms.
Davis, Otis, Mr.
Davis, Robert W., Mr. & Mrs.
Davis, William E., Mr. & Mrs.
Daymond, Martin
DeYoung, Bob, Mr. & Mrs.
DeYoung, Lynn
DeYoung, Lynn
Deerman, Woodson, Mr.

Degaris, John, Mr. & Mrs.
Deklavon, John, Mr.
Deluca, Rick, Mr.
Dewees, Lynn, Mr.
Dib, G. T.
Dobbs, Mae, Ms.
Doggett, Doug, Mr.
Dolberry, Tommy, Mr.
Donahoo, Red, Jr., Mr. & Mrs.
Donelly, Bob, Mr.
Donelly, Sheila A., Ms.
Dotson, David, Mr.
Dressler, Harold, Mr.
DuCharme, Yvonne, Ms.
Dubberly, Agnes, Ms.
Duckett, Charles, Mr.
Duckett, R. G., Mr.
Duncan, Charles, Mr. & Mrs.
Duncan, Pete, Mr.
Duncan, Ronald G., Mr.
Dunivant, Ken, Mr.
Dunlap, Jim, Mr.
Dunnavant, Robert, Jr., Mr.
Durham, Jimmy, Mr.
Dutton, Charlotte, Ms.
Dutton, Ronnie H., Mr.
Earrifon, Cora, Ms.
Ecann, John L., Mr.
Edwards, Janice, Ms.
Edwards, Martha, Ms.
Edwards, William R., Mr. & Mr
Ehresman, Paula, Ms.
Elliott, Alton D., Mr.
Estes, Tenia, Ms.
Etheridge, Bill, Rev.
Evans, John L., Mr.
Evans, Mollie, Ms.
Evans, Scotty K., Mr.
Fann, Ashley
Farmer, Billy J., Mr.
Farmer, Kelvin, Mr. & Mrs.
Farmer, Marlon, Mr.
Farris, Bobbye, Ms.
Farris, Jack E., Mr. & Mrs.
Faulkner, Larry, Mr.
Felder, James T., Mr.
Fenn, Hollis, Mr.
Fennell, Everette O., Mr.
Ferguson, E. T., Mr.
Ferguson, Russell, Mr.
Ferrell, H. C., Mr.
Ferrell, W. K., Mr.
Ferruzza, Joanne, Ms.
Filgaw, Ann, Mrs.
Fincher, Johnnie, Mr. & Mrs.
Fleming, Mary Kay, Ms.
Floring, William F., Mr. & Mr
Forssell, Eric, Mr.
Fortenberry, Ken, Mr.
Fortenberry, William, Mr.
Foster, M. E., Mrs.
Foster, Pat, Mrs.
Foster, Thomas, Mr.
Fowler, Wilbur P., Mr.
Franklin, Bill, Mr.
Franklin, Susan D., Ms.
Freeman, Jenny, Ms.
Freeman, Opal, Ms.
Fretwell, Maye, Ms.
Fricks, June, Ms.
Friesema, H. Paul, Mr.
Frost, Walter, Dr.
Fry, Deborah, Ms.
Fullerton, Charles P., Mr.
Gainer, Lila, Mrs.
Galdis, Allen, Mr.
Galimore, Vince, Mr.
Gallant, Charles, Mr.
Garber, Sandra L., Ms.
Gardner, Bennie, Mr.
Garrard, Oneal, Mr.
Garrett, Wayne, Dr.
Garrison, Edgar, Mr.
Garrison, Melinda, Ms.
Gateley, B. D.
Gavett, Mary, Ms.
Gayle, W. C.
Gentry, Richard, Mr.
Gholston, Willie Joe, Mr.
Gibson, Andrew, Mr.
Gibson, James, Mr. & Mrs.
Gibson, Marion
Gilbreath, Ruby, Ms.
Gilchrist, John R., Mr.
Gillespie, Pruitt, Mr.
Gilmore, James F., Mr. & Mrs.
Gist, Kenneth A., Mr.
Givens, Helen, Ms.
Glenn, James R., Mr.
Glover, Joyce, Ms.
Godsey, Melissa, Ms.
Godwin, Billy, Mr. & Mrs.
Godwin, Bobby, Mr. & Mrs.
Godwin, Claude, Mr. & Mrs.

Godwin, G. R., Mr. and Mrs.
Godwin, James D., Mr. & Mrs.
Godwin, Melvin, Mr. & Mrs.
Godwin, Tony, Mr.
Godwin, Wynell, Ms.
Gomez, Angie, Ms.
Gonsoulin, Gene J., PhD
Gont, Luna M., Mrs.
Goodpaster, C. Richard, Mr.
Gorenflo, Louise, Ms.
Graham, Jerry M., Dr.
Granat, Rhonda, Ms.
Granger, Tom, Mr.
Grayson, Bessie, Ms.
Green, Jerry, Mr.
Green, Nicky, Mr. & Mrs.
Green, Ronald J., Mr.
Green, William A., Mr.
Greer, Julian A., Mr.
Grey, Martin, Mr.
Griffith, Louise M., Ms.
Gunter, Sally N., Ms.
Guthrie, Leon, Mr.
Guthrie, Phyllis, Ms.
Guyse, Windell, Mrs.
Haden, Robert W., Dr.
Halder, Jay, Mr.
Hall, John D., Dr.
Hambrick, Joe, Mr. & Mrs.
Hammon, Reed, Mr.
Handet, Linda, Ms.
Handley, Bobby, Mr.
Hannah, Herbert, Mr.
Hanner, Dwight, Mr.
Hanners, Phillip D., Mr.
Harbin, Frank, Mr. & Mrs.
Harbin, Pat, Mr.
Hard, James P., Mr. & Mrs.
Hard, James, Mr. & Mrs.
Hardcastle, Jim, Mr.
Hardesty, W. C., Mr. & Mrs.
Harkins, Shirley, Ms.
Harpe, Felicia, Ms.
Harris, Evelyn, Ms.
Harris, James, Mr.
Harrison, George, Mr.
Harvey, Sam, Mr.
Hassebrock, Susan, Ms.
Hastings, Philip, Mr.
Hawkins, Jim, Mr.
Hayes, Demorah
Hayes, Drew A., Mr.
Haynes, Donald, Mr. & Mrs.
Helderman, Frank, Jr., Mrs.
Hellums, Charles, Mr. & Mrs.
Helton, Joe, Mr.
Henderson, Robert J., Mr.
Henner, Dwight, Mr.
Henry, James A., Mr.
Henton, Jimmy, Mr.
Herd, Opal, Ms.
Hill, Jay, Mr.
Hill, Roger, Mr.
Hillstrom, John, Mr.
Himburg, Jimmy, Mr. & Mrs.
Hindman, M. James, Mr.
Hodges, C. T., Mr.
Hodges, David M., Mr.
Hodges, Earl, Mr. & Mrs.
Hodges, Elka, Ms.
Hodges, Ernest Earl, Mr.
Hodges, Jimmy, Mr. & Mrs.
Hodges, John Will, Mr.
Hodges, Karen, Ms.
Hodges, M. G. III, Mr.
Hodges, M. G., Jr., Mr. & Mrs
Hodges, Randy, Mr.
Hodges, Rilla, Ms.
Hodges, Rudy, Mr.
Hoelscher, James E., Jr., Mr.
Holloway, James R., Mr.
Holtzclaw, Steve, Mr. & Mrs.
Hooper, Watson, Mr.
Hoover, Jeff, Mr.
Horne, P. L., Mr. & Mrs.
Horneck, Craig W., Mr.
Horton, Don, Mr.
Houston, Denny W., Mr.
Howel, Mae Hattie, Ms.
Howell, Bridinjo, Mr.
Howell, Jesse L., Jr., Mr.
Hudson, Dan, Mr.
Huff, Scott, Mr.
Hughes, Karen, Mrs.
Hughes, Martha, Ms.
Hulley, Keith R., Mr.
Hulsey, Cathy, Ms.
Hutcheson, James, Mr. & Mrs.
Hutcheson, Verna, Ms.
Iglar, Albert F., Dr.
Immonen, Sakari
Ingram, Max W., Mr. & Mrs.
Inman, Bob, Mr.
Isom, Donald B., Mr.

Jackson, Thomas H., Mr.
James, David Lee, Esq.
Jared, Wirt F., Mr. & Mrs.
Jarnigan, Bill, Mr.
Jeffreys, Allen, Mr.
Jensen, James D., Mr. & Mrs.
Jesse, Dale, Mr.
Johnson, Henry M., Mr.
Johnson, Jimmy, Mr.
Johnson, Kenneth C., Mr.
Johnson, Kenneth C., Mr.
Johnson, Larry, Mr.
Johnson, Lynn
Johnson, Mike, Mr.
Johnson, Paul, Mr. & Mrs.
Johnson, Phillip, Mr.
Jones, Harvey, Mr.
Jones, Katherine, Ms.
Jones, Raiford, Mr. & Mrs.
Jones, Rodney, Mr.
Jones, Wilma, Ms.
Justice, Jill, Ms.
Kaprelien, Steve, Mr.
Kaps, Martin, Mr.
Katz, Harold, Mr.
Keen, Elaine K., Ms.
Kelley, Carl S., III, Mr.
Kempf, Kenneth, Mr.
Kennedy, B. W.
Kentros, Al, Mr.
Ketchersid, James S., Mr.
Killingsworth, Lawrence, Mr.
Killingworth, Ronald, Mr.
Kilpatrick, Wendy, Ms.
Kimbrel, Lois, Ms.
Kimsey, J. R., Mr.
Kincaid, Hugh, Mr.
King, Bill, Mr.
King, Tom, Mr.
Kitchens, William E., Mr.
Klyce, A. S. III, Mr.
Knauss, James D., Dr.
Knc[illegible]s, Buford, Mr.
Kohl, Larue, Mr.
Kracke, Stanley, Mr.
Kucera, Rudy, Mr.
Kyle, John E., Mr.
Kyle, Phillip, Mr.
Kyser, James B., Dr. & Mrs.
Lamb, James A., Mr.
Lambert, Billy Joe, Mr.
Lamont, P. A.
Land, Peter J., Mr. & Mrs.
Land, Peter J., Mrs.
Lang, C. R., Mr. & Mrs.
Lash, Larry, Mr.
Lawhorn, Bill, Mr.
Lawhorn, Mary L., Ms.
Lawhorn, William T., Jr.
Lawson, Curtis, Mr.
Lawson, Ricky, Mr.
Layman, Maynard, Mr.
Leach, R. P., Mr.
Lee, Lewis, Mr.
Legal, Cass
Lemay, Marjorie, Ms.
Lemezis, Sylvester, Mr.
Leppin, Dennis, Mr.
Leslie, Buford, Mr.
Leslie, Connie, Ms.
Leslie, Debbie, Ms.
Leslie, Ethel, Ms.
Leslie, Frances, Ms.
Leslie, J. B.
Leslie, Larry, Mr.
Leslie, Marvin, Mr.
Leslie, Steven, Mr.
Lewin, Diana, Ms.
Lewis, Michael, Mr.
Lichtenberg, Paula, Ms.
Little, Bill, Mr.
Little, Buddy, Mr.
Little, Grover, Mr.
Little, Haskel, Mr.
Little, J. C., Mr.
Little, James, Mr.
Little, Jean, Ms.
Little, Jeff, Mr.
Little, Judie, Ms.
Little, Lucy, Ms.
Little, Rebecca, Ms.
Lloyd, Howard P. Mr.
Lloyd, W. P.
Lloyd, W. P., Jr.
Locke, Rollin K., Maj.
Lombardi, Chris
Long, Ram, Mr.
Lucas, James W., Sr., Mr.
Lurivog, Vivian B., Ms.
Lynn, Deanna, Ms.
Lynn, Laura J., Ms.
Lyons, Norman, Mr. & Mrs.
Ma, J. L.
Maddox, Emily, Ms.

Mann, Philip C., Mr.
Marifi, Dr.
Marone, Ernest, Mr.
Marsh, Martha, Ms.
Martin, Dave, Mr.
Martin, Eria, Mr.
Martin, J. M., Mr.
Martin, James C., Mr.
Martin, Joe, Mr. & Mrs.
Massingill, George W., Mr.
Mastrodomenico, Cynthia, Ms.
Matkin, Patrick O., Mr.
Matthews, Lee, Mr.
Mayville, Paul, Mr.
McAbee, Elizabeth, Ms.
McCann, Randy, Mr.
McCarley, Rudy, Mr.
McClanahan, J. H., Mr.
McClendon, E. K., Mr. & Mrs.
McCormick, Rayburn, Mr.
McCullar, Kate W., Mrs.
McDaniels, Ray, Mr.
McDonald, Anne M., Ms.
McDonald, B. Hamilton, Jr., M
McDonald, Mary, Ms.
McDonald, W. R., Mrs.
McDowell, Lee, Mr.
McGregor, Rosia Ann, Ms.
McGriff, Joel, Mr.
McNeese, Roger, Mr.
Mead, Wendell, Mr.
Mercer, Clayton, Mr.
Mercer, Clayton, Mr.
Merritt, Carol, Ms.
Michaels, Jennie L., Ms.
Milbraith, Lester, Dr.
Miller, Edward Gary, Mr.
Miller, Lynne Y., Ms.
Millirons, Paul L., Mr.
Mitchell, Jerry, Mr.
Money, Joe, Mr.
Monroe, Bob, Mr.
Monroe, H. E. Jr., Mr. & Mrs.
Monson, M. T., Jr., Mr.
Moon, Chloe W., Ms.
Moore, Charles D., Mr.
Moore, Charles, Mrs.
Morgan, Herb, Mr.
Morgan, Ruth, Ms.
Moring, Frank, Mr.
Morris, Mary, Ms.
Morrow, John D., Mr.
Mroczynski, R. P.
Mulligan, Hugh F., Dr.
Murray, William F., Mr.
Myers, Oliver, Mr.
Myers, Shelby, Mr. & Mrs.
Myracle, Judy, Ms.
Myrick, Les, Mr.
Nakamura, Mr.
Neely, Jimmy, Mr.
Nelson, Helen, Ms.
Nelson, James, Mr. & Mrs.
Nelson, Roger, Mr.
Newell, J. C., Mr.
Newman, John, Mr.
Newman, Russell, Mr. & Mrs.
Nichols, Corand
Nichols, Duane G., Dr.
Noles, Coy, Mr. & Mrs.
Noojin, J. M., Jr., Mr.
Northrop, Gaylord, Mr.
Norton, Printess, Mr.
Norwood, Barbra, Ms.
Oberta, A. F.
Odum, Frank, Mr.
Ogden, E. C., III, Mr.
Ohst, Alice M., Ms.
Olsecuski, Joseph, Mr.
Olsson, A. T.
Oppenheimer, Max, Mr.
Osborn, Palmer, Mr. & Mrs.
Ott, John, Sr., Mr. & Mrs.
Owen, Alfred, Dr.
Owen, Cleveland S., Mr.
Owen, James W., Mr.
Owen, Jean, Ms.
Owen, Philip R., Mr. & Mrs.
Owings, Suzanne, Dr.
Ownes, O. B., Mr.
Page, Gordon C., Mr.
Parker, Gary, Mr.
Parker, Marlene, Ms.
Parks, Bently, Mr. & Mrs.
Parrish, Mike, Mr.
Pate, David, Mr.
Patterson, J. L., Jr., Mr.
Patterson, Nina, Ms.
Patterson, R. O., Mr. & Mrs.
Patterson, Steve, Mr. & Mrs.
Pay, David, Mr.
Pearl, W. L.
Pederson, Thomas R., Mr.
Peques, Wayne, Mrs.

Perry, Hilda, Ms.
Perry, Mike, Mr.
Peters, Bruce, Mr.
Peterson, Fred, Mr.
Petrey, John W., Mr.
Petty, Inez, Ms.
Phillips, Durand, Mr.
Phillips, Hollis, Mrs.
Phillips, Patricia Bowman, Ms
Pianta, Ronald, Mr.
Pickens, Miles, Mr.
Pierce, Luna C., Ms.
Pillow, Margaret, Ms.
Pitts, Dan, Mr.
Plant, R. W.
Polstorff, W. K., Mr.
Popejoy, D. B., Mr. & Mrs.
Popejoy, W. E., Mrs.
Potter, William R., Mr.
Poy, David, Mr.
Presley, Charlotte, Ms.
Presley, Jimmy, Mr.
Price, Don, Mr.
Price, Marty, Mr.
Pruitt, Theron, Mr.
Pullen, J. B., Mrs.
Pullen, Joe N., Mr.
Pullen, R. J., Mr.
Puntozzi, Pascal S., Mr.
Quast, Ted, Mr.
Quinn, John, Mr.
Quinn, John, Mr.
Radcliffe, Larry, Mr.
Rayfield, Judy, Ms.
Reding, Denzel, Mr.
Reding, Liddie, Ms.
Reeder, Jim, Mr.
Reese, Inez, E., Ms.
Reynolds, Dallas B., Dr. & Mr
Richardson, Stu, Mr.
Rickey, Thomas J., Mr.
Rickey, Wallace, Mr. & Mrs.
Riggs, Davis, Mr. & Mrs.
Riley, Larry, Mr.
Robbins, James, T., Jr., Mr.
Roberson, Debbie, Ms.
Rogers, Charles, Mr.
Rogers, John E., Mr.
Rose, Ed, Mr.
Rosevink, Ellon M., Ms.
Rousseau, John, Mr.
Row, T. H.
Rowe, Benji, Mr.
Rowe, Marie P., Ms.
Rush, Bob, Mr. & Mrs.
Rush, Robert, Mr.
Sanderson, Louis, Mr.
Sandridge, Howard, Mr.
Sandridge, J. C.
Satchel, Charles, Mr.
Schetter, James R., Mr.
Schmidt, Fred, Mr.
Schulz, Robert L., Mr.
Sears, Franklin, Mr. & Mrs.
Seluhan, Adam. T., Mr.
Selvage, Glen, Mr.
Selvage, T. T., Mr.
Sharp, C. G., Mr.
Sheerer, Connie S., Ms.
Shelton, Barrett C., Mr.
Shenker, Gary, Mr.
Shewbart, Patricia, Ms.
Shody, J. L.
Shuford, Richard, Mrs.
Silk, Ralph., Mr. & Mrs.
Sims, Robert, Mr.
Skeney, E. C.
Smart, John M., Mr.
Smith, Bill, Mr.
Smith, Charlotte, Ms.
Smith, Freeman, Mr.
Smith, Glynaus, Ms.
Smith, J. E.
Smith, Jimmy, Mr.
Smith, Lora, Ms.
Smith, Pete, Mr.
Smith, Ralph E., Mr.
Smith, Ralph, Jr., Mr.
Smith, Ricky, Mr.
Smith, Robert F., Mr.
Smith, Talmadge R., Mr.
Smitti, Linda, Ms.
Snodgrass, Thelma, Ms.
Solemire, Barbara, Ms.
Sparkman, Brandon, Dr.
Sparks, Doug, Mr.
Sparks, Rymon N., Mr. & Mrs.
Sparks, V. W., Mr.
Spaw, Rod, Mr.
Speake, Harold, Mr.
Stallcup, Leon, Mr.
Stanford, Mike, Mr.
Stapler, Cynthia Gail, Ms.
Starnes, John W., Mr.

Steigelmann, William H., Mr.
Stephens, Arthur, Mr.
Stephens, Paul, Mr.
Stephens, Tommy, Mr.
Stephenson, Charles M., Mr.
Stepp, Brenda, Ms.
Sternfels, Ernest A., Mr.
Stevens, Carol, Ms.
Stewart, Kathren, Ms.
Stewart, Ollie Sue, Ms.
Stewart, Sue, Ms.
Stewart, Wayne, Mr. & Mrs.
Stickles, R. Peter, Mr.
Stiplin, W. Howard, Dr.
Stone, Bill, Mr.
Stone, S. M. Mr. & Mrs.
Stooksberry, W. J.
Stooksberry, W. J., Mr. & Mrs
Storm, Bob, Mr. & Mrs.
Strickland, Terry, Mr.
Strinich, Mike, Mr.
Struble, Richard H., Mr.
Sutherland, H. L., Dr.
Swaggert, Gertrude, Ms.
Swords, Tonlo, Mr.
Taliaferro, Mitch, Mr.
Tally, William J., Mr.
Tatum, James T., Jr., Mr.
Taturo, William B., Mr.
Taylor, Don, Mr.
Taylor, Jennie, Ms.
Taylor, W. George, Mr. & Mrs.
Teal, Margaret P., Mrs.
Terry, A. C., Mr.
Terry, Benny, Mr.
Terry, Benny, Mr.
Terry, Brenda, Ms.
Terry, Carnell, Mr.
Terry, Charles G., Mr.
Terry, Eleanor G., Ms.
Terry, Shirley, Ms.
Tevepaugh, J. A.
Thalassinas, Perry, Mr.
Thompson, Becky G., Ms.
Thompson, Bill, Mr.
Thompson, Bill, Mr.
Thompson, Denis W., Mr.
Thompson, Edward L., Mr. & Mr
Thompson, H. Jack, Mr.
Thompson, June, Ms.
Thurston, James, Mr.
Todd, E. R., Mr.
Tomlinson, William, Mr.
Tucker, Charles, Mr. & Mrs.
Tucker, J. D.
Tucker, William, Mr.
Turner, A. J., Mr. & Mrs.
Tyson, Tim, Mr.
Unsworth, Lynn
Varagore, Janet, Ms.
Varneill, James, Dr.
Vaught, Floyd L., Mr.
Veazey, Charles F., Dr.
Waldrep, Paul, Mr.
Walker, Bert, Mr.
Walker, Herbert P., Sr., Mr.
Walker, Mike, Mr.
Walker, Steve, Mr.
Wallick, Bill, Mr. & Mrs.
Walls, Barbara E., Ms.
Wann, William B.
Waple, Eric R., Mr.
Ward, Bill, Mr.
Ward, Eddy G., Mr.
Ward, Ira Lee, Mr. & Mrs.
Ward, Jim, Mr.
Ward, Reda, Ms.
Ward, Robert, Mr.
Warden, Joan, Ms.
Weaver, Fred Seldom, Mr.
Webb, Shirley, Ms.
Weems, Bill, Mr.
Welch, W. T., Mr. & Mrs.
Wellborn, Samuel G., Mr.
Wersely, Eleanor, Ms.
West, Pat
Westerfield, Cynthia, Ms.
Wheeley, Otto, Mr.
White, Beulah, Ms.
White, Eileen B., Ms.
White, George, Mr.
White, Hoover, Mr.
White, Nicholas, Mr.
Wicker, Robert, Mr.
Wiener, John, Mr.
Wiggins, Lyna L., Ms.
Wilborn, Ed, Mr.
Wilborn, Edd, Jr., Mr.
Wilborn, Ernest, Mr.
Wilborn, Glen, Mr. & Mrs.
Wilborn, James E., Mr.
Wilborn, Leo, Mr.
Wilborn, Lucille, Ms.
Wilborn, Lynn, Mr.

Wilborn, Mr. & Mrs.
Wilborn, Phillip, Mr. & Mrs.
Williams, J. H., Mr.
Williams, M. L., Mr.
Williams, Marge, Ms.
Williams, Susan, Ms.
Willis, Byron H., Dr.
Willis, Greg, Mr.
Wilson, James H., Mr. & Mrs.
Wilson, James H., Mr. & Mrs.
Wilson, James R., Mr.
Wilson, Kenneth D., Mr.
Wilson, Kenneth, Dr.
Wilson, Mike, Mr.
Wilson, Tom, Mr.
Wilson, Virginia, Ms.
Winston, Betty Jean, Ms.
Winston, Johnnie M., Mr.
Winter, Richard C., Mr.
Witt, Walter, Mrs.
Wood, Andrew J., Mr.
Woodall, Minor
Woodall, William, Mr.
Woodford, Alan, Mr.
Woods, Andy, Mr.
Woodward, Duncan, Mr.
Woodward, Lee
Worborn, Conner, Mr.
Worley, Eugene, Mr.
Wright, Rayford, Mr.
Wright, Walter Dr.
Wyatt, Frances, Ms.
Wynn, J. B.
Yancey, Claud B., Mr. & Mrs.
Yancy, Wayne, Mr.
Yarbrough, Ed, Mr.
Yarbrough, James F., Mr.
Yaroma, Geoffrey F., Mr.
Yates, John M.
Yerushelmi, Joseph, Dr.
York, Larry, Mr.

APPENDIX A

- Letter from the Environmental Protection Agency (EPA) Administrator indicating TVA's activities with the EPA Synfuels effort;
- Letter from TVA to EPA;
- TVA Conceptual Monitoring Program - Proposed North Alabama Coal Gasification Project;
- Schedule of Pending Detailed Design Decisions on Pollution Control Strategies.

United States
Environmental Protection Agency
Washington, D.C. 20460
July 11, 1980

The Administrator

Mr. S. David Freeman
Chairman
Tennessee Valley Authority
Knoxville, Tennessee 37902

Dear Mr. Freeman:

I am glad to hear that our respective staffs are working closely on the design for your proposed coal gasification facility to make that plant an environmental yardstick for the synfuels industry. This work will result in EPA's development of the Pollution Control Guidance Document (PCGD) for coal gasification.

This cooperation should expedite both EPA's review of TVA's EIS and the permitting of the facility. But, most important of all, it should assure that you build environmental protection into the design of the plant. Further, having TVA's design information available will greatly assist us in developing a guidance document that will be practicable and assure that the public is fully protected at all such plants.

An extensive data base of the effluent characteristics of coal gasification processes is being developed; it will be used to determine best available control technology for coal gasification processes. As you know, TVA is represented on the coal gasification/indirect liquefaction working group, and the information being developed is made available to TVA through that groups.

I understand that TVA will utilize the material from the working group in the design of the proposed facility and the preparation of the EIS. This parallel development of EPA's guidance document and the evaluation and design of your proposed facility appears to be both practicable and appropriate. If TVA's final design is similar to the recommendations of the PCGD, it will provide a benchwork of good environmental practice for the synfuels industry.

The cooperation between EPA and TVA should result in the development of a facility that not only demonstrates the economic feasibility of coal gasification but also the environmental acceptability of the technology. I believe it can also demonstrate that good environmental protection need not cause delays. I share your conviction that the proposed facility can become a model for future plants and look forward to expanding our cooperative relationship.

Sincerely,

Douglas M. Costle

TENNESSEE VALLEY AUTHORITY

NORRIS, TENNESSEE 37828

JUL 16 1981

Ms. Rebecca W. Hanmer
Regional Administrator
U.S. Environmental Protection
  Agency, Region IV
345 Courtland Street
Atlanta, Georgia 30365

Dear Ms. Hanmer:

Upon further consideration and after discussion with your staff, we no longer see the need for the proposed Memorandum of Agreement (MOA) between TVA and EPA covering the proposed coal gasification plant. This neither diminishes our commitment to ensuring that the plant is constructed and operated in an environmentally acceptable manner nor lessens our desire to work closely with EPA to accomplish this.

We believe that it would be inappropriate to enter into the MOA in light of the new direction to rely more upon the private sector and TVA's proposal to turn construction and operation of the proposed plant over to a consortium of private entities. Further, the various environmental permitting processes and the cooperative relationship we have with EPA, Region IV, and Research Triangle Park on this and other matters should substantially achieve the objectives of the proposed MOA.

The most important measures which would minimize potential environmental impacts are reflected in TVA's design of the facility which would essentially be sold to the consortium. This design will serve as the basis for obtaining the necessary Federal and State permits and most other nondesign-related measures will be required as conditions to the various permits.

In addition to permit-related measures, TVA would ensure that the following actions are taken either by TVA or the consortium by making them part of the contract between TVA and the consortium or as conditions to the transfer of the site to the consortium.

1. Development of a comprehensive postoperational monitoring program coordinated with EPA and the State of Alabama. This program will be made publicly available.

2. Preparation of a summary of postoperational environmental monitoring data with interpretations of the data. This also will be made available to the public.

Ms. Rebecca W. Hanmer

JUL 16 1981

3. Consistent with TVA's obligations in respect to proprietary data, distribution of copies of engineering data and reports related to the environmental permitting process, as they become available to EPA, Region IV, and EPA-IERL-RTP (i.e., Gasification - Indirect Liquefaction Working Group) for review on technology-related matters. This includes the results of waste characterization and treatability studies.

We understand that this approach would be satisfactory to you. We look forward to continuing our cooperative efforts in this and future projects.

Sincerely,

Mohamed T. El-Ashry, Ph.D.
Assistant Manager of Natural
Resources (Environment)

cc: Mr. John E. Hagan III
Chief, EIS Branch
U.S. Environmental Protection
Agency, Region IV
345 Courtland Street
Atlanta, Georgia 30365

Appendix A

TVA Conceptual Monitoring Program
Proposed North Alabama Coal Gasification Project

Developing a project of the magnitude of the proposed north Alabama coal gasification plant requires that considerable effort be given to environmental protection. This overall effort would include a number of different tasks aimed at designing, constructing and operating the 10,000 ton per day coal gasification facility in an environmentally acceptable manner. TVA's initial efforts have focused on assessing the overall impacts of the facility and identifying those design options (intake, discharge, dock locations, site layouts, etc.) that are practicable and that would be used to provide for an environmentally acceptable facility. Procedures have been developed that would be followed during construction in order to protect the environment. Waste characterization and treatability studies, including appropriate biological studies, have begun on K-T and Texaco gasifier wastes to support the design of waste treatment and disposal systems and permit applications. Appendix B provides more detailed information on these studies. A preoperational/operational monitoring plan has been submitted to (and approved by) the State of Alabama describing minimal instream and onsite compliance related studies. Final activities to be undertaken by TVA involve completing treatability and design studies and developing a monitoring program focusing on system performance.

These programs would be based primarily on permit requirements or activities which TVA identified in the EIS as necessary to minimize environmental impacts. TVA plans to coordinate the development of this monitoring plan with the State of Alabama and the Environmental Protection Agency (EPA) and to make the draft plan available to the public. Some program activities would be required under various permits such as NPDES, PSD, Section 404, and Section 10. TVA will begin implementing the construction phase of the program before the project is transferred to a private entity. Specific plans and schedules for the remainder of the program will be determined by the requirements of Federal and State regulatory agencies, the entity constructing and operating the proposed facility, and TVA.

TVA has assembled a team of specialists from various disciplines to develop the monitoring program. This team is addressing a number of areas including the gasification process; gas conversion; gas cleanup and emission; wastewater sources, their combination, treatment and discharge; solid waste management; noise control; air quality; water quality; biological effects, including bioassays for ecological and health effects; data management; and integrated environmental assessment.

This approach facilitates preparing a comprehensive monitoring program. This program is focusing on the following major objectives:

- to evaluate the performance of the chosen pollution control technology process;

- to further characterize the plant discharges (gaseous emissions, wastewater streams, and solid wastes) as a function of process operating conditions including steady and unsteady states; and

- to further define the impacts of plant operations on biota and human health.

The development of the system performance aspects of the program could encompass the following twelve steps:

1. Process units would be identified with input and output stream compositions and sampling points;

2. Waste discharge points and specific process variables that influence composition would be identified;

3. Provisions would be made to monitor the input and output stream compositions of control technology units;

4. Sampling devices would be specified;

5. Sampling techniques would be described;

6. Sampling frequency would be specified;

7. Flowcharts would be established for the analysis of each sample;

8. Samples would be identified for use in ecological bioassay work;

9. Additional instream investigations would be proposed, if appropriate.

10. Data management techniques would be developed to match process conditions, sampling locations, and sample analyses along with data correlation;

11. Interorganizational and work flowcharts would be established to provide orderly presentation of monitoring results and a historical record of how the results were obtained;

12. The duration of each monitoring activity would be established.

PENDING DETAILED DESIGN DECISIONS

TVA has assessed the environmental impacts of the proposed facility based on the best available design description, experience, and existing data. A number of detailed design decisions for wastewater and solid waste control strategies have not yet been made. TVA has selected the Rectisol acid gas removal system, Claus sulfur recovery system, and the Beavon/Stretford tailgas cleanup system to control the major potential emissions to the air from this facility. Listed below are a number of pending decisions regarding solid waste disposal and wastewater treatment and an estimated time frame for making the decisions:

ITEM	DATE
Solid Waste Disposal Strategy	
Chemical Characterization of Waste	9/81
Physical Characterization of Waste	9/81
Geohydrological Baseline Studies	1/82
In Situ Foundation Studies	
Phase One	3/81
Phase Two	9/81
Submit Solid Waste Disposal Plan to the State of Alabama with a Copy to EPA	2/82
Wastewater Treatment Strategy	
Complete Chemical Characterization	10/81
Complete Initial Treatability Studies	12/81
Prepare Report on Recommended Initial Design Criteria and Required Additional Studies	2/82
Submit Engineering Report to the State of Alabama with a Copy to EPA	*
Receive NPDES Permit from the State of Alabama	*
Air Emissions Control Strategy	
Submit Air Quality Permit Application to the State of Alabama with a copy to EPA	*
Receive PSD Permit from the State of Alabama	*

*Date to be determined later.

APPENDIX B

APPENDIX B

This appendix contains information used by TVA to support environmental evaluations of the proposed coal gasification plant. Information is presented on gasifier wastes (air, liquid, and solid), ancillary facility waste such as coal pile runoff and cooling tower blowdown, and conceptual wastewater treatment studies undertaken by TVA. Additional information on waste characteristics can be found in Reference 1.

In addition, TVA is conducting a testing program (see Section 3 below) to ensure the operational readiness of the 2 preferred gasification processes using eastern high-sulfur coal. As a part of this program, TVA will collect and analyze environmental data. This data will be used to expand and confirm the effluent characteristic data base and as input to the design process.

1. Waste Characteristics

1.1 Wastewater

1.1.1 Coal Gasification and Gas Processing Systems

Process wastewaters are a result of gas scrubbing to remove soluble and insoluble substances, gas quenching to control operating temperatures, steam condensation or reforming during methanation or hydrotreating, condensate during methanol production, and quenching of ash or slag for disposal. Gas liquor (sour water) is the total liquid stream from condensing or scrubbing in the total coal gasification processing system. This gas liquor would likely contain a wide variety of the components found in the product gas as well as sulfur and nitrogen compounds, particulates, phenols, tar and oils (depending on gasifier configuration), and soluble salts. Contamination of methanation reforming water should be minimal because the gases are cleaned before methanation. The sour water produced by the hydrotreating process would contain hydrogen sulfide (H_2S), ammonia (NH_3), oils, char, and other coal-derived materials. Water formed during methanol production would contain higher alcohols including ethanol, dimethyl ether, and low molecular weight hydrocarbons. This waste stream is relatively small and would be generated during crude methanol distillation which is a standard refinery technology. Wastewater from slag or ash quenching would contain any water-soluble components in the slag or ash.

The majority of tars and oils are created by lower temperature processes (Lurgi dry-ash and Lurgi slagging) that first contact the coal at relatively low temperatures with the raw product gas exiting the gasifier (see Section 2.3). At extreme temperatures, as in the case of the Koppers-Totzek (K-T) reactor, no tars and oils are formed.

Tables B-1 through B-6 give wastewater characteristics of the five candidate gasifiers. These data show the effect of process temperature on the gasifier wastewater. The wastewater from high temperature processes (B&W, K-T, and Texaco) contain little, if any, organic constituents. The wastewater from lower temperature processes (Lurgi dry-ash and Lurgi slagging) contain a variety of organic constituents.

The basic character of the complex organic structure of coal is aromatic. Therefore, the tars that are expelled from the coal during devolatilization in lower-temperature reactors may be expected to contain naphthalenes, indenes, anthracenes, and similar compounds. Oxygenated compounds, such as phenols and cresylic acids, may be expected in addition to nitrogen- and sulfur-containing ring structures. In moderate-temperature reactors, these complex aromatics are hydrocracked and possibly hydrodealkylated to simpler BTX (benzene-toluene-xylene) streams. In higher-temperature systems, even these simple aromatics are cracked to gaseous forms.

The lower temperature processes that produce tars and oils tend to have high-molecular weight organic sulfur species in the product gas. Low-temperature reactors also tend to form various high-molecular-weight nitrogenous compounds, such as pyridines, pyrroles, azoles, indoles, quinolines, anilines, amines, and similar compounds.

During gasification, trace metals found in feed coal are expected to appear predominately in the gasifier ash or slag; those metals that do volatilize into the gasifier product gas are expected to be removed during gasifier quench and scrubbing. It has been noted that during combustion of coal, fly ash particles are enriched in trace elements such as arsenic, cadmium, copper, chromium, molybdenum, lead, antimony, zinc, sulfur, boron, nickel, vanadium, selenium, silver, mercury, chlorine, fluorine, beryllium, and uranium. While little data exist, the more volatile trace elements may condense on the fine particulates and contribute to their toxicity.

Of the volatile trace elements that may appear in the gasifier product gas, most of the elements would be expected to be removed in the gas purification steps, and a great majority of the trace elements would appear in the washwater, eventually to be removed during the wastewater treatment process. Certain trace elements in coal (viz. aluminum, cadmium, copper, molybdenum, lead, antimony, and zinc) preferentially concentrate on smaller particles during combustion, whereas mercury, chlorine, and bromine are discharged as vapors. These trace metals may be found in higher concentrations in the quench waters from entrained bed gasifiers than in those from fixed bed gasifiers, because of a larger carry-over of fly ash into the gas quench step in entrained bed gasifiers.

1.1.2 Ancillary Facilities

In addition to wastewaters previously described, several additional wastewater streams would be produced, namely drainage

TABLE B-1

ESTIMATED B&W GASIFIER EFFLUENT CHARACTERISTICS

Parameter	Concentration, mg/l
BOD_5	600
COD	1,200
TSOC	300
Phenols	100
NH_3	2,000
SCN	500
CN	30
Oils	20
TSS	0

Source: Wyatt, J.M., D.B. Cox, and L.H. Woosley, "Characterization, Treatment, and Disposal of Liquid and Solid Wastes from Coal Gasification Facilities", Vol. I, Water Quality Branch, Division of Water Resources, Office of Natural Resources, Tennessee Valley Authority, June 1980.

TABLE B-2

ANALYSIS OF WATER FROM KOPPERS-TOTZEK PLANT
KUTAHYA, TURKEY

Component	Concentration at Sample Location[a], mg/l[b]				
	1	2	3	4	5
pH[b]	8.8	8.8	8.9	8.8	8.9
CaO	78	101	78	135	179
MgO	97	161	194	145	113
Na	17.5	17.5	17.5	17.5	17.5
K	5.6	8.8	10.0	8.0	8.0
Zn	0.01	0.03	0.02	0.02	0.02
Fe	0.05	0.22	1.95	0.20	0.64
NH_4	0.32	157	184	137	122
NO_2	58.2	3.32	13.7	24.7	22.9
PO_4, total	1.89	0.81	1.21	0.81	2.70
Cl	18	85	96	57	46
SO_4	42	216	155	255	109
CN	0.26	0.52	12.5	1.4	14.0
H_2S[c]					
$KMnO_4$, consumed	8	9	400	11	145
Chemical O_2 demand	14	18	128	16	63
SiO_2	14.8	15.0	14.8	19.8	42.6
Suspended solids	14	4612	5084	3072	50
Cu	0.01	0.01	0.01	0.01	0.06

a. 1) Cooling water to slag quench tank.
2) Water from slag quench tank.
3) Washwater after washer-cooler.
4) Water into clarifier.
5) Clarifier effluent.

b. All measurements in milligrams per liter (mg/l) except for pH.

c. Not detected.

Source: Farnsworth, J.F., Mitsak, D.M.; and Kamody, J.F.; "Clean Environment with Koppers-Totzek Process", Symposium Proceedings: Environmental Aspects of Fuel Conversion Technology (May 1974, St. Louis, Missouri), EPA-650/2-74-118, October 1974.

TABLE B-3

CHARACTERISTICS OF KOPPERS-TOTZEK CONDENSATE

Components	Concentration, mg/l
COD	420
TOC	40
NH_3	17,000
CN	25
SCN	68
S	42
SO_3	170
Carbonate CO_2	42,000

Source: Wyatt, J.M., D.B. Cox, and L.H. Woosley, "Characterization, Treatment, and Disposal of Liquid and Solid Wastes from Coal Gasification Facilities", Vol. I, Water Quality Branch, Division of Water Resources, Office of Natural Resources, Tennessee Valley Authority, June 1980.

TABLE B-4

TEXACO GASIFIER BLOWDOWN CHARACTERISTICS

Parameters	Concentration
Total Suspended Solids	330 mg/l
Total Dissolved Solids	2,000 mg/l
Ammonia	1,600 mg/l
Chloride	1,320 mg/l
Total Organic Carbon	760 mg/l
Total Inorganic Carbon	104 mg/l

Source: Wyatt, J.M., D.B. Cox, and L.H. Woosley, "Characterization, Treatment, and Disposal of Liquid and Solid Wastes from Coal Gasification Facilities", Vol. I, Water Quality Branch, Division of Water Resources, Office of Natural Resources, Tennessee Valley Authority, June 1980.

TABLE B-5

CHARACTERISTICS OF RAW AND PROCESSED WASTEWATER
FROM THE LURGI DRY ASH PROCESS PLANT AT SALSOLBURG, SOUTH AFRICA

General Properties

Parameter	Values: Raw Wastewater	Values: Processed Wastewater
Phenol, mg/l	1,250	3.2
Chemical oxygen demand, mg/l	12,500	1,330
Organic carbon, mg/l	4,190	a
Total dissolved solids, mg/l	2,460	596
pH	8.9	8.9
Ammonia, mg/l	11,200	150

Concentration of Specific Compounds

Compound	Concentration (mg/l)[b]: Raw Wastewater	Concentration (mg/l)[b]: Processed Wastewater
Fatty Acids		
Acetic acid	171	123
Propanoic acid	26	30
Butanoic acid	13	16
2-Methylpropanoic acid	2	5
Pentanoic acid	12	7
3-Methylbutanoic acid	1	5
Hexanoic acid	1	8
Monohydric Phenols		
Phenol	1,250	3.2
2-Methylphenol	340	0.2
3-Methylphenol	360	0.2
4-Methylphenol	290	0.2
2,4-Dimethylphenol	120	c
3,5-Dimethylphenol	50	c
Aromatic Amines		
Pyridine	117	0.42
2-Methylpyridine	70	0.05
3-Methylpyridine	26	0.05
4-Methylpyridine	6	0.05
2,4-Dimethylpyridine	1	c
2,5-Dimethylpyridine	1	c
2,6-Dimethylpyridine	1	c
Aniline	1	c

a. Not determined.

b. Data obtained from single samples. Raw wastewater samples were less than 6 months old, and treated wastewater samples were less than 1 month old.

c. Not found.

Source: Singer, P.C.; Pfaender, F.K.; Chinchilli, J.; Maciorawski, A.F.; Lanb, J.C., III; Goochman, R. 1978. Assessment of coal conversion wastewaters: Characterization and preliminary biotreatability. EPA-600/7-78-181, University of North Carolina. Prepared for Office of Energy, Minerals, and Industry, U.S. Environmental Protective Agency.

TABLE B-6

CHARACTERISTICS OF WASTEWATER FROM THE LURGI SLAGGING PROCESS PLANT USING BITUMINOUS COAL AT WESTFIELD, SCOTLAND

Component	Concentrations at Sample Location[a], mg/l[b] 1	2	3
pH[b]	6.6	9.1	9.2
Alkalinity	188	12,550	4,279
Chemical Oxygen Demand	14	1,140	1,220
Total Suspended Solids	55	108	70
Total Dissolved Solids	400	2,618	6,468
N, nitrate	29.9	1,100	1,326
N, ammonia	1,075	71,400	1,400
Sulfate	52	81	38
Cl	21	58	78
F	10	28.2	100
Cd	0.01	0.01	0.01
Mn	0.03	0.09	0.1
Pb	0.1	0.3	0.01
Cr	0.03	0.3	0.01
Ca	27	1.9	5.35
Mg	7.25	1.15	3
Cu	0.1	0.02	0.02
Ni	0.06	0.3	0.1
K	6.25	10	26.5
Ag	0.03	0.03	0.03
Zn	7.7	0.01	0.21
Na	88	7.1	25
Ti	20	1,600	870
Al	1	1	1
Fe	4.17	231	149
Hg		0.76	0.0002
Be		0.007	0.007
As		0.52	1.3
Sb		0.15	0.23
Se		0.087	2.9
Tl		0.007	0.007
Cn		17	0.38
Phenols		2,000	2,400
Flourene		0.01	1.3
Acenaphthene		0.01	1.4
Naphthalene		2.0	1.6
Phenanthrene		0.78	1.0
Ethyl hexyl phthalate		0.014	0.23
Pyrene		0.02	0.01
Flouranthene		0.06	0.01
Benzene		92.0	1.9
Toluene		5.8	1.8
Ethyl benzene		1.1	0.01
1,1,1-trichloroethane		0.16	2.5
Chloroform		0.70	0.01
Bromodichloromethane		0.14	0.01
Phenol		103.0	193
2,4-dimethylphenol		0.01	1.2
Polychlorinated biphenyls		0.30	0.75
Pesticide		0.75	0.30

a. (1) slag quench water; (2) oil separater water effluent; (3) tar separater water effluent

b. All measurements in milligrams/liter (mg/l) except pH

Source: Heunisch, G.W., and Gordon J. Leaman, Jr., "Phase I: The Pipeline Gas Demonstration Plant. Analysis of Coal, By-Products and Wastewaters from the Technical Support Program", DOE, FE-2542-23, August 1979.

from coal and sulfur storage piles, cooling tower blowdown, metal cleaning wastes, boiler blowdown, and various low volume wastes.

Coal pile runoff is commonly acidic and contains high concentrations of suspended and dissolved solids, sulfate, iron, aluminum, beryllium, copper, mercury, nickel, selenium, and zinc. Coal pile runoff at either site could be combined with the gasifier blowdown stream for neutralization and reduction, to some degree, of certain metals. The combined flow could then be treated in subsequent downstream wastewater treatment processes or the coal pile drainage could be treated separately and discharged or reused.

If byproduct sulfur were stored on site in dry form, the area around the storage pile would be diked and runoff collected and treated prior to discharge or reuse. The pollutants of concern are total suspended solids, chemical oxygen demand (COD), and oil and grease.

During chemical cleaning of system components, both acidic and alkaline solutions are utilized and waste liquors contain metals, nutrients, and organics. Constituents of particular concern are COD, Total Organic Carbon (TOC), phenols, nitrogen, phosphorus, arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, silver, and zinc. These cleaning wastes would be routed to the appropriate onsite wastewater treatment facilities.

The chemical characteristics of cooling tower blowdown discharge would consist primarily of the constituents found in the makeup water, which have been concentrated by virtue of the evaporative losses within the condenser cooling system. In addition, chlorination or other techniques may be used as a biocide, and corrosion inhibitors may need to be added to the cooling water. Chlorinated blowdown water discharged from the plant may require dechlorination due to recent concerns for the health risk and ecosystem effects associated with the use of chlorine. Any chlorinated discharge would comply with National Pollutant Discharge Elimination System (NPDES) permit effluent limitations for the facility. It may also be possible to treat this blowdown for reuse within the facility. Any other biocides selected would be used in accordance with the requirements of the Federal Insecticide, Fungicide, and Rodenticide Act and discharged according to NPDES permit limitations. The chemical characteristics and concentrations in condenser cooling water discharge are affected by the concentration factor at which the system is to be operated, the use of biocides and the use of corrosion inhibitors.

During construction at either of the 2 sites, it has been estimated that the onsite construction force will range from approximately 500 to 3,600 employees with a resultant domestic wastewater onsite flowrate of from approximately 8,000 to 90,000 gal/day. Two alternatives exist for handling the construction force domestic wastewaters. One option is to install and operate over the entire construction schedule a wastewater treatment facility devoted entirely to this waste stream. The second option is to install and operate a wastewater treatment facility to handle the anticipated flow between 1981 and 1985, after which the excess portion of future, domestic wastewaters could be routed to the gasification wastewater treatment facility. If the latter alternative were selected, the gasification wastewater treatment facility would be designed to accept the domestic wastewater stream.

Construction runoff is another miscellaneous waste stream that must be handled. The means by which this waste stream will be controlled and monitored is described in Chapter 4 of the text. Pollutant parameters of concern include total suspended solids, oil and grease, and pH.

1.2 Solid Waste

The waste coal ash from the gasifier is similar in nature to that from a coal-fired utility boiler (see Table B-7). The ash or slag is comprised of a number of elements; but silicon, iron, and aluminum comprise as much as 90% or more of the total ash. The ash would contain a number of trace elements, some of which are potentially toxic to plants and animals at certain levels. These trace elements have been discussed in the previous section.

A characteristic of the gasifier ash that was of concern was its potential for leaching. Recent regulations promulgated pursuant to the Resource Conservation and Recovery Act (RCRA) are aimed at protecting ground water from contamination. Leaching of trace metals from coal ash was viewed as presenting potentially adverse impacts on ground water. The Environmental Protection Agency established a toxic extraction procedure (EP) which is designed to determine if a waste is toxic as defined by RCRA. If the waste were to meet the criteria after being subjected to the test procedure, it would be considered "hazardous" and would be subjected to more stringent disposal requirements than if it had not met the criteria. A solid waste is considered "hazardous" if the extract from a sample of the waste contains any of a specified list of contaminants at a concentration equal to or greater than a specified concentration. Table B-8 lists the EPA EP toxicity criteria pollutants and their respective limits as well as the results of leaching tests done on TVA coal-fired power plant ash and slag.

As can be seen from this table, TVA has performed a number of tests on the leaching characteristics of slag and fly ash from its power plants using the EP. All of the leachate trace element concentrations of concern were substantially below the EPA limits. It was found that when ash or slag was subjected to the EP, fly ash was more susceptible to leaching. With few exceptions, higher amounts of fly ash constituents were "leached" from the fly ash than from slag. It is thought that slag is more resistant to leaching due to its vitreous physical qualities and larger particle size. The finer fly ash particles may not have

TABLE B-7
CHEMICAL COMPOSITIONS OF WASTES AND COAL

Element	Gasifier Slag: Lurgi Dry Ash*	Gasifier Slag: Texaco**	Coal: Illinois No. 6*	Fly Ash***
	PERCENTAGE			
Aluminum	20.5	19.1	1.20	25.1
Calcium	2.3	3.9	0.93	2.1
Carbon	--	7.39	71.47	--
Hydrogen	--	0.45	4.83	--
Iron	20.5	13.7	1.50	12.4
Magnesium	0.6	0.88	0.04	1.2
Nitrogen	--	0.08	1.35	--
Silicon	49.3	12.2	2.45	52.4
Sulfur	1.5	0.70	3.13	1.0
Titanium	1.0	0.56	0.06	1.1
	MICROGRAMS PER GRAM			
Arsenic	26	5	1.0	--
Boron	380	250	132	--
Barium	1900	160	--	--
Cadmium	2.4	0.8	.4	9
Chromium	440	600	20	170
Lead	40	21	10	105
Mercury	.03	3	1.1	--
Manganese	790	670	20	70
Nickel	200	100	14	115
Zinc	32	175	43	920

*Ghassemi, M., et al. Environmental Assessment Report: Lurgi Coal Gasification Systems for SNG, EPA-600/7-79-120, May 1979.
**Personal Communication, S. Dirk Van Hoesen, Oak Ridge National Laboratory to Bill Yee, TVA. This chemical composition may or may not be typical of the Texaco process waste ash because the samples analyzed were taken during unknown operating conditions at the Texaco pilot plant.
***TVA Data

TABLE B-8: TVA Coal Ash and Scrubber Sludge Performance Under the EPA "Extraction Procedure"*

	Concentration of Metals in Extraction Liquor, mg/l							
Boiler Unit	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
A - Bottom Ash	<0.004	0.26	<0.003	<0.005	<0.010	<0.0002	0.001	<0.01
- Fly Ash	0.026	0.45	0.23	<0.005	0.086	<0.0002	0.006	<0.01
B - Bottom Ash	0.010	0.25	<0.003	<0.005	<0.010	<0.0002	<0.001	<0.01
- Fly Ash	0.060	0.20	0.014	<0.005	<0.010	0.0004	0.006	<0.01
C - Bottom Ash	<0.004	0.24	<0.003	<0.005	<0.010	0.0003	<0.001	<0.01
- Fly Ash	0.016	0.32	0.096	<0.005	<0.010	0.0003	0.002	<0.01
D - Bottom Ash	<0.004	0.19	<0.003	<0.005	<0.010	<0.0002	<0.001	<0.01
- Fly Ash	0.13	0.70	0.010	0.11	<0.010	<0.0002	0.078	<0.01
E - Bottom Ash	0.018	0.22	<0.003	<0.005	<0.010	<0.0002	<0.001	<0.01
- Fly Ash	0.17	0.50	0.19	<0.005	<0.010	<0.0002	0.015	<0.01
F - Bottom Ash	0.005	0.39	<0.003	<0.005	<0.010	<0.0002	<0.001	<0.01
- Fly Ash	0.018	0.18	0.010	<0.005	<0.010	<0.0002	0.015	<0.01
G - Bottom Ash	<0.004	<0.10	<0.003	<0.005	<0.010	<0.0002	<0.002	<0.01
- Fly Ash	0.12	0.71	0.007	0.027	<0.010	<0.0002	0.080	<0.01
H - Bottom Ash	<0.004	<0.10	<0.003	<0.005	<0.010	<0.0002	<0.001	<0.01
- Fly Ash	1.65	0.25	0.028	<0.005	0.012	<0.0002	0.002	<0.01
I - Bottom Ash	<0.004	0.18	<0.003	<0.005	<0.010	<0.0002	<0.001	<0.01
- Fly Ash	0.027	0.22	0.009	<0.005	0.040	<0.0002	0.025	<0.01
J - Bottom Ash	<0.004	0.30	<0.003	<0.005	<0.010	<0.0002	<0.001	<0.01
- Fly Ash	0.010	0.40	0.011	0.32	<0.010	<0.0002	0.030	0.02
K - Bottom Ash	<0.004	<0.10	<0.003	<0.005	<0.010	0.0002	<0.001	<0.01
- Fly Ash	0.42	0.18	0.003	<0.005	<0.010	<0.0002	0.011	<0.01
L - Bottom Ash	0.010	0.24	<0.003	<0.005	<0.010	<0.0002	<0.001	<0.01
- Fly Ash	0.034	0.51	0.053	0.15	<0.010	<0.0002	0.060	0.01
M - Bottom Ash	0.026	<0.10	<0.003	<0.005	<0.010	<0.0002	<0.001	<0.01
- Fly Ash	0.099	0.60	0.009	0.078	<0.010	<0.0002	0.100	<0.01
N - Bottom Ash	<0.004	0.50	0.003	<0.005	0.015	<0.0002	<0.002	<0.01
Scrubber Sludge	0.016	1.0	0.005	<0.005	0.011	<0.0002	0.020	0.03
EPA Criteria*	5.0	100.0	1.0	5.0	5.0	0.2	1.0	5.0

*Published final May 19, 1980 in Federal Register, 40 CFR Part 261, "Identification and Listing of Hazardous Wastes," p.33119.

passed through a molten phase (as slag has) and the finer particles provide a larger surface area for contact with water and possible leaching.

Recent studies have provided limited information on the leachability of ash or slag from different gasifiers using various coals (see Table B-9). One study reported the maximum values obtained with slag from Combustion Engineering, Texaco, and BGC/Lurgi Slagging gasifiers using various coals.[2] Another study examined slag from the Lurgi Slagging gasifier using Pittsburg No. 8 coal.[3] A third study examined various gasifiers, coals, and ash particle sizes, including the Lurgi dry-ash gasifier with Illinois No. 6 coal (one of the design coals) and ash particle sizes ranging from <100 mesh to 3/8 in.[4] In all of these studies, the ash or slag was tested using the EPA EP technique. Since the leachate concentrations for EPA EP toxicity criteria pollutants were below the limits, the solid wastes were not considered hazardous. Although the data were limited and the variations in the coal used and the detection limits for measuring pollutant concentrations sometimes prevented comparison, the metal concentrations observed in leachate from gasifier slag or ash generally fell within the ranges of values reported for boiler slag. However, higher concentrations were sometimes found for mercury, cadmium, and selenium.

Due to the limited information on gasifier ash and slag, from the perspective of protecting ground water, a gasifier producing a vitreous slag-like material similar in nature to power plant bottom ash would be more desirable than a gasifier producing a solid waste similar to power plant fly ash. It appears, however, that neither slag nor ash would present a serious threat to ground water contamination if properly handled and disposed.

1.3 Estimated Emissions to the Air

Gaseous and particulate matter (PM) emissions to the air from plant operations were estimated from conceptual design information and/or conservative assumptions. The emissions, their sources, and their levels are discussed below as well as in Sections 4.1.2.1 and 4.2.2.1 of Volume 1 and Section 4.2.1 of Volume 2, in which potential air quality impacts were also discussed.

The estimated levels of emissions to the air were based on worst-case assumptions to envelope effects on the environment. It was assumed that the facility would consist of 4 modules gasifying 20,000 TPD of coal, although the proposal is to construct and operate a 2-module facility initially, with the capability of expanding to 4 modules at a later date if technically and economically feasible. The emission levels of the initial 2-module facility would be expected to be approximately one-half of those estimated below. Emission levels were also determined, assuming that coal washing would not occur, although coal washing near the mine locations is being considered.

TABLE B-9

LEACHING OF GASIFIER WASTE
USING THE EPA "EXTRACTION PROCEDURE"

Element	EPA Criteria[a]	Max Values of 3 different Gasifiers[b] (various coals)	Slagging Lurgi[c] Pittsburg (No. 8 Coal)	(Illinois No. 6 Coal)[d] 3/8 in-20 mesh	20-100 mesh	<100 mesh
	Concentration in extraction liquor, mg/l					
Arsenic	5	<0.2	0.00027	0.004	<0.001	<0.001
Barium	100		<0.2	<0.2	<0.2	<0.2
Cadmium	1	<0.01	0.000054	0.013	0.0051	0.0043
Chromium	5	<0.02	0.0016	0.003	0.003	<0.002
Lead	5	<0.14	<0.0003	0.0013	0.0013	0.0016
Mercury	0.2	<0.002	0.00064	<0.0004	<0.0004	<0.0004
Selenium	1	<0.08	<0.005	0.003	<0.001	<0.001
Silver	5	<0.02	<0.0003	0.0009	0.0014	<0.0002

a. Source: Federal Register, 40 CFR Part 261, "Identification and Listing of Hazardous Wastes", p. 33119, May 19, 1980.

b. Represents maximum values for extracts obtained from slag produced in BGC/Lurgi Slagger, Texaco and Combustion Engineering Gasifiers (Source: Holt, N.A., et al, "Environmental Test Results from Coal Gasification Pilot Plants", presented at the EPA Fifth Symposium on Environmental Aspects of Fuel Conversion, September, 1980).

c. Source: Heunisch, G.W. and Gordon J. Leaman, Jr., "Phase I: The Pipeline Gas Demonstration Plant. Analysis of Coal, By-Products and Wastewaters from the Technical Support Program", DOE, FE-2542-23, August, 1979.

d. Represents values for extract obtained from unquenched ash (Source: Yu, K.Y., and G.M. Crawford, "Characterization of Coal Gasification Ash Leachate Using the RCRA Extraction Procedure", presented at the EPA Fifth Symposium on Environmental Aspects of Fuel Conversion, September, 1980).

The major sources of PM emissions during the operational phase would include coal transportation, handling, and preparation facilities. Since barge unloading would probably occur 5 days per week, on each of these days it would be necessary to unload about 28,000 TPD of coal to maintain adequate inventory levels for a 4-module facility. During the barge transport of 28,000 tons of coal, PM emissions (which would result mainly from wind losses) would be about 1.3 lb/mi.[5]

Estimated levels of PM emissions from coal handling and preparation are given in Table B-10. The emission levels for the K-T facilities were based on control efficiency and conceptual design information. Similar emission levels would be expected for the Texaco facilities, except for the deletion of PM emissions from the coal pulverizing (1.7 lb/hr) and drying (9.4 lb/hr) facilities that would be required by K-T facilities. The estimated PM emissions would total about 529 lb/day.

Additional potential sources of PM emissions would include the drift from cooling towers, and, to a lesser extent, the use of unpaved haul roads. Based on preliminary plant design information, the maximum drift rate would be estimated as about 82 lb/day.

The sources of gaseous emissions during normal plant operation would include acid gas removal units and tail gas cleanup systems, among other sources. Initial plant startup or emergency gasifier shutdown would require flaring of raw product gas which would also result in gaseous emissions to the air.

Gaseous emissions from the acid gas removal (AGR) units and the tail gas cleanup systems were evaluated using conceptual design information for a gasfication plant using either the K-T or the Texaco process. The emission points for both systems are shown in Figures 2-5 and 2-6 of Chapter 2 of the EIS text. Tables B-11 and B-12 summarize the expected composition of these emissions from an operational 4-module coal gasification plant.

This facility plans to utilize a Rectisol AGR system to remove H_2S and carbon dioxide (CO_2) from the product gas stream. Through selective absorption of H_2S and CO_2 from the product gas stream, followed by desorption, two gas streams (one consisting mainly of CO_2 and another rich in H_2S) are obtained. In the production of either methanol synthesis gas or synthetic natural gas, excess CO_2 would be removed and vented to the atmosphere. The expected composition of the CO_2 waste gases is given under the "CO_2 vent" heading in each of Tables B-11 and B-12. It can be seen that the major components of these gas streams are CO_2, nitrogen, methanol (CH_3OH), and water (H_2O). Smaller amounts of H_2, CO, methane (CH_4), and H_2S/COS are emitted from one or both of the CO_2 vents.

TABLE B-10

ESTIMATED AMOUNTS OF SUSPENDED PARTICULATE MATTER (PM) DURING OPERATION OF PROPOSED COAL GASIFICATION PLANT

Air Pollution Source	Primary Control Efficiency(%)	Secondary Control Efficiency(%)	Estimated Controlled Emissions(lb/hr)
Barge unloading[a]	80	99	1.6
Shoreside transfer house[a]	80	99	0.16
Silo feed[a]	-	99	4.8
Silo discharge[a]	-	99	1.0
Crusher building[a]	80	99	0.8
Transfer feed conveyor discharge	80	99	0.07
Stacker load-in/out of live silos	-	99	2.04
Transfer from reclaim conveyor to feed conveyor	80	99	0.07
Dead storage load-in/out[a]	80	99	0.2
Coal Pulverizing (K-T)	-	99	1.7
Ash/slag disposal silo	-	99	0.22
Product gas-fired coal dryer (K-T)	40	99.9	9.4

a. This rate applicable to 5 day/week, 16 hr/day operations.

TABLE B-11

ESTIMATED GASEOUS EMISSIONS
FROM TVA'S PROPOSED COAL GASIFICATION PLANT
KOPPERS-TOTZEK PROCESS

	Estimated Gaseous Emissions for all 4 Modules (lb/hr unless otherwise noted)		
Constituent	Treated Tail Gas	CO_2 Vent-1	CO_2 Vent-2
H_2	-	28	4
CO	< 500 ppmv	683	34
CO_2	735,424	1,846,191	201,658
CH_4	-	26	384
N_2/Ar	465,000	98,134	-
H_2S / COS	< 10ppmv	< 10ppmv	-
SO_2	179	-	-
O_2	32,320	-	-
CH_3OH	-	1,250[a]	-
H_2O	120,585	-	1,150

[a] The use of a control device to recover methanol for reuse is being considered.

TABLE B-12

ESTIMATED GASEOUS EMISSIONS
FROM TVA'S PROPOSED COAL GASIFICATION PLANT
TEXACO PROCESS

	Estimated Gaseous Emissions for all 4 Modules (lb/hr unless otherwise noted)		
Constituent	Treated Tail Gas	CO_2 Vent-1	CO_2 Vent-2
H_2	-	48	4
CO	< 500ppmv	728	-
CO_2	825,700	2,098,092	192,548
CH_4	-	128	385
N_2/Ar	379,684	216,364	-
H_2S } COS	< 10ppmv	< 10ppmv	-
SO_2	128	-	-
O_2	13,324	-	-
CH_3OH	-	1,410[a]	-
H_2O	87,484	-	828

[a] The use of a control device to recover methanol for reuse is being considered.

The H_2S-rich gas stream, which also contains some COS, would be treated in sulfur removal units, consisting most likely of the Claus plant and the Beavon/Stretford tail gas treating unit. According to preliminary design information, about 99.8% of the sulfur would be removed from the waste gas stream, before the treated tail gas is released to the atmosphere. The major components of the treated tail gas (Tables B-11 and B-12) would be CO_2, nitrogen, H_2O, and oxygen (O_2). This gas stream would also be the major source of sulfur emissions from the facility. Sulfur would be emitted primarily as sulfur dioxide (SO_2), but trace amounts of H_2S/COS would be emitted as well.

Coal gasification potentially could result in the release of small amounts of other gaseous emissions. Trace amounts of polynuclear aromatic hydrocarbons (PAH) or polycyclic organic matter (POM), may be released to the atmosphere. In addition, insignificant levels of ozone (O_3), hydrocarbons, NH_3, HCN, and some non-H_2S sulfur compound emissions would be expected.

The quantities of gaseous emissions resulting from combustion of product gas or other low-sulfur fuels would depend on the final boiler design. The carbon monoxide (CO) emission rate, if it is assumed to be similar to that of a natural gas-fired boiler, would be about 340 lb/day. The estimated NO_x emission rate would be about 2 tons/day (TPD), assuming that the emission levels would be just capable of meeting the New Source Performance Standards for this type of fuel. Small additional quantities of SO_2 would also be emitted.

Normal operating conditions could result in emissions from other sources. The air separation plant would probably release between 2,200 and 2,700 tons/hr of nitrogen/argon, which are normal constituents of air, to the atmosphere. In addition, coal dust may release very small quantities of toxic/heavy metals to the atmosphere. Table B-13 summarizes the expected emissions levels of lead, beryllium and mercury as well as the EPA "de minimus" levels.[6] Estimated emission levels of some other trace elements found in coal dust are given in Table B-14.[6]

During initial plant startup, 2 gasifiers per module would need to be operational before the sulfur removal systems could be brought on line. To reduce the impacts of sulfur compound emissions from the 2 gasifiers, the intermittent release of raw product gas would be flared during brief periods (approximately 100 to 300 hr spread over several weeks or months). Flaring of raw product gas could also result in the event of an emergency gasifier shutdown, although the duration of such emergency flaring probably would be less than 30 minutes (often lasting less than 10 minutes).

Table B-15 summarizes the expected potential maximum emissions to the air from flaring during initial plant startup. The major emission would be SO_2, which would be estimated to have an

TABLE B-13

COMPARISON OF THE EXPECTED ANNUAL EMISSIONS OF THREE TOXIC TRACE ELEMENTS FOUND IN COAL DUST WITH THE MINIMUM SIGNIFICANCE LEVELS ESTABLISHED BY EPA

Metal	Typical composition of Illinois No. 6 coal (ppm)[a]	Expected Annual Emission[b]	"de minimis" emissions (tons/yr)
Lead	11	4.67 lb (.0023 ton)	0.6
Beryllium	1.0	0.42 lb (.0002 ton)	0.0004
Mercury	0.12	0.05 lb (.00003 ton)	0.1

a. Reference 6, Table 2.

b. Based on emission of 1162 lb/day of coal dust. However, more recent control plans indicate that emissions of 540 lb/day of PM or less are more likely.

TABLE B-14

EXPECTED ANNUAL EMISSIONS OF SOME TRACE ELEMENTS PRESENT IN COAL DUST

Trace Element	Typical Composition of Illinois No. 6 coal (ppm)[a]	Expected Annual Emission(lb)[b]
Arsenic	24	10.2
Selenium	13	5.5
Tellurium	8.1	3.4
Antimony	1.1	0.2
Cadmium	0.89	0.16

a. Reference 6, Table 2.

b. Based on emission of 1162 lb/day of coal dust. However, more recent control plans indicate that emissions of 540 lb/day of PM or less are more likely.

TABLE B-15

ESTIMATED POTENTIAL MAXIMUM EMISSIONS TO THE AIR FROM FLARING OF RAW PRODUCT GAS DURING INITIAL STARTUP PHASE OF THE PROPOSED COAL GASIFICATION PLANT[a]

Pollutant Emissions From Flares	Estimated Emissions (g/s)[b]	
	Koppers-Totzek	Texaco
Sulfur Dioxide	1214 (~116 TPD)	1116 (~106 TPD)
Particulate Matter	2 (~0.2 TPD)	2 (~0.2 TPD)
Nitrogen Oxides	c	c

a. Initial startup phase is assumed to include flaring of untreated raw product gas from two gasifiers for one week before tail gas cleanup system could be used.

b. Totals for 2 gasifiers. Half as much for 1 gasifier.

c. Not quantified. Not expected to be large enough quantity or long enough duration to have a significant impact.

emission rate of about 106 to 116 TPD, depending on the gasification process selected. Approximately 0.2 TPD of PM as well as insignificant levels of NO_x would also be released during flaring.

2. Wastewater Treatment

Table B-16 presents a summary of wastewater treatment technologies (including anticipated control effectiveness) that are under consideration for coal gasification processes. There are additional candidates for consideration, such as powdered activated carbon addition to activated sludge, ozonolysis for dissolved organics removal, biological nitrification-denitrification for nitrogen removal, and mixed media filtration for suspended solids removal. This table indicates control effectiveness in terms of percent removal of certain parameters; but these data are not predicated upon actual experience with coal gasification wastewater. In addition, there is little information on control effectiveness for the priority pollutants or the fate of these pollutants within the individual processes, i.e., whether these pollutants remain in the liquid effluent or in the sludges generated.

Because of the unknowns related to the wastewater characteristics mentioned in the previous section, the specific wastewater treatment processes cannot, at this time, be chosen with absolute certainty. The wastewater treatment processes discussed are considered to cover those most viable; however, their sequencing is not yet proven for treatment of gasifier wastewaters.

Preliminary estimations made by TVA on probable wastewater from its Ammonia From Coal Project (which uses a Texaco gasifier) indicate that the use of chemical precipitation, NH_3 stripping, and activated sludge processes may produce a treated gasifier and gas processing combined effluent with the following ranges of effluent characteristics: BOD_5 - 30 to 100 mg/l; COD - 60 to 1,000 mg/l; NH_3 - 9 to 300 mg/l; cyanide - 3 to 8 mg/l; phenols approximately 0.01 mg/l; and total suspended solids - 30 to 150 mg/l. Further treatment including ozonolysis, biological nitrification-denitrification, and mixed media filtration may further improve the effluent quality to the following: BOD_5 - 13 to 100 mg/l, COD - 18 to 200 mg/l, NH_3 - 1 to 3 mg/l, cyanide 1 to 3 mg/l, phenols - essentially zero, and total suspended solids - 10 to 15 mg/l. Some removal of toxic and hazardous pollutants by these treatment processes is expected, but the resultant effluent concentration is not yet known.

Some of the wastewater treatment processes presented in Table B-16 indicate a potential for producing various byproducts. Chemical precipitation and biological treatment processes produce sludges which require further processing for either ultimate disposal or reuse. An option under consideration is the combination and dewatering of sludges and transfer to the gasifier for combustion.

TABLE B-16

SUMMARY OF WATER POLLUTION CONTROL PROCESSES[7]

Treatment function	Suspended solids and oils removal			Dissolved organics removal			Dissolved inorganics removal	Residual contaminant removal			Ultimate disposal
	Flocculation Flotation	Oil-water separation	Filtration	Liquid-liquid extraction (Phenosolvan)	Activated carbon adsorption	Biological oxidation (activated sludge)	Acid gas stripping	Forced evaporation	Activated carbon adsorption	Cooling tower oxidation	Evaporation ponds
Development Status	Commercial	Commercial	Commercial	Commercial	Commercial	Commercial	Commercial	Commercial	Commercial	Commercial	Commercial
Coal Gas Applicability											
• Presently used	yes	yes	yes	yes	no	yes	yes	no	no	yes	no
• Potential future use	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Control Effectiveness											
• Suspended solids removal	~75%	~90%	52–83%		~90%	70%			~90%		
• Free oil removal	~97%	~90%	52–83%		~93%	80%			~93%		
• Phenol removal		~25%		>94%	99+%	95–99%	20–40%	~99+%			
• Total organics removal				~90%	~90–95%	~90–95%	~90–95%		~90–95%	~90–95%	
• BOD removal	~80%		36%			~90%				90%	
• Sulfide removal						~97%	~99%				
• NH_3 removal						15%	~90%				
• Cyanate removal					~1%	~70%			1%		
• COD removal	80%	~50 ppm ≤	25–44%		~90%	~99.9%			~90%	~99.9%	
• Trace element removal	✓					✓		✓			
• Total dissolved solids removal								99%			
Utility Requirements											
• Steam				✓							
• Electricity	✓	✓	✓	✓	✓		✓	✓	✓	✓	
• Cooling/backwash H_2O			✓	✓	✓	✓	✓	✓	✓	✓	
• Fuel gas					✓	✓			✓		

(continued)

TABLE B-16

SUMMARY OF WATER POLLUTION CONTROL PROCESSES[7] (continued)

Treatment function	Suspended solids and oils removal			Dissolved organics removal			Dissolved inorganics removal	Residual contaminant removal			Ultimate disposal
	Flocculation Flotation	Oil-water separation	Filtration	Liquid-liquid extraction (Phenosolvan)	Activated carbon adsorption	Biological oxidation (activated sludge)	Acid gas stripping	Forced evaporation	Activated carbon adsorption	Cooling tower oxidation	Evaporation ponds
Raw Materials Required											
• Solvent				✓							
• Chemical additives	✓					✓				✓	
Allows By-Product to be Recovered	✓	✓	✓	✓			✓				
Generates Effluents Requiring Further Control											
• Gaseous					✓		✓	✓	✓		
• Aqueous	✓			✓	✓				✓		
• Treated effluent	✓	✓		✓			✓				
• Solid/semisolid	✓	✓				✓		✓		✓	
Process Limitation/ Sensitivity											
• Temperature change						✓				✓	
• pH level					✓	✓			✓	✓	
• Contaminant size distribution	✓	✓									
• Requires regeneration			✓	✓	✓				✓		
• Adversely affected by trace elements						✓				✓	
• Nutrients required						✓				✓	
• Chemical additives required	✓					✓			✓	✓	
• Hydraulic loading	✓					✓				✓	

✓ - Although it cannot be quantified, it is a factor to be considered for the processes.

Regeneration by combustion of activated carbon used in any wastewater treatment system may produce undesirable air emissions of trace elements or organics removed from the wastewater. Disposal of spent activated carbon in the slag disposal area may be the most viable option.

The volume and characteristics of sludge or solid byproducts produced in wastewater treatment are not well defined. However, handling and disposal practices will be chosen that will minimize any potential adverse environmental impacts.

2.1 Conceptual Wastewater Treatment Studies

TVA conducted conceptual wastewater treatment/discharge studies for the proposed gasification plant to determine relative differences in cost and specifically to evaluate a zero-discharge option. The studies evaluated 3 conceptually different wastewater treatment schemes for each of the gasification technologies under consideration by TVA, each of which would be environmentally acceptable. Conceptual wastewater treatment system designs by 3 architectural/engineering firms formed the bases for these treatment schemes. Descriptions of the assumed schemes are given below.

For each technology, Option I assumed zero discharge of the majority of the liquid waste streams. Since no cooling tower blowdown would be discharged in this case, the cooling towers were assumed to be operated at very high cycles of concentration (20 - 25). The large concentration factor would require acid injection for proper operation of the towers, and would result in a relatively small blowdown flow which would require treatment. All cooling tower makeup was assumed to be filtered. It was assumed that the cooling tower blowdown would be treated via lime softening which would preferentially remove the scaling constituents (Ca, Mg) from the blowdown stream. Most of the effluent from the lime softener would be returned to the cooling tower makeup; the remainder was assumed to be treated with a vapor compression distillation (VCD) unit. The VCD unit is essentially a thin-film evaporator that condenses the water from the influent stream at elevated temperatures, thus producing a concentrated waste brine (slurry) and a clean condensate stream. The VCD unit was chosen for this study because it offers high reliability, energy efficiency, and water recovery. The waste brine would be further dried, perhaps by use of a spray dryer, before disposal.

The water used for cooling the product gas formed by either gasifier becomes contaminated and must be treated prior to recycling. In the Texaco gasification system, the wastewater is contaminated with small amounts of H_2S, NH_3, hydrogen cyanide (HCN), thiocyanates, sulfites, and chlorides. The wastewater would be stripped of acid components and NH_3 prior to being treated in the biological treatment package. For the K-T process, the wastewater contains many similar impurities (NH_3, cyanides, thiocyanates) as well as suspended solids. The gasifier wastewater would be pretreated via clarifiers to remove the solids prior to flowing through the stripping tower and biological treatment system.

In Case I, it was assumed that sanitary waste, gasifier wastewater stripping waste, and runoff from the coal piles and slag disposal areas would be treated in a biological treatment package. The treatment was assumed to consist of primary sedimentation (sanitary waste flows only) followed by biological nitrification/denitrification, filtration, and disinfection. After such treatment, the effluent was suitable for reuse within the plant. For the purposes of this study, it was assumed that the effluent from the biological treatment package is reused as cooling tower makeup.

Liquid wastes such as building drainage, demineralizer regenerant solutions, and other service water flows (EPA low-volume wastes) were treated by clarification and returned to the cooling tower makeup.

For Case II, cooling tower blowdown, slag disposal area runoff, and coal pile runoff would be treated and discharged. The slag disposal area runoff and coal pile runoff would be combined prior to discharge, as they tend to neutralize each other. For Case II, it was assumed that raw water (not filtered) was used as cooling tower makeup. The cooling towers were assumed to be operated at lower cycles of concentration than in Case I to avoid discharge of concentrated levels of trace elements occurring in the river.

Case II assumed zero discharge of battery wastes (those wastes generated within the chemical plant portion of the gasification facility). It was assumed that gasifier wastewater was stripped and biologically treated and the low-volume wastes treated in a similar manner to Case I. After treatment, the 2 waste streams were treated in a reverse osmosis (RO) unit and VCD unit in series. The RO/VCD treatment train effectively removed dissolved solids present in the waste stream. The VCD unit was necessary because the RO unit cannot produce a slurry concentrated enough for satisfactory operation of the spray dryer. More than one VCD unit could effectively treat the waste stream (deleting the need for an RO unit), but would be significantly more expensive than the RO/VCD treatment train.

Case III assumed treatment and discharge of all waste streams. Cooling tower makeup would not be filtered. The gasifier wastewater stream was assumed to undergo the same level of treatment in Case III as in the other 2 (non-discharge) cases described above.

TVA has preliminarily estimated the capital costs, engineering costs, and operational and maintenance (O&M) costs for each of the schemes discussed above. The results of that cost estimate (± 30%) are given in Table B-17. The O&M costs have been capitalized over the proposed 20-yr life of the plant and include such items as electric power consumption, fuel costs for the spray dryers (the dryers are assumed to be fueled by product gas), chemical costs, spare parts, equipment maintenance, sludge disposal, and manpower requirements. For the purposes of the estimate, sludges generated from treatment of battery wastes were

TABLE B-17

TVA PRELIMINARY COST ESTIMATES[1]
FOR WASTEWATER TREATMENT
CONCEPTUAL DESIGNS

	Texaco-I	KT-I	Texaco-II	KT-II	Texaco-III	KT-III
Total Field Construction	$34.0	26.5	30.0	22.5	18.5	12.5
Engineering/ Overhead	5.7	5.2	5.5	5.0	4.7	4.2
Subtotal	39.7	31.7	35.5	27.5	23.2	16.7
O&M Capitalized Costs	59.9	36.9	64.2	29.8	20.2	10.0
Total	99.6	68.6	99.7	57.3	43.4	26.7

1. Costs are given in millions of 1982 dollars, and do not include interest during construction on the subtotal. Costs given are for 2 modules. Initially 2 modules would be build with the capability of expanding to 4 modules at a later date.

assumed to be hazardous under RCRA, and disposal costs were generated on that basis. All other sludges were assumed to be non-hazardous under RCRA.

Due to the large costs incurred by restricting liquid discharges and the unknown deleterious effects that water recycle may have on the product gas quality and overall process operation, TVA is recommending incorporation of Case III treatment schemes for either gasification process. It is believed that the level of treatment given in Case III provides the appropriate environmental safeguards to the water quality of Guntersville Lake.

2.2 Wastewater Treatment Conceptual Design

A possible scheme for treating wastewater from the proposed coal gasification plant has been developed, but it would not be finalized until ongoing wastewater characterization and treatability studies are completed. This information, therefore, is being presented for information purposes only and is not intended to represent the final wastewater treatment system. It is intended rather to indicate the present direction regarding wastewater treatment strategies.

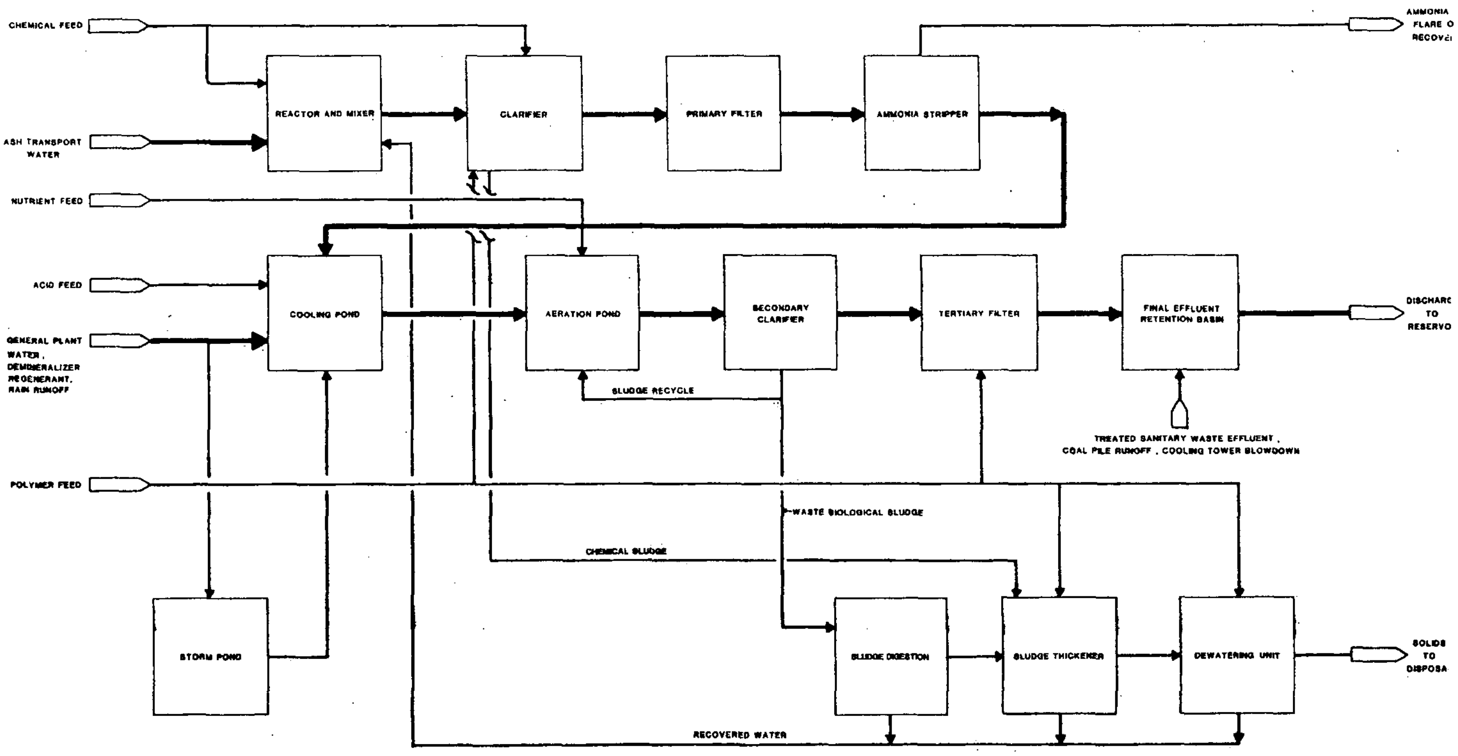
TVA is committed to working closely with EPA to determine the best available control technology needed to treat plant wastewaters. TVA would coordinate the results of waste treatability and other environmental studies with the State and EPA as the final wastewater treatment plan evolves. TVA expects the results of these studies to confirm our preliminary determinations regarding wastewater treatment strategies.

The preliminary conceptual wastewater treatment system consists of 4 treatment stages - primary, secondary, tertiary, and sludge handling. The overall wastewater treatment systems for K-T and Texaco gasification technology are shown in Figures B-1 and B-2, respectively. The gasifier waste characteristics shown in Tables B-18 and B-19 were assumed when developing the preliminary conceptual design.

In both systems, primary treatment would consist of chemical treatment, filtration, and stripping. Chemical treatment may consist of ferrous sulfate and lime additions for converting soluble contaminants to an insoluble form. Other chemicals, such as alum and polymers, will be investigated before a decision is made on the method of chemical treatment. This addition followed by sedimentation and filtration would remove suspended solids, cyanide, sulfide, and heavy metals. Following chemical treatment, wastewater would be steam stripped for NH_3 removal. The NH_3 gas would be either incinerated or recovered.

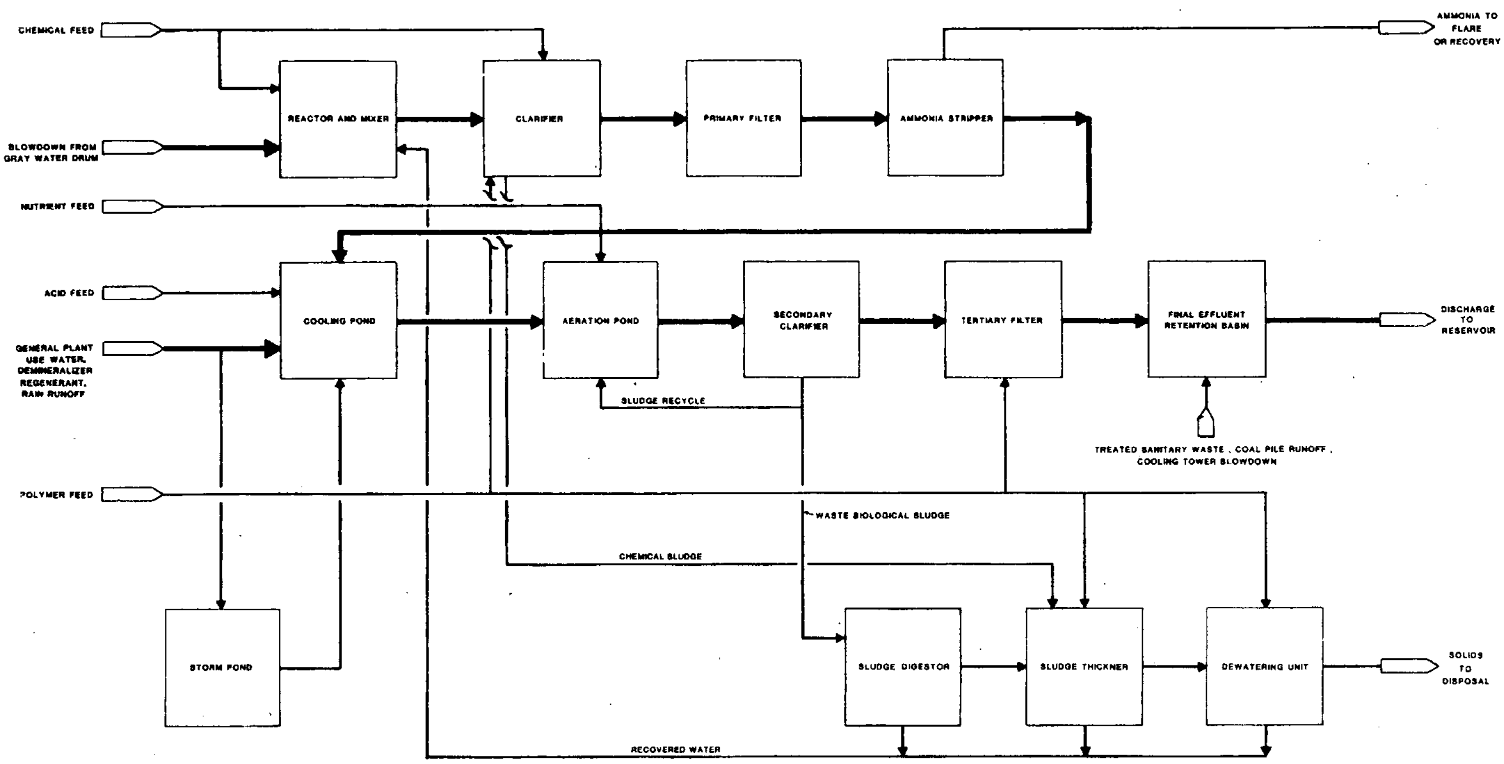
Secondary treatment of the NH_3 stripped wastewater may consist of a biological oxidation process where biodegradable organics are removed. There is some question as to the need for

FIGURE B-1. CONCEPTUAL WASTEWATER TREATMENT SYSTEM FOR TVA'S PROPOSED COAL GASIFICATION PLANT USING KOPPERS-TOTZEK GASIFICATION TECHNOLOGY.*



* SUBJECT TO VERIFICATION WITH WASTEWATER TREATABILITY STUDIES.

FIGURE B-2. CONCEPTUAL WASTEWATER TREATMENT SYSTEM FOR TVA'S PROPOSED COAL GASIFICATION PLANT USING TEXACO GASIFICATION TECHNOLOGY.*



* SUBJECT TO VERIFICATION WITH WASTEWATER TREATABILITY STUDIES

TABLE B-18

ASSUMED KOPPERS-TOTZEK GASIFIER WASTEWATER CHARACTERISTICS FOR DEVELOPING CONCEPTUAL WASTEWATER TREATMENT SYSTEM[1]

	Waste Stream, mg/l unless otherwise noted	
CONSTITUENT	WASHER-COOLER WASTEWATER	SLAG QUENCH WASTEWATER
pH (units)	8.9	8.8
TSS	5084	3072
TDS	1560	150
COD	420	60
TOC	40	8
TIC	(na)[2]	(na)[2]
NH_3	1500	15
CN^3	25	1
SCN	68	2
S	42	-
SO_3	170	-
SO_4	730	-
Cl	150	120
BOD_5	25	15
HCOOH	(na)[2]	(na)[2]

1. Assumed wastewater characteristics based on information available in literature (refer to Tables B-2 and B-3) and professional judgments.
2. Data not available.

TABLE B-19

ASSUMED TEXACO GASIFIER WASTEWATER CHARACTERISTICS FOR DEVELOPING CONCEPTUAL WASTEWATER TREATMENT SYSTEM[1]

	Waste Stream, mg/l unless otherwise noted	
CONSTITUENT	GASIFIER BLOWDOWN	SLAG QUENCH WASTEWATER
pH (units)	8.8 ± 0.2	8.9 ± 0.1
TSS	330	-
TDS	2000	1500
COD	-	-
TOC	760	-
TIC	104	-
NH_3	3200	460
CN	45	2
SCN	130	15
S	100	1
SO_3, SO_4 } TOTAL SULFUR	290	14
Cl	250	1500
BOD_5	350	250
HCOOH	350	-

1. Assumed wastewater characteristics based on information in literature (refer to Table B-4) and professional judgments.

biological treatment of K-T wastewaters. This will be investigated as part of TVA's treatability studies. Thiocyanates and traces of cyanides and sulfides that are not removed in the primary treatment may be oxidized during biological treatment. Any sludge would undergo digestion before final disposal.

A tertiary treatment step may be needed, such as filtration of secondary effluent, to ensure that even under upset conditions, a minimum amount of solids is discharged into the receiving body of water. Filtered effluent would be expected to have very small or negligible levels of NH_3, cyanides, organics, and suspended solids. Pending the results of wastewater treatability studies, TVA should be able to more accurately estimate the effluent characteristics from this facility. TVA has, however, estimated the effluent characteristics for its Ammonia from Coal Project which utilizes a Texaco gasifier and a wastewater treatment system very similar to the one described above. These estimates are given above under part 2., "Wastewater Treatment".

Sludge handling for the Texaco conceptual design, Figure B-2, would involve aerobic digestion of biological sludge produced in the secondary treatment. The digested sludge would then be combined with chemical sludge from the primary treatment and undergo a thickening operation. The thickened sludge would be further dewatered for ultimate disposal in an offsite landfill. Under the K-T conceptual design, Figure B-1, sludge handling involves digestion, thickening, and dewatering of combined primary and secondary sludge. At the present time, it is not clear to what extent the K-T wastewater would be biologically treated. Based on available information, the K-T wastewater treating system is not expected to produce biological solids in sufficient quantities to require a sludge digestion step. This is being investigated further in the treatability studies.

Treated effluent from the treatment plant would probably not be discharged directly to the lake but first would pass through a retention basin where other effluents such as cooling tower blowdown, treated coal pile runoff, slag pile runoff (treated, if necessary), and treated sanitary effluent would be combined. This final retention basin would provide hydraulic and quality equilization and reduce variability in the discharge. A continuous flow biomonitor would be installed at the end of the system to provide an early warning to plant operators if toxic wastewaters left the treatment area. Figures B-3 and B-4 are block flow diagrams showing the conceptual design for the plant water distribution system for K-T and Texaco gasification systems, respectively. These figures have been included to give an indication of the relationship between the wastewater treatment system and the overall plant water distribution system.

It must be emphasized that these treatment schemes are subject to verification with the results of wastewater characterization and treatability studies that are presently being conducted. Section 3.2 below provides information on the environmental studies presently being undertaken by TVA.

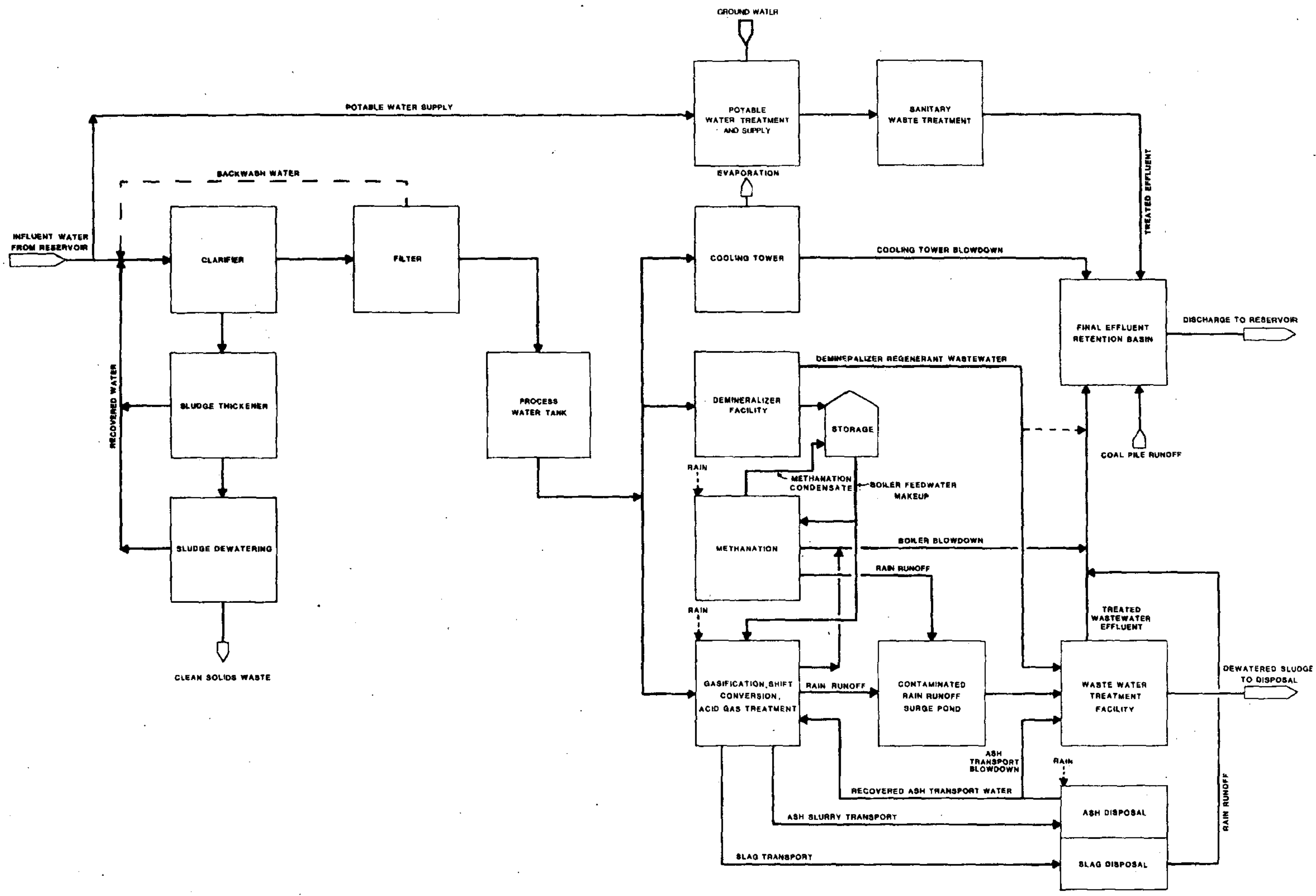


FIGURE B-3. CONCEPTUAL DESIGN FOR PLANT WATER DISTRIBUTION -KOPPERS-TOTZEK PROCESS

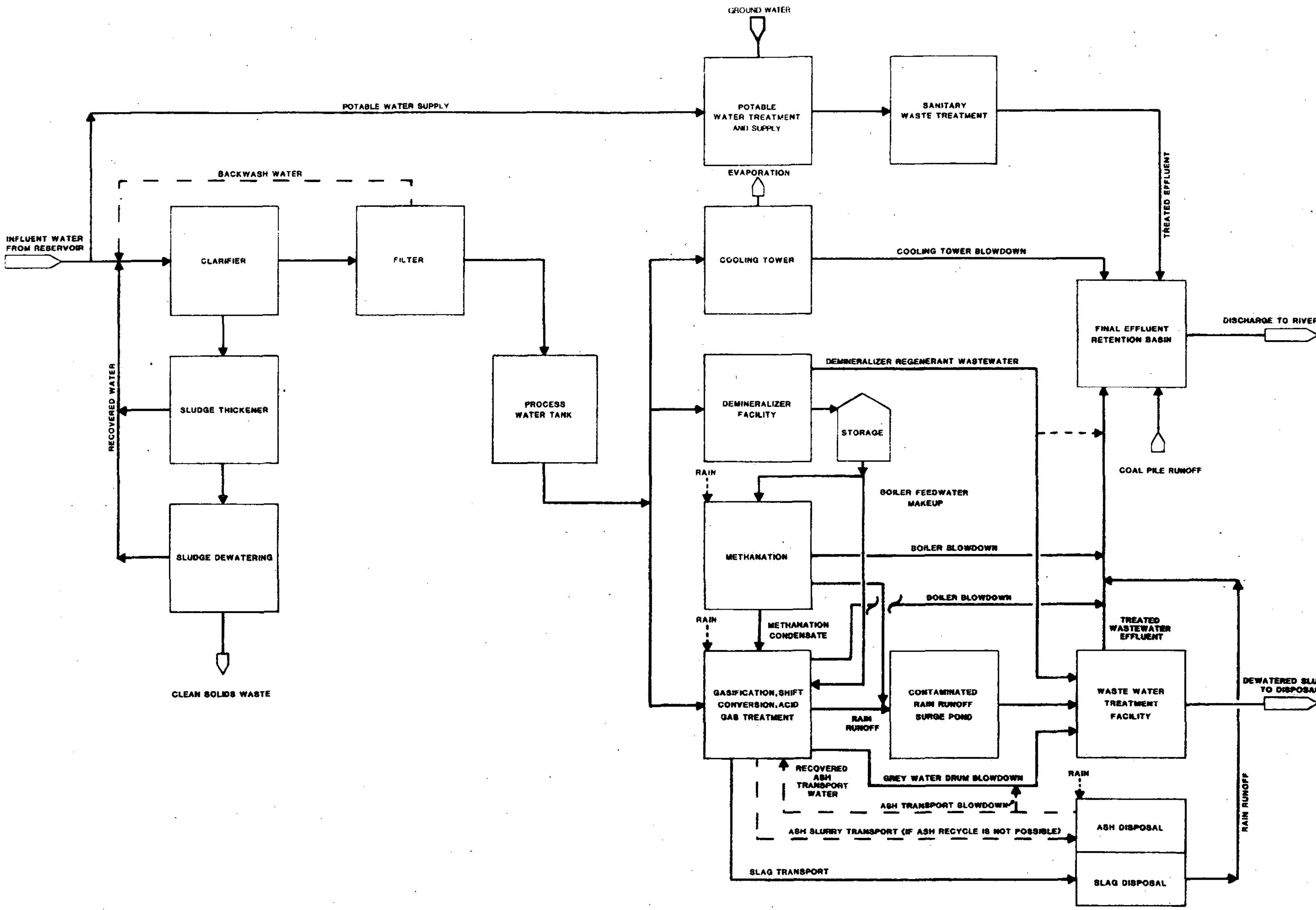


FIGURE B-4. CONCEPTUAL DESIGN FOR PLANT WATER DISTRIBUTION - TEXACO PROCESS

3. Environmental Assessment of Commercial-Scale Gasification Tests with TVA Coal

As part of its technical evaluation, TVA has contracted for the testing of the design coal at 2 gasification facilities in Europe at an approximate cost of $8 million. Tests were conducted at the Ruhrchemie Texaco gasification pilot plant in Oberhausen-Holten, West Germany, in November 1980. Coal tests were conducted during March and April 1981 at the Nitrogenous Fertilizers Industry (NFI) Plant in Ptolemais, Greece, which uses K-T technology. These tests should provide important data regarding operational conditions and characteristics when gasifying eastern U.S. coal. Specifically, this technical information would be used as input to the detailed design of the gasifier selected for the north Alabama facility and its associated subsystems. In addition to obtaining engineering data for process designs, TVA is collecting data on the characteristics and treatability of waste streams to aid in the design of pollution controls.

In each of these testing programs, data are being collected and studies undertaken to: (1) better define the expected characteristics of raw waste streams potentially generated in the proposed facility, (2) design appropriate pollution control unit operations and identify their configuration, and (3) further evaluate potential biological impacts of waste treatment/disposal alternatives to support environmental permitting activities.

Taken together, these 3 components of the environmental testing plan would provide additional information on the expected wastes characteristics and potential environmental impacts of wastes from the proposed north Alabama coal gasification facility The following material describes the studies that were conducted at the Texaco and the K-T facilities and studies which are continuing in the U.S.

3.1 Waste Characterization Studies (Physical-Chemical)

The primary purpose of these studies is to obtain engineering data for the design of a commercial-scale gasifier capable of using eastern high-sulfur coal. Process data and samples of material during the operation of the gasifier and associated units were obtained under a series of different operating conditions. For purposes of this test program, 1 gasifier, along with coal drying and preparation equipment, was dedicated to gasifying the design coal at the NFI facility, where sampling was performed in March 1981. Environmental samples were obtained at the Ruhrchemie Texaco gasification pilot plant in November 1980. Samples from both facilities are presently undergoing analysis. Liquid and solid waste samples were obtained and numerous tests are being performed on them including analyses for trace metals, trace organics, radioactivity, solids levels, NH_3, cyanide, H_2S, and biochemical oxygen demand to name a few. Information is also being obtained on the physical characteristics and leachates of solid wastes.

Results of these waste characterization studies would aid in identifying waste constituents that would require treatment and the kinds of treatment or handling that could be necessary to protect the environment.

3.2 Wastewater Treatability Studies

TVA and its contractor, C. F. Braun, have developed preliminary conceptual designs for a wastewater treatment system based on available information and professional judgements. However, before a wastewater treatment system design can be finalized, treatability studies must be conducted to confirm that the application of a given unit operation is appropriate and in the proper sequence for treating wastewater.

An important part, therefore, of TVA's environmental testing program is the wastewater treatability studies. K-T and Texaco gasification wastewaters would be subjected to benchscale simulations of wastewater treatment processes to determine their treatability. Removal of wastewater constituents such as solids, NH_3, biochemical oxygen demand (if applicable) and others, as appropriate, would be evaluated. The data produced would be used to confirm TVA's conceptual wastewater treatment systems and serve as a basis for design activities.

3.3 Environmental Assessment of Gasifier Wastes

The third aspect of TVA's present environmental assessment activities involves evaluating gasifier waste to define its potential for adversely affecting the environment. Toxicity screening tests are being conducted on gasifier wastewater, effluents from the treatability studies, and leachates from solid wastes to confirm if there are constituents present in treated and untreated wastewaters or leachates that are harmful to aquatic organisms or human health. Appropriate tests are being run to detect chronic and acute toxicity to fish and aquatic invertebrates, potential for bioaccumulation, and indications of mutagenicity or carcinogenicity. These continuing studies provide a check on the effectiveness or appropriateness of wastewater treatment operations in reducing or eliminating the toxic effects of wastewater.

References

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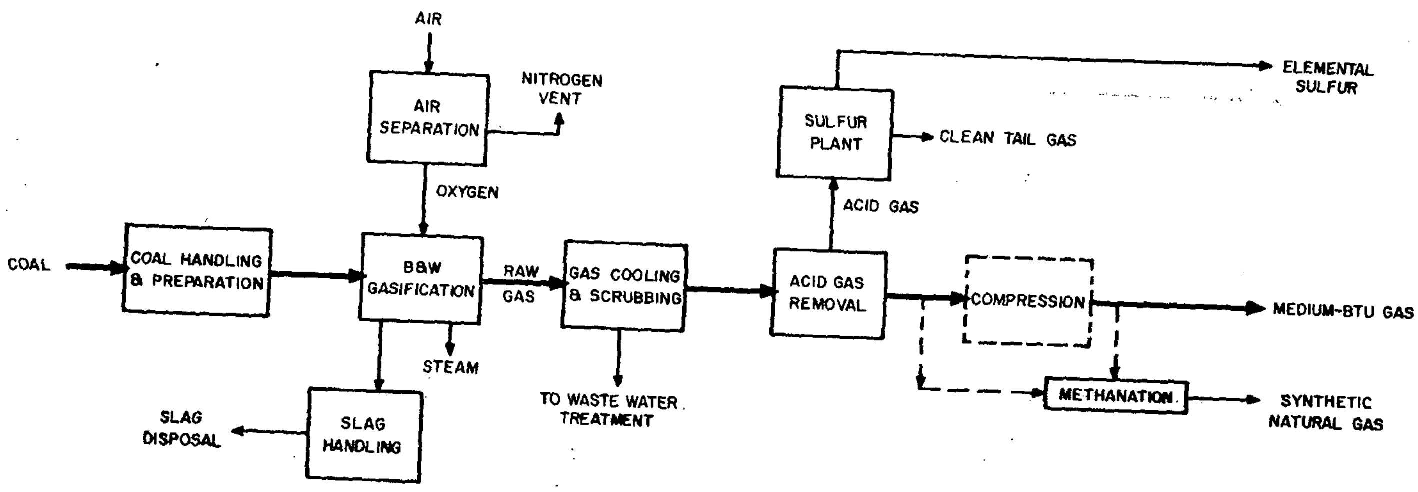

FIGURE B-5 PROCESS BLOCK FLOW DIAGRAM - B&W GASIFIER

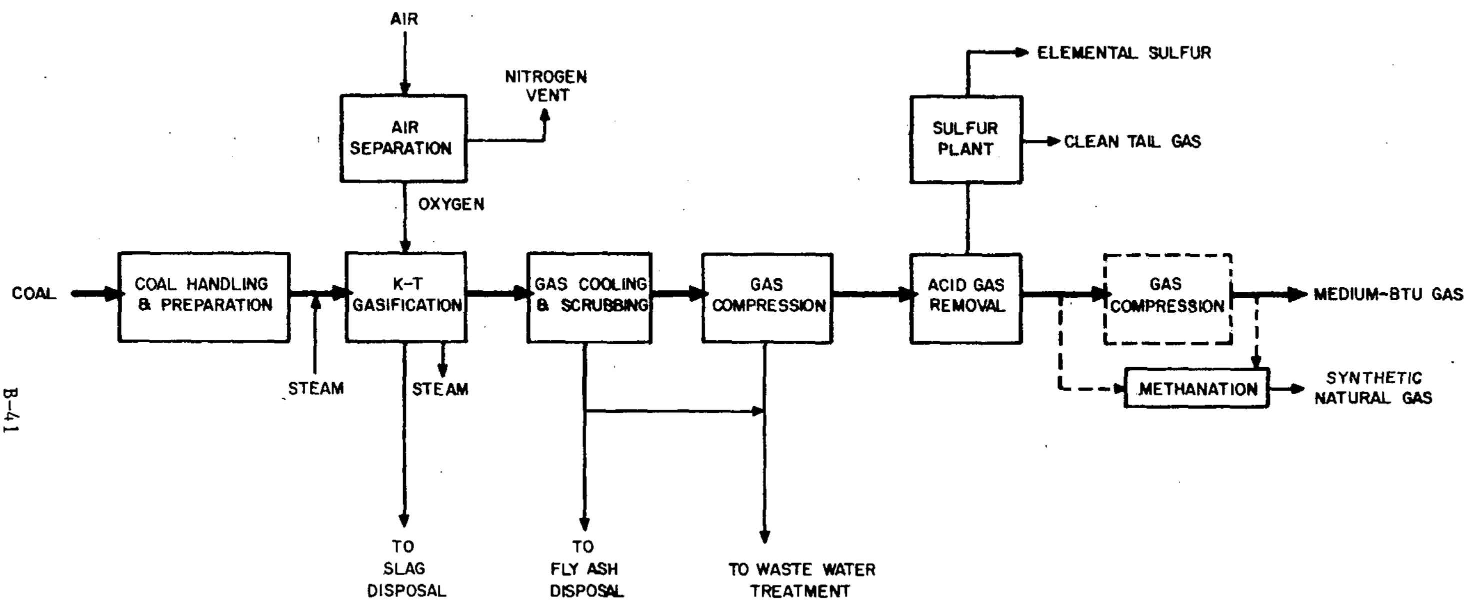

FIGURE B-6 PROCESS BLOCK FLOW DIAGRAM - KOPPERS-TOTZEK GASIFIER

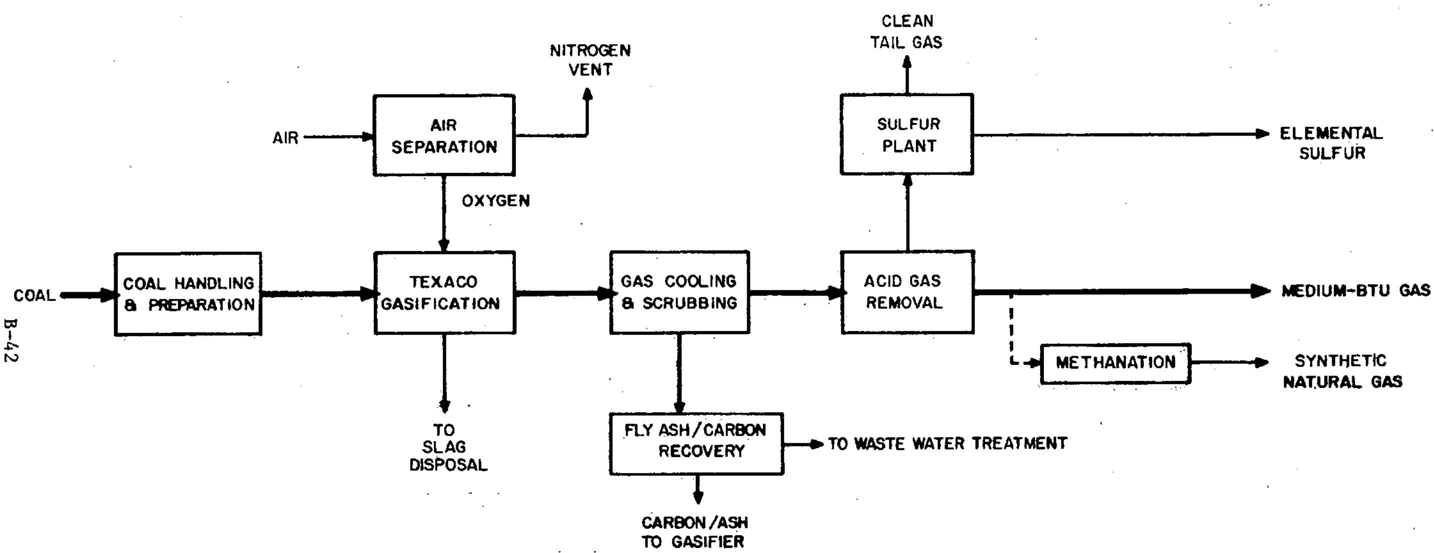

FIGURE B-7 PROCESS BLOCK FLOW DIAGRAM - TEXACO GASIFIER

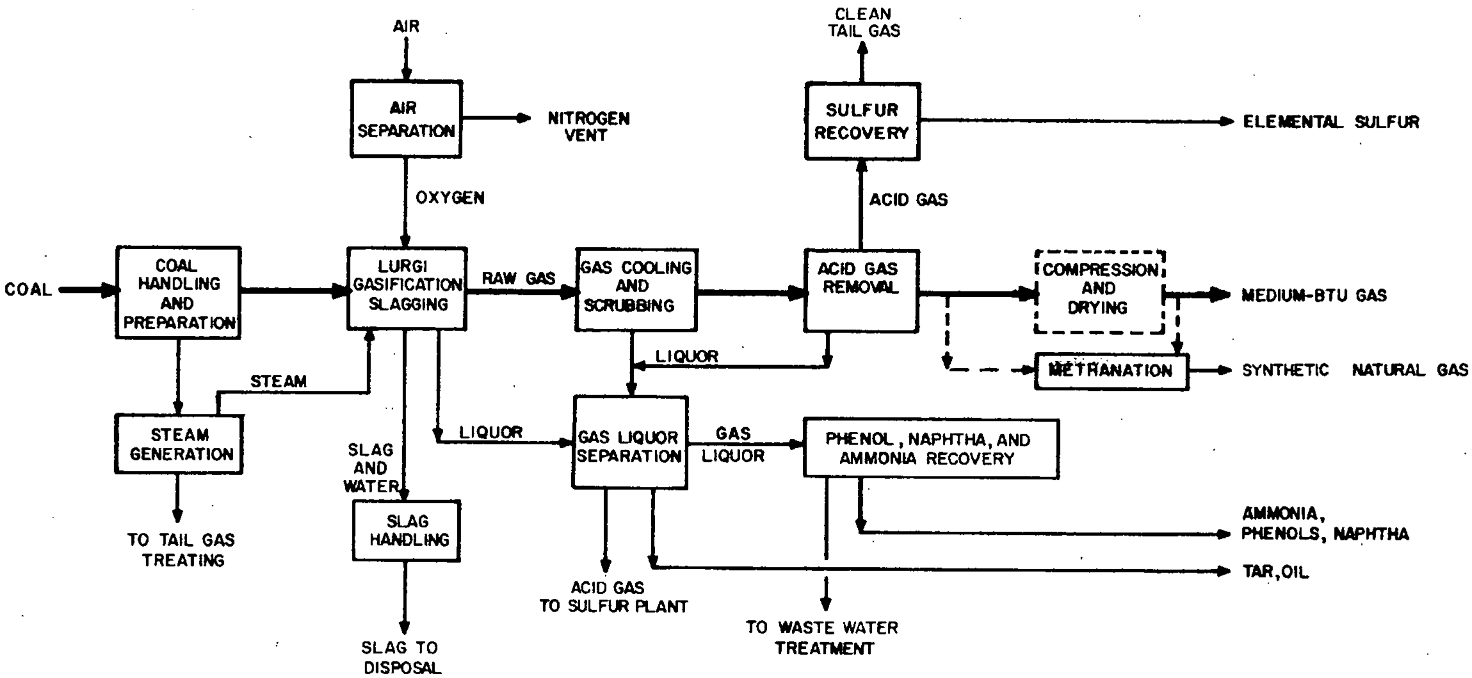

FIGURE B-8 PROCESS BLOCK FLOW DIAGRAM - BGC / LURGI SLAGGING GASIFIER

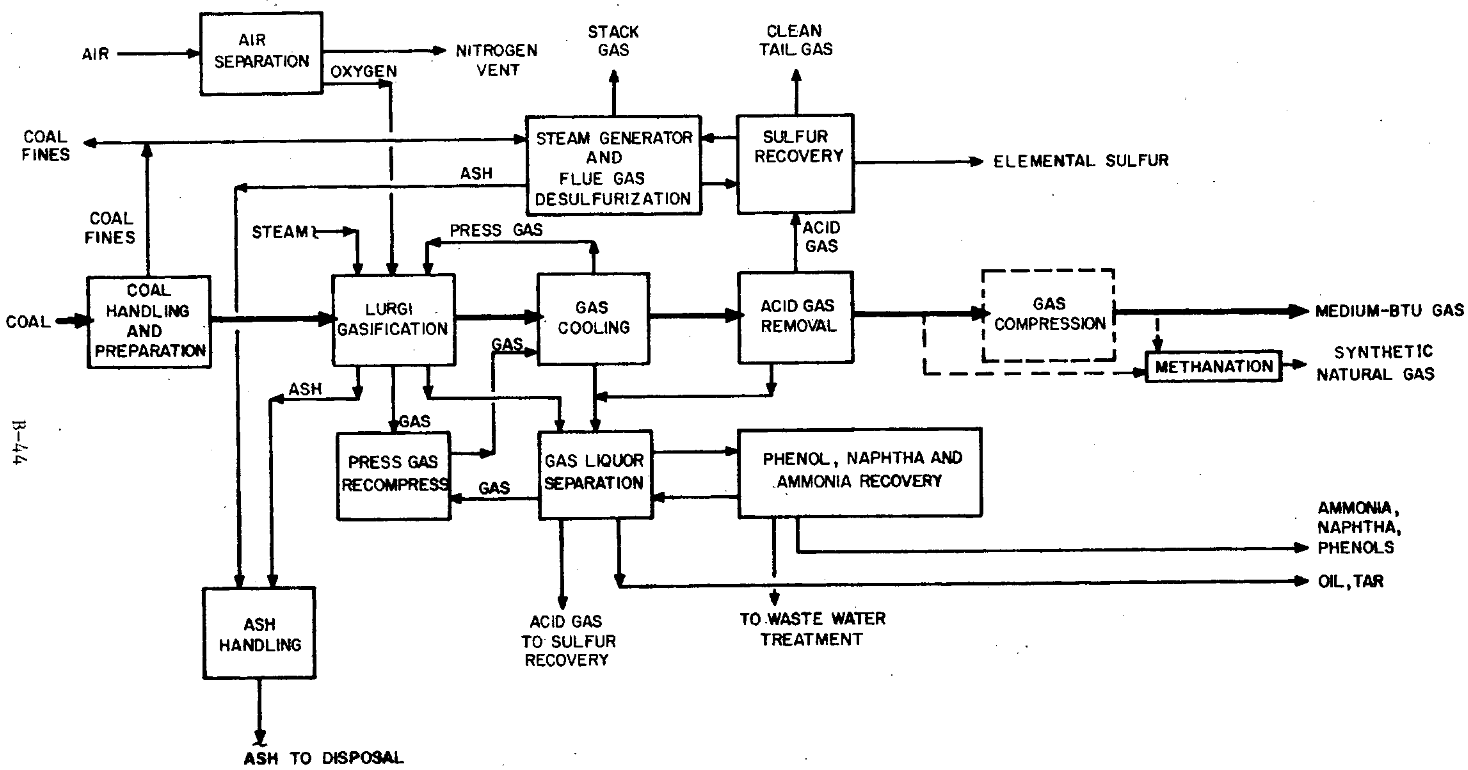

FIGURE B-9 PROCESS BLOCK FLOW DIAGRAM - LURGI DRY ASH GASIFIER

APPENDIX C

PIPELINES

APPENDIX C
PIPELINES

In order to deliver either medium-Btu gas (MBG) or synthetic natural gas (SNG) to the consumer, it would be necessary for a pipeline or pipelines to be constructed from the proposed plant to the consumer's facilities or to tie to an existing pipeline network. While it is likely that the construction and operation of pipeline facilities would be carried out by private industry, a possible routing for such lines and a generic discussion of the potential environmental impacts associated with these pipelines are discussed below. Construction of a pipeline is not being proposed at this time.

1. General Considerations for Locating Pipelines

As a first step in the location process for the MBG pipeline, topographic maps were examined to determine the best apparent route locations. From this initial determination, a study area or corridor was selected which contained the best apparent routes. Major constraints and apparent control points along the corridor were identified for further study and field investigation. Engineers then conducted field reconnaissance to further define control points such as the most suitable places to cross major highways, secondary roads, and streams. They attempted to avoid residential, commercial, and industrial areas for safety and economic reasons. Recreational areas and other developments and areas of historical, cultural or scenic significance were also avoided to the extent possible. Routes for SNG pipelines were developed by major natural gas companies using a similar process and are shown in Figure 2-7 in the EIS text.

The pipeline routing which resulted from the above process is not intended to be the exact routing that will definitely be utilized in association with this project. The identification of preliminary routes by TVA does, however, indicate that routes, which appear feasible from an engineering and environmental standpoint, are available to serve a coal gasification facility located at either the Courtland or Murphy Hill site. If a MBG pipeline is constructed at a later date, a more detailed environmental assessment of the pipeline route would be undertaken. (Please refer to Section 2.3.6.21.)

1.1 Route Description

The hypothetical MBG pipeline route was established such that the coal gasification plant could be sited at either Courtland or Murphy Hill. This analysis was conducted for the purpose of evaluating relative economic differences between these 2 candidate sites. The potential MBG pipeline route would originate at the proposed coal gasification plant site located at Murphy Hill in

Marshall County, Alabama, on Guntersville Lake. The site is approximately 12 mi northeast of Guntersville, Alabama. The route is shown in Figure 2-7.

The route extends 1.4 mi across the Tennessee River near TRM 370 in a direction generally northwestward and then continues in that direction for approximately 8.2 mi. The terrain is generally mountainous and wooded in nature with little development.

From Paint Rock River in Madison County, Alabama, the route continues in a westward direction to the Tennessee River at a point approximately 1.6 mi south of Huntsville, Alabama, near Hobbs Island. The terrain is generally open and flat except for a 1.1 mi section across Wallace Mountain in southwest Madison County.

The route crosses the Wheeler Lake near TRM 333. It then proceeds generally southwestward. Approximately 6.2 mi southeast of Decatur, Alabama, and 1.6 mi from its intersection with State Route 67, the route intersects Interstate Highway 65. From I-65 the route continues generally westward until it intersects U.S. Highway 31, a 4-lane, heavy-duty divided roadway. The pipeline passes 0.3 mi south of the southern-most boundary of the Wheeler Wildlife Refuge.

From U.S. 31, the route extends generally northwestward until it intersects State Route 24, a 2-lane, heavy-duty roadway. An approximately 2.3 mi portion of this segment lies in the northwest section of Wheeler Lake and crosses West Flint Creek at 3 locations. It also crosses Flint Creek about 0.2 mi west of U.S. 31. The terrain in this area is mostly wooded and mountainous in nature and sparsely populated.

From State Route 24, the route continues northwestward until it intersects State Route 33. This approximately 10.3 mi segment generally parallels TVA's Wilson Dam-Trinity 161,000-volt Transmission Line. The terrain in this area is mostly wooded and mountainous in nature. Continuing from State Route 33 in a northwestward direction, the route extends to the site of the abandoned Courtland Air Base. The terrain is generally open and flat in nature.

From Courtland Air Base, the route extends westward until it intersects State Route 157, a 2-lane, heavy-duty roadway. This segment is approximately 12.9 mi long. The area is generally open and flat in nature and sparsely populated.

From its intersection with State Route 157, the route continues west then northwestward until it intersects U.S. Highway 43, a 4-lane, heavy-duty divided roadway. This approximately 5.9 mi segment parallels a portion of TVA's Colbert-Reynolds 161,000-kV Transmission Lines. The terrain is generally open and rolling in nature with heavy woods all along the creek.

Continuing from U.S. 43, the route proceeds northwestward 1.3 mi then westward until it intersects Little Bear Creek. The total length of this segment is approximately 6.1 mi. This segment parallels, in part, two 46,000-volt transmission lines. The terrain is generally mountainous and wooded in nature with little development.

From Little Bear Creek, the route continues northwestward for 3.8 mi, where it intersects the right-of-way of the Tennessee Gas Transmission Company pipeline. The terrain is generally rolling in nature and densely wooded in some areas.

After its intersection with the Tennessee Gas pipeline, the route turns 2.5 mi westward, and then northward for approximately 1.5 mi. It then proceeds northwestward approximately 4.4 mi, paralleling TVA's Colbert-Cherokee 161,000-volt Transmission Line and terminates. This segment in total is approximately 8.4 mi long. The gently rolling terrain is mostly cultivated with occasional woods along creek drainage areas.

The above described route is approximately 112 mi long and crosses generally open and rolling terrain. The physical and geographical elements which must be given significant consideration in final design development are listed below:

Major lakes crossed	2
Rivers or large creeks crossed	13
Small streams crossed	107
Heavy-duty roads crossed	13
Medium-duty roads crossed	35
Light-duty roads crossed	43
Railroads crossed	4
500,000-volt transmission lines crossed	1
161,000-volt transmission lines crossed	16
110,000-volt transmission lines crossed	1
46,000-volt transmission lines crossed	8
Underground pipelines crossed	4
Underground telephone lines crossed	1

1.2 Proposed Alternate Route Description

To avoid spanning Guntersville Lake at the Murphy Hill site with the proposed MBG pipeline, an alternate route was considered and is described as follows:

> The proposed pipeline route originates at the proposed coal gasification plant site located on Murphy Hill in Marshall County, Alabama. The site is approximately 12 mi northeast of Guntersville, Alabama.
>
> The route extends generally southward approximately 1 mi, then southwestward until it intersects U.S. Highway 431 at a point approximately 4 mi northwest of Albertville, Alabama. The segment is approximately 21 mi long and crosses the

Louisville and Nashville Railroad approximately 3 mi northwest of Albertville, Alabama.

From its intersection with U.S. 431, the route extends southwestward approximately 5.2 mi until it intersects State Route 79.

The route continues westward from State Route 79 approximately 1.8 mi, then northwestward until it intersects State Route 69 approximately 2.7 mi northeast of Arab, Alabama.

From State Route 69 the route extends northwestward approximately 6.0 mi until it intersects the right-of-way of TVA's Decatur-Guntersville 161,000-volt Transmission Line.

The route continues generally northwestward parallel to the high-voltage transmission line right-of-way for approximately 18.5 mi until it intersects a point on the originally proposed route. This intersection is approximately 5.0 mi southeast of Priceville, Alabama, and 0.8 mi southwest of Echols Crossroads (see Figure 2-7 in text).

The length of alternate route from the Murphy Hill plant site to its intersection with the original route is 53.5 mi. Selecting this proposal would increase the length approximately 15 mi more than the original route spanning Guntersville Lake.

Physical and geographical features of the alternate route and that portion of the original route that would be replaced are compared below:

	Alternate	Original (Spanning Lake)
U.S. Highways crossed	2	2
State Roads crossed	4	1
Medium-duty roads crossed	2	11
Railroads crossed	1	1
161,000-volt transmission lines crossed	3	3
110,000-volt transmission lines crossed	2	1
46,000-volt transmission lines crossed	1	0
Major lakes crossed	0	2

2. Construction Procedures

Based on a review by TVA of the construction practices of the gas pipeline industry, the following information has been compiled.

All work performed would conform to provisions and requirements of DOT's Title 49, Part 192--"Transportation of Natural and Other Gas By Pipeline: Minimum Federal Safety Standards" and latest amendments thereto.

2.1 Survey

The entire pipeline route would be surveyed. The land portion would be staked prior to right-of-way clearing; the centerline of the pipeline would be marked at intervals of approximately 200 ft and all road crossings would be marked at both sides of the crossing.

2.2 Right-of-Way Clearing

The right-of-way would be a strip of land varying from 50 to 75 ft wide, depending upon the size of the pipe and the type of terrain. In those situations where the width of right-of-way would not be adequate to handle construction activities, additional working areas might be required adjacent to the planned route to provide the necessary space. Permission would be sought from landowners for use of access roads across their property to the right-of-way.

Before clearing operations are started, the clearing supervisor would be made familiar with all special provisions included in the right-of-way easements and with all environmental commitments. Clearing would be restricted to only that amount of right-of-way necessary for actual ditching, laying of pipe, and construction activities. A minimum 50-ft right-of-way would be required to provide room for construction activites.

Various clearing methods would be employed, depending on tree size, contour of the land and the ability of the ground to support heavy clearing equipment. Power saws would be used to fell large timber, while smaller timber and brush would be cut by dozer-type machines equipped with special cutting blades. Appropriate safety regulations would be strictly followed and firefighting equipment would be available. Care would be taken to protect trees, shrubs and vegetation adjacent to the right-of-way clearing.

2.3 Ditching

Topographical irregularities would be graded to ensure rapid and safe passage of the work crews. Dozers would be used for removal of tree stumps and roots which would be disposed of in an approved manner. Topsoil in cultivated areas would be carefully stripped from the ditch line and preserved for later restoration of the right-of-way after the pipe laying crews pass. The patterns of existing streams and drainage systems would be maintained and new drainage patterns would be formed where they are required to limit erosion.

The ditch would be excavated to a minimum width to provide 8 in of clearance on either side of the pipe and the adjacent sides of the ditch and a depth to provide a minimum of 3 ft cover.

In areas where temporary filling would be utilized, the depth would be measured from the original ground surface. Ditch crossings would be provided where necessary for movement of farm equipment or livestock. If existing pipelines are to be crossed, crossings would be preferably under the existing line with 2 ft minimum clearance between the lines. Should the new pipeline be laid above the existing pipeline, the 2-ft clearance would be maintained by use of separating material such as earthfilled sacks.

2.4 Pipe Installation

Trucks or all-terrain vehicles would be used to transport the pipe from the storage yards to the prepared pipeline right-of-way. Where the supply, schedule and location permit, the pipe would be transported directly from rail yards. The pipe would be placed along the right-of-way on the side of the ditch. Some additional pipe would be deposited for bending. In order to minimize possible pipe damage, the pipe would be carefully inspected at transfer points and appropriate lifting equipment would be used, all in accordance with proven pipeline construction practices.

Following behind the "lineup" crew, welders would complete each weld as required to meet the welding procedure specifications. The completed welds would be tested and checked for adequacy and integrity in conformance with pipeline safety regulations. These specifications would be finalized prior to construction and would be in accordance with proven pipeline construction practices.

The pipe would be received at the project area precoated. Coating of the field joints would be applied prior to lowering in, according to the coating manufacturer's recommended specifications.

An electronic detector would be passed over the entire length of the pipe to check for and locate defects or voids in the coating. All defects or voids would be properly repaired before the coated pipeline is lowered into the ditch.

Padding materials would be required in areas where the ditch bottom is irregularly shaped and where the excavated spoil materials are unacceptable for backfilling around the pipe. To protect the pipe coating from damage in these areas and for support, sand or gravel, crushed rock and screened spoil materials from the ditch excavation or a combination of each would be used for padding. This padding material would be placed in the bottom of the ditch to a depth of a minimum of 6 in prior to lowering in of the pipe.

Prior to lowering in, the ditch would be cleaned of all debris and the bottom would be smoothed. The pipe would be lifted from the supports and lowered directly into the ditch by tractors with safety equipment to prevent damage to the pipe and pipe coating.

2.5 Highway and Other Crossings

Principal highways, county roads, and railroads would be crossed by horizontal tunneling; casing would be installed where required. Cased crossings would be constructed in accordance with the railroad company's or highway department's specifications. A minimum of 3 ft of covering would be utilized over the casing top. Where casings would not be required, a minimum of 5 ft of cover would be used.

Where permitted, such as on unsurfaced and lightly traveled rural roads, road crossings would be made using open cut, conventional ditching methods similar to those described previously. Temporary passage of traffic would be provided for by either a detour acceptable to the jurisdictional authorities, by temporary bridging over the excavated ditch, or a combination of the 2 methods. Detour and warning signs, lights, flagmen, barricades, pilot vehicles, watchmen and any other features required for maintaining safe passage of traffic would be supplied and maintained.

Construction of the pipeline crossings, including repair, restoration and cleanup operations, would be expeditiously conducted in a neat and orderly fashion in accordance with proven pipeline construction practices. Construction of all crossings would be as required by highway, railroad, public road, and street agencies or any other authority with jurisdiction.

2.6 Backfill and Cleanup

Before backfilling begins, a final inspection would be made to assure that all debris was removed from the ditch and that the pipe and pipe coating were undamaged. Where gravel and other materials are encountered of a size or shape that could cause damage to the pipe or pipe coating, the placement of select padding material would be placed around the pipe to a thickness of 4 in. Sand, gravel, cement or cement-filled sacks would be installed in the ditch over and around the pipe to provide full protection against erosion in vulnerable areas.

Only material excavated from the pipeline ditch or padding would be used for backfilling; at no time would other soil or rock from the right-of-way be used. Soil removed from the ditch line would be used to form a slight mound over the ditch centerline to compensate for settling. Openings would be left in the completed mound to permit lateral surface drainage.

All backfilling equipment would be operated so as to minimize surface damage in sensitive areas. When backfilling is completed, accumulated construction debris would be removed from the right-of-way. Drainage ditches, terraces, roads, and fences would be restored to their former condition.

Potholes, ruts, and depressions would be filled, and the pipeline right-of-way would be left in a neat condition. Pipeline markers and warning signs would be erected at roads, watercourses, and other points in accordance with DOT regulations. All surplus materials and construction equipment would be removed.

At the completion of the backfilling and cleanup operation, the right-of-way, where necessary for erosion control and with the permission of the landowner, would be disked, seeded, and fertilized.

2.7 Pipeline Cleaning

Prior to hydrostatic testing, pipeline sections would be cleaned by use of a scraper, brush, or cleaning plug.

2.8 Hydrostatic Testing

The hydrostatic testing of the pipeline would conform to the regulations of the DOT (49 CFR 192). The pipeline would be tested to substantiate the proposed maximum allowable operating pressure as well as for potential leaks. Water would be used as the testing medium. Where test sections are continuous, the quantity of water required would be minimized by reusing the water, where possible, from one tested section to the succeeding test section. The minimum hydrostatic test pressure would be based on DOT specifications.

3. Effects of Pipeline Construction

3.1 Land Use Compatibility

Any new gas pipelines would be constructed on a right-of-way acquired by easement. The easement agreement would allow construction, operation, and maintenance of a pipeline and would prohibit certain activities on the right-of-way. No permanent structures would be allowed on the right-of-way and no other activities which could potentially damage the pipeline, such as strip mining, would be permitted. However, most other uses of the right-of-way would be permitted.

The land use along the proposed route for the MBG pipeline and the SNG pipelines is primarily agricultural with most of the farmland being used for the production of soybeans, cotton, and corn. Urbanization in proximity to the proposed routes is primarily limited to the vicinities of Gadsden, Decatur, Tuscumbia, and Muscle Shoals.

The depth at which the pipelines would be buried would allow continued agricultural use of the right-of-way except during line construction itself. Landowners would be reimbursed in accordance with easement terms for any damage to crops resulting from construction or maintenance.

Every effort would be made to avoid existing residences and other buildings in pipeline routing. No significant adverse impacts to existing structures or further development off the right-of-way would be anticipated. Also recreation use in the areas along most of the routes is widely dispersed and would not be affected by pipeline construction or operation of the pipelines.

The aesthetic impacts of pipeline construction would be primarily the visual impacts of clearing and excavation and the noise associated with the construction process. These effects would be of short duration and would generally be limited to an area in close proximity to the line. After the closing of the pipeline ditch and its revegetation, visual evidence of the pipelines' presence would be limited to valving mechanisms, spaced at wide intervals along the right-of-way. Consequently, the pipeline would have little aesthetic impact.

3.2 Terrestrial Ecology

Clearing of the pipeline right-of-way, trench excavation, return of soil materials to the trench after pipe laying, and general construction activities, would disturb habitats along the pipeline route. These effects are expected to be minimal in agricultural and cleared areas. Pasturelands would be planted with species best suited for the existing soil conditions. Runoff would be minimal because of the flatness of these areas, and planting and terracing to prevent washing away of any soils due to rainfall would be carried out.

The effect on forested areas would be greater than on agricultural lands due to the alterations caused by the right-of-way clearing through these areas. Cleared areas would be seeded following construction to stabilize soils before native plant species are reestablished.

During construction and until revegetation is adequate, erosion may occur in some steep slope areas. Terracing and other measures would be employed to reduce this impact.

Animals most directly affected by pipeline right-of-way construction would be those most commonly associated with forest and agricultural habitats. Animal species would either proportionally relocate, assuming similar surrounding habitats are at some level below carrying capacity, or would be lost from their respective populations assuming surrounding similar habitats are at full carrying capacity.

Regrowth of vegetation along the edge of the rights-of-way would produce an "edge effect" composed of seeded grasses, soon to be replaced by naturally regenerated trees, shrubs, and herbs. Generally, these areas are important as food and shelter for many faunal species including cottontail rabbit, whitetail deer, and a variety of songbirds.

In agricultural areas, the loss of animal life is expected to be of short duration since habitats would return to their original status soon after completion of construction. Repopulation of the right-of-way would occur soon after construction.

3.3 Aquatic Ecology and Water Quality

As discussed in Section 1.1, the preferred MBG pipeline route crosses the Tennessee River twice, in addition to crossing numerous small streams. All these streams would be temporarily affected by increased turbidity and silt loads. There would be some change in the physical configuration of the bottom surfaces and some temporary disruption of animal movements. No lasting impacts on fisheries resources would be expected. Benthic organisms in the immediate area of the pipeline would be lost as a result of excavation and refilling activities; however, the pipe ditch would be refilled to the level of the original streambed and benthic organisms would be expected to repopulate the area. Pipeline installation would require Sections 10 and 404 review by the Corps.

The amount of additional silt reaching water courses as a result of dry-land construction would vary depending on proximity to water courses, terrain, and weather. It is expected that best management construction practices, such as terracing and rapid revegetation of the right-of-way, would prevent excessive erosion and subsequent silt loading of nearby streams. Pipeline routes would avoid water supply intakes and ecologically sensitive or unique areas to the extent practicable, and removal of riparian vegetation would be minimized.

3.4 Threatened or Endangered Species

The proposed pipeline routes would be evaluated to determine the presence on or near the right-of-way of any ecologically sensitive area, threatened or endangered species, or critical habitat. If such areas or species are identified, the pipeline route would be reevaluated taking into account the potential for impact to these species or habitats.

3.5 Historical and Archaeological Resources

All properties in the vicinity of a proposed pipeline route which are listed in the National Register of Historic Places or are eligible for listing would be identified. Any impacts on these properties would then be assessed.

Once a final route was established, an archaeological survey would be conducted on the proposed right-of-way to determine if any resources exist which would be affected by construction of a pipeline. Should the survey reveal any significant resource in conflict with the proposed route, the line location would be reevaluated or mitigative activities undertaken.

3.6 Air Quality

Activities associated with the construction phase of a pipeline, such as earth moving and the burning of brush and slash, would be the source of some limited, temporary air emissions. These would be in the form of particulate (smoke) and gaseous emissions from combustion processes (both from direct burning and internal combustion engines), and fugitive dust from earth moving and wind erosion.

Sources of combustion during the construction phase include both heavy and light duty engines together with some open burning of debris, where permitted. However, the increases would be small, localized and will not significantly affect overall local air quality.

Fugitive dust may result from numerous activities (e.g., earth movement, wind erosion, and dust caused by traffic). Dust from these causes is similar to that resulting from heavy agricultural activity and would not be expected to cause any significant impact.

3.7 Noise

The various pipeline construction operations described earlier would generate varying noise levels depending on the specific operation. These noise levels would be of relatively short duration and would diminish rapidly at increasing distances from the right-of-way. Therefore, no significant adverse noise effects are expected.

3.8 Solid Waste Management

Where practicable, merchantable timber removed from the right-of-way would be marketed. Generally, disposal of the remaining brush cleared from the rights-of-way would be by open burning. Open burning of slash would be performed in conformance with applicable guidelines and regulations. In locations where disposal by burning is not permitted, other means of disposal would be employed.

In general, the amount of domestic solid waste that may be generated while constructing the pipeline would be very small. However, it would be stored, collected, and disposed of in conformance with applicable requirements.

3.9 Floodplain Management and Protection of Wetlands

The proposed routes shown in Figure 2-7 cross several areas which are at elevations below the 100-yr (1% chance) flood level. Due to the terrain traversed by these pipeline routes, there is no practical alternative to location in a floodplain.

The location of a pipeline in a floodplain would have no impact on the flood-carrying capacity of the floodplain, on the flowage patterns of flood waters, or on water table recharge capabilities. The natural qualities of a floodplain would not be affected beyond the manner described under "Terrestrial Ecology" and "Aquatic Ecology and Water Quality."

No wetland areas were identified during the identification of the pipeline routes shown in Figure 2-7. In the event a detailed ecological review of a proposed route resulted in the identification of a wetland along the route, the pipeline route would be reevaluated. In the event a wetland area could not be avoided, a site-specific evaluation and mitigation strategy would be developed.

3.10 Adverse Environmental Effects Which Cannot Be Avoided

There would be certain unavoidable impacts associated with the construction of either a MBG pipeline or a SNG pipeline. These impacts are discussed in the preceding sections and include loss of vegetation as a result of right-of-way clearing, loss of some wildlife habitat, soil loss through erosion during construction, and temporarily increased silt levels in the Tennessee River and streams.

None of these impacts would be expected to produce long-term, adverse impacts.

4. Conclusion

As stated previously, this identification of environmental impacts associated with pipeline construction is not intended to identify routes which will definitely be used or provide a detailed environmental assessment. It is TVA's intention to show that feasible pipeline routes do exist for both MBG and SNG.

The environmental assessment of these routes demonstrates that no unusual environmental problems would be expected as a result of gas pipeline development. Should more detailed future assessments identify a particular environmental conflict, it would not be expected to be of such magnitude that mitigation could not be achieved by rerouting or by using special construction precautions.

The routes discussed herein have been reviewed by persons with extensive professional experience in the routing and construction of gas pipelines. No significant environmental or engineering problems were identified during their review.

APPENDIX D

- February 14, 1980, TVA letter to the U.S. Department of Interior (DOI), Fish and Wildlife Service, requesting identification of species which are listed or proposed for listing as threatened or endangered and which may occur on or in the vicinity of the preferred and alternate sites.

- February 26, 1980, U.S. DOI, Fish and Wildlife Service acknowledgement letter.

- March 20, 1980, U.S. DOI, Fish and Wildlife Service notification concerning threatened and endangered species.

- April 2, 1980, TVA acknowledgement letter.

- Concurrence with TVA's Cultural Resources Assessment of the Murphy Hill Site by the State Historical Preservation Officer, Alabama Historical Commission.

February 14, 1980

Mr. Kenneth E. Black, Regional Director
U.S. Fish and Wildlife Service
Richard B. Russell Federal Building
75 Spring Street, SW
Atlanta, Georgia 30303

Dear Ken:

The Tennessee Valley Authority (TVA) is conducting an analysis of alternatives and potential environmental impacts associated with the development of a Coal Gasification Demonstration Project. Two candidate sites for the project located in Marshall and Lawrence Counties, Alabama, known as the Murphy Hill and Courtland sites, respectively, have been identified. The Marshall County (Murphy Hill) site is considered the preferred alternative. TVA is preparing an EIS for the proposed project. See 45 Fed. Reg. 7360, (February 1, 1980).

This letter serves as a request for the identification of species which are listed or proposed for listing as threatened or endangered and which may occur on or in the vicinity of the two alternative sites. If notified of the possible presence of such species, TVA will prepare a biological assessment which will be included as a part of the draft EIS. The enclosed maps indicate the two alternative sites under investigation. If there are any questions or additional information is required, please contact J. Ralph Jordan at FTS 856-6450.

Sincerely,

Thomas H. Ripley, Manager
Office of Natural Resources

JML:MKW
Enclosures

United States Department of the Interior
FISH AND WILDLIFE SERVICE
75 SPRING STREET, S.W.
ATLANTA, GEORGIA 30303

FEB 26 1980

Mr. Thomas H. Ripley
Manager, Office of Natural Resources
Tennessee Valley Authority
Norris, Tennessee 37828

Dear Mr. Ripley:

This acknowledges your letter of February 14, 1980, received February 19, 1980, requesting information on whether any endangered, threatened, or proposed to be listed species may be present in the area of the coal gasification demonstration project which is located in Marshall and Lawrence Counties, Alabama. We have assigned log number 4-3-80-A-96 to this project and we request that you refer to this number in all future correspondence.

We have forwarded the information that you provided to our Jackson Area Office for their review. Upon completion of their review, we will provide you with a list of species that may be present in the area of the proposed action and the information needed in the biological assessment if it is required.

We appreciate your concern and interest for the preservation of listed species.

Sincerely yours,

Richard M. Smith

Acting Regional Director

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FEB 29 1980
Tennessee Valley Authority
OFFICE OF NATURAL RESOURCES
DCN NO. 009

3/3/80--THR
cc: M. T. El-Ashry, FOR B-N
R. L. Morgan, Jr., FOR B-N

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
200 EAST PASCAGOULA STREET, SUITE 300
JACKSON, MISSISSIPPI 39201

March 20, 1980

Mr. Thomas H. Ripley
Manager, Office of Natural Resources
Tennessee Valley Authority
Norris, Tennessee 37828

Dear Mr. Ripley:

We have reviewed the two alternative sites for the Coal Gasification Demonstration Project to be located in Marshall or Lawrence County, Alabama (log 4-3-80-A-96) as requested in your letter of February 14, 1980. It appears that some endangered species (Table 1) may be present on the alternative sites. There are no threatened species, proposed species, or Critical Habitats present in the area to be influenced by the project.

Once it is determined that listed or proposed species may be present, Section 7(c) requires Federal agencies to provide a biological assessment for the species which are likely to be affected. The biological assessment shall be completed within 180 days after the date on which initiated, before any contracts for construction are entered into, and before construction is begun. We do not feel that we can adequately assess the effects of the proposed action on listed and proposed species or Critical Habitat without a complete assessment. The following information should be included:

1. Results of a comprehensive survey of the area.

2. Results of any studies undertaken to determine the nature and extent of any impacts on identified species.

3. Agency's consideration of cumulative effects on the species or its Critical Habitat.

4. Study methods used.

5. Difficulties encountered in obtaining data and completing the proposed study.

6. Conclusions of the agency including recommendations as to further studies.

7. Where an impact is identified to proposed and listed species or Critical Habitat, a discussion of efforts that will be taken to eliminate any adverse effects.

8. Any other relevant information.

The Fish and Wildlife Service representative who will provide you with assistance is Mr. Fred Bagley, Endangered Species Specialist, U.S. Fish and Wildlife Service, 200 East Pascagoula Street, Suite 300, Jackson, Mississippi 39201, telephone FTS 490-4900, commercial (601) 969-4900.

After your agency has completed and reviewed the assessment, you should send a copy of the assessment with your determination of "no affect" or "may affect" on any of the listed species. If the determination is "may affect", you shall initiate consultation by a written request to the Regional Director, Fish and Wildlife Service, Richard B. Russell Federal Building, 75 Spring Street, S.W., Suite 1282, Atlanta, Georgia 30303.

Your attention is also directed to Section 7(d) of the 1978 Amendment to the Endangered Species Act, which underscores the requirement that the Federal agency and the permit or license applicant shall not make any irreversible or irretrievable commitment of resources during the consultation period which in effect would deny the formulation or implementation of reasonable alternatives regarding their actions on any endangered or threatened species.

For your information and assistance we have enclosed a copy of the interim definitions and two "step down processes" for general guidance. In future correspondence please refer to the appropriate log number.

Sincerely yours,

Harry L. Hickman

Area Manager

Enclosures

cc: ES, FWS, Decatur, AL
Director, Department of Conservation
Montgomery, AL
Regional Director, FWS, Atlanta, GA

Table 1 Endangered Species Possibly Occurring on the Coal Gasification Demonstration Project Alternative Sites

Common Name	Scientific Name	Site
Gray bat	Myotis grisescens	Murphy Hill/Courtland
Indiana bat	Myotis sodalis	Murphy Hill/Courtland
Bald eagle *	Haliaeetus leucocephalus	Murphy Hill
Red-cockaded woodpecker	Picoides borealis	Courtland
	Lampsilis virescens	Murphy Hill
	Fusconaia cuneolus	"
	Toxolasma cylindrellus	"
	Lampsilis orbiculata orbiculata	"
	Plethobasis cicatricosus	"
	Plethobasis cooperianus	"
	Conradilla caelata	"
	Dromus dromas	"
	Epioblasma florentina florentina	"
	Epioblasma torulosa torulosa	"
	Epioblasma turgidula	"
	Epioblasma walkeri	"
	Pleurobema plenum	"
	Quadrula intermedia	"

* According to Mr. Tom Imhoff, a bald eagle nest was formerly located on Guntersville Reservoir in Marshall County.

Explanation of Step Down Process

The 1978 Amendments to the Endangered Species Act have changed the consultation process under Section 7. The following definitions and two "Step Down Processes" are for general guidance and are not to be considered final, inasmuch as the Fish and Wildlife Service and National Marine Fisheries Service are preparing new Interagency Cooperation Regulations for the implementation of the new amendments to Section 7.

Interim Definitions

Activities or programs means all actions of any kind authorized, funded, or carried out by Federal agencies, in whole or in part, in the United States, upon the high seas or in foreign countries, examples of which include, but are not limited to: (1) actions intended to conserve listed species or their Critical Habitats: (2) the promulgation of regulations; (3) the granting of licenses, contracts, leases, easements, rights-of-way, permits, or grants-in-aid; or (4) actions directly or indirectly causing modifications to the land, water, or air.

Biological assessments. If the Director, [redacted] Regional Director or AREA MANAGER indicates that any species which is listed or proposed to be listed may be present in the area affected by a project, the Federal agency shall conduct a comprehensive survey of the area to identify any listed species or species proposed to be listed which may be affected by the construction project and shall determine the nature and extent of impact that the proposed project may have on such species and shall conduct any studies necessary to make such determination. Biological assessments shall include (1) the results of the comprehensive survey of the area; (2) the results of any studies undertaken to determine the nature and extent of any impacts on identified species; (3) the agency's consideration of cumulative effects on the species or its Critical Habitat; (4) the study methods used; (5) difficulties encountered in obtaining data and completing the proposed study; (6) conclusions of the agency including recommendations as to further studies; and (7) any other relevant information.

Conservation means bringing a listed species to the point at which a species may be removed from the List of Endangered or Threatened Wildlife and Plants. Methods and procedures of conservation include, but are not limited to, all activities associated with scientific resource management such as research, census, law enforcement, habitat acquisition and maintenance, propagation, live trapping, and transplantation; and, in the extraordinary case where population pressures within a given ecosystem cannot be otherwise relieved, may include regulated taking of animals.

Construction Project means any major Federal action which significantly affects the quality of the human environment, designed primarily to result in the building or erection of man-made structures such as dams, buildings, roads, pipelines, channels, and the like. This includes Federal actions such as permits, grants, licenses, or other forms of Federal authorization or approval which may result in construction.

Critical Habitat means: (1) specific areas within the geographical area occupied by the species at the time it is listed that are determined by the Director to include those physical or biological features essential to the conservation of the species and which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time it is listed upon a determination by the Director that such areas are essential for the conservation of the species.

Critical Habitat shall not include either the entire geographical area which can be occupied by a listed species or existing man-made structures or settlements, unless determined by the Director to be essential for the conservation of the species. Critical Habitat may include land, water, or air. Physical or biological features of Critical Habitat include, but are not limited to: physical structures and topography, biota, climate, human activity, and the quality and chemical content of land, water, and air. Critical Habitat determinations are listed in parts 17 and 226 of this title.

Cumulative effects means the effects of the Federal action under consideration coupled with the identifiable effects of reasonably foreseeable actions of the Federal agency or other persons upon a listed species or its habitat. Cumulative effects can result from individually minor but collectively, significant actions taking place over a given period of time.

Destruction or adverse modification means a direct or indirect alteration of Critical Habitat which appreciably diminishes the value of that habitat for conservation of a listed species. Such alterations may include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining the habitat to be critical. There may be many types of activities or programs which could be carried out in Critical Habitat without causing such diminution.

Director or Regional Director means the Director or one of the Regional Directors of the United States Fish and Wildlife Service or the National Marine Fisheries Service.

Federal agency means any department, agency, or instrumentality of the United States.

Forseeable actions means all reasonably identifiable planned or potential future actions by any person which have a reasonable likelihood of occurrence and which affect the same geographic area as the Federal action which is the subject of the consultation.

Jeopardize the continued existence of means to engage in an activity or program which reasonably would be expected directly or indirectly to appreciably reduce the likelihood of the conservation of listed species in the wild by destroying or adversely modifying habitat essential to the conservation of a listed species, to reducing the reproduction, numbers, or distribution of a listed species. The level of reduction necessary to constitute "jeopardy" would be expected to vary among listed species.

Listed species means any species of fish, wildlife, or plant which is determined Endangered or Threatened under Section 4 of the Act. Listed species are found in 50 CFR 17.11-17.12.

Reasonable and prudent alternatives refers to alternative courses of action open to the Federal agency with respect to an activity or program that are technically capable of being implemented and consistent with the intended primary purpose of the activity or program, and would avoid jeopardizing the continued existence of listed species or destruction or adverse modification of Critical Habitat.

Service means the United States Fish and Wildlife Service and/or the National Marine Fisheries Service, as appropriate.

Special management considerations or protection means any methods or procedures useful to the conservation of listed species.

Instrumentality means any person that carries out actions or performs functions for a Federal agency as a result of having been awarded a contract, permit, lease, or grant.

Irreversible or irretrievable commitment of resources means any action or activity carried out after the initiation of consultation by an agency relative to the subject of this consultation, which has the effect of foreclosing the formulation or implementation of any reasonable and prudent alternative measures which would avoid jeopardizing the continued existence of any endangered or threatened species or adversely modifying or destroying the Critical Habitat of any such species. Depending on the activity or program and the species involved, the degree of commitment of resources that would constitute an irreversible or irretrievable commitment could vary from the agency's total actions on the project to a very few segments of the proposed action. Although the degree of commitment that is irreversible or irretrievable is to be determined by the project agency, such agencies should be aware that possible jeopardy to a listed species along with reasonable and prudent alternative measures which would avoid jeopardizing the continued existence of an endangered or threatened species will only be presented in the Biological Opinion that concludes a consultation.

Good faith consultation means that a Federal agency has made a reasonable and responsible effort to develop and fairly consider modifications or reasonable and prudent alternatives to the proposed agency action which will avoid jeopardizing the continued existence of an endangered or threatened species or result in the adverse modification or destruction of Critical Habitat. Since the occurrence of this condition need only be determined when an application for exemption for an agency action is being considered, the determination will be made by the Review Board only. The Service's concern should be that it has made every effort to provide reasonable and prudent alternatives to the agency action along with the biological opinion that concludes a consultation.

STEP DOWN PROCESS
CONSTRUCTION PROJECT

AREA MANAGER

1. Federal Agency requests from [redacted] whether any species which is listed or proposed to be listed may be present.

AREA MANAGER

2. [redacted] advises which species may be present. Minimum information needed in a Biological Assessment:

   A. Results of the comprehensive survey of the area.

   B. Results of any studies undertaken to determine the nature and extent of any impacts on identified species.

   C. Agency's consideration of cumulative effects on the species or its Critical Habitat.

   D. Study methods used.

   E. Difficulties encountered in obtaining data and completing the proposed study.

   F. Conclusions of the agency including recommendations as to further studies.

   G. Any other relevant information.

AREA MANAGER'S

3. Federal Agency has 180 days after the date of receipt of [redacted] letter or mutually negotiated date to complete Biological Assessment.

4. Federal Agency then reviews assessment and determines if any listed species is affected.

5. Sends a copy of the assessment and their determination to the Regional Director.

6. If Federal Agency determines:

   A. "No effect" - Consultation is <u>not</u> necessary, unless requested by the Regional Director.

   B. "May affect" - Consultation is requested in writing from the Regional Director.

7. Regional Director acknowledges request and must issue a Biological Opinion within 90 days of "date of receipt" or by a mutually negotiated date.

8. Request is assigned to the appropriate Area Office to accomplish the consultation.

9. Area Office must review the information provided as soon as possible to determine if additional information will be needed and identify the type of information needed.

10. If additional information is needed, a letter will be sent to the agency requesting the information and requesting an extension of time to complete the consultation.

11. After receipt of information a Biological Opinion will be issued stating:

    A. Action will contribute to the conservation of the listed species.

    B. Action is not likely to jeopardize the continued existence of listed species or destroy or adversely modify Critical Habitat.

        (1) May include recommendations which would enhance.

    C. Action is likely to jeopardize the continued existence of listed species and/or destroy or adversely modify Critical Habitat.

        (1) Presentation of reasonable and prudent alternatives which will avoid jeopardy to the listed species or destruction or adverse modification of Critical Habitat and which can be taken by the Federal agency, or the permit or license applicant.

12. Reinitiation of Consultation

    A. New information reveals impacts of action that may affect listed species or their habitats.

    B. The Federal action is subsequently modified.

    C. A new species is listed that may be affected by the action.

STEP DOWN PROCESS
NON-CONSTRUCTION PROJECTS

1. Federal agency reviews the project and determines:

   A. "No effect" - Consultation is not necessary, unless requested by the Regional Director.

   B. "May affect" - Consultation is requested in writing from the Regional Director and the agency:

      (1) Provide biological information which includes:

         a. Identification of proposed and listed species or Critical Habitat determined to be present in area of activity.

         b. Description of proposed activities.

         c. Assessment of potential impacts of the activity on the proposed and listed species or Critical Habitat.

         d. Where an impact is identified to proposed and listed species or Critical Habitat, a discussion of efforts that will be taken to eliminate any adverse effects.

      (2) Other relevant information.

2. Regional Director acknowledges request and must issue a Biological Opinion within 90 days of "Date of Receipt," or by a mutually negotiated date.

3. Request is assigned to the appropriate Area Office.

4. Area Office must review the information provided as soon as possible to determine if additional information will be needed and identify the type of information needed.

5. If additional information is needed, a letter will be sent to the agency requesting the information and requesting an extension of time to complete the consultation.

6. After receipt of information, a Biological Opinion will be issued stating:

   A. Action will contribute to the conservation of the listed species.

   B. Action is not likely to jeopardize the continued existence of listed species or destroy or adversely modify Critical Habitat.

(1) May include recommendations which would enhance.

C. Action is likely to jeopardize the continued existence of listed species and/or destroy or adversely modify critical habitat.

(1) Presentation of reasonable and prudent alternatives which will avoid jeopardy to the listed species or destruction or adverse modification of Critical Habitat and which can be taken by the Federal agency, or the permit or license applicant.

7. Reinitiation of Consultation

A. New information reveals impacts of action that may affect listed species or their habitats.

B. The Federal action is subsequently modified.

C. A new species is listed that may be affected by the action.

APR 2 1980

Mr. Gary L. Hickman, Area Manager
U.S. Fish and Wildlife Service
200 East Pascagoula Street, Suite 300
Jackson, Mississippi 39201

Dear Mr. Hickman:

Thank you for your March 20, 1980, letter concerning animal species which are listed as endangered and which may occur in the vicinity of the two alternative sites for the Coal Gasification Demonstration Project to be located in Marshall or Lawrence Counties, Alabama. TVA will prepare a biological assessment addressing the potential for impacts to the 18 species mentioned in your letter. This assessment will be developed as a part of the Environmental Impact Statement (EIS) which is currently being prepared for this project. We expect that the draft EIS will be distributed for external review prior to the expiration of the 180-day time limitation for conducting the required biological assessment. However, if it appears that 180 days will not be sufficient to allow completion of our assessment, we will submit a written request for an extension of this time frame.

If the results of our biological assessment indicate that the development of the proposed project "may affect" any listed species or their critical habitat, TVA will submit a written request for consultation as required by Section 7 of the Endangered Species Act of 1973 as amended in 1978 and 1979.

We appreciate your prompt assistance in handling our previous request.

Sincerely,

Thomas H. Ripley, Manager
Office of Natural Resources

JRJ:JML:MKW
cc (Attachment - Hickman's letter):
M. T. El-Ashry, FOR B-N
H. G. Parris, 500A CST2-C
H. S. Sanger, E11B33C-K
J. F. Weinhold, 1345 CUBB-C

Principally prepared by J. Ralph Jordan, Jr.

BC (Attachment - Hickman's letter):
E. H. Lesesne, 448 EB-K
R. L. Morgan, Jr., FOR B-N

xc (Attachment - Hickman's letter):
R. B. Fitz, FOR B-N
O. E. Gray III, 1000 CST2-C
J. J. Jenkinson, FOR B-N
J. R. Jordan, Jr., FOR B-N
J. M. Loney, FOR B-N

STATE OF ALABAMA
ALABAMA HISTORICAL COMMISSION
725 MONROE STREET
MONTGOMERY, ALABAMA 36130

F. LAWERENCE OAKS
EXECUTIVE DIRECTOR

TELEPHONE NUMBER
832-6621

March 7, 1980

Mr. M. D. Ramsey
Manager, Cultural Resource Program
Tennessee Valley Authority
Forestry Building
Norris, Tennessee 37828

RE: Cultural Resources Assessment of the Murphy Hill Plant in Marshall County, Alabama

Dear Mr. Ramsey:

Mr. Bennett Graham has contacted the Alabama Historical Commission for our concurrance of the above referenced project. Based upon the cultural resource assessment conducted by Archaeologist Carey B. Oakley in 1973 and the subsequent mitigation measures conducted at site 1Ms 300, it is the State Historic Preservation Officer's determination that construction of the Murphy Hill Plant will not have a affect upon any cultural resources eligible for or on the National Register of Historic Places.

Sincerely,

Milo B. Howard, Jr.

Milo B. Howard, Jr.
State Historic Preservation Officer

MBH,Jr./djd

APPENDIX E

INTRODUCTION

This Appendix of TVA's final environmental impact statement (FEIS) for the proposed coal gasification project contains the responses to public comments on the draft environmental impact statement (DEIS) and supplement to the DEIS. The comments were submitted to TVA by the interested public and Federal, State, and local agencies through letters and during a public hearing on the DEIS held on September 23, 1980. The various public comments were reviewed by TVA and were combined as appropriate to form generic comments. TVA responded to those comments that raised substantive questions regarding project alternatives or environmental impacts. After each generic comment, the individuals making the comment are listed followed by TVA's response. Some of TVA's responses consist of referencing a portion of the FEIS that adequately addresses a given comment. The public comment letters received on the DEIS and the DEIS supplement during the public review period are found in Appendix H, Volume 3.

A. PROJECT OBJECTIVES

1. <u>Comment</u>

Why was medium-Btu gas selected as the end product instead of methanol? How does this product selection relate to locating the site so far from the source of the coal?

<u>Comment By</u>

W. K. Polstorff, 9/6/80 letter, page 1, paragraph 2.

<u>Response</u>

Medium-Btu gas (MBG) was initially selected as the end product because of its potential to serve a variety of energy needs--feedstock to produce methanol and other chemicals, methanation to synthetic natural gas, industrial fuel gas, and fuel cells. It also is the simplest synthetic fuel to produce with currently available technology. Subsequent studies indicate that methanol production onsite is economically attractive and may be included in the project.

Identification of the preferred site was based on the judgment that existing and new industries would be most effectively served if the plant were located in an area where there were existing industries capable of using a significant fraction of the gas. At this point, one cannot say for sure which, if any, existing firms in northern Alabama would switch to the product gas, but it is certain that existing markets could not be served if the gasification plant were located in a less industrialized region. Access to the Tennessee River allows the proposed facility to barge coal from a variety of mines and seams in and adjacent to the Tennessee Valley. While coal transportation costs would be lower if the plant were located adjacent to a several-hundred-million-ton reserve, TVA evaluations conclude that pipeline construction costs are more significant than costs associated with barge transport of coal. The economical transport distance for the MBG is approximately 100-150 miles (mi).

Please refer to the purpose and need section of the final environmental impact statement (FEIS) for additional information related to this question.

2. <u>Comment</u>

Is the building and operating of a demonstration coal gasification plant within the scope of responsibilities outlined in the TVA charter?

Comment By

Julian A. Greer, 9/10/80 letter, page 1, paragraph 7; Philip R. Owen, 9/20/80 letter, comment B1.

Response

The Tennessee Valley Authority Act of 1933, 48 Stat 58, as amended 16 U.S.C 831-831dd (1976), grants TVA broad authority to develop the natural resources of the Tennessee Valley region and to carry out demonstrations which will foster the physical, economic, and social development of the region. The proposed coal gasification plant was initiated in furtherance of those objectives. This project would also help meet the national objective of increased reliance on coal for energy needs. It is further believed that initiating the project and transferring it to private sponsorship with Federal loan guarantees is consistent with TVA's objectives of taking action to provide for the general welfare of the Valley citizens. Please refer to the EIS introduction for additional information on the question.

3. Comment

It is not necessary for TVA to demonstrate the economic feasibility and environmental acceptability of a coal gasification facility, since private industry will accomplish this objective.

Comment By

Philip R. Owen, 9/20/80 letter, comments B1, B18.

Response

As indicated in the response to question 2 above, TVA is charged with developing the Valley resources, and this project is in response to that responsibility. Nearly 2 yrs ago TVA commenced evaluating the feasibility of conducting a synthetic fuels demonstration project. The objective was to show that a commercial synthetic fuels plant could be built in an economically and environmentally acceptable manner in the TVA region. Subsequent to this evaluation, loan guarantees and other financial incentives have been made available by the U.S. Synthetic Fuels Corporation which make synfuel projects attractive for private financing. This has resulted in a number of proposed synfuel projects by private and public entities, all of which are looking toward some sort of government assistance. This appears to be the most appropriate method of financing these large commercial-scale projects, and TVA has now proposed to enter into agreements with a private entity to continue this project under private sponsorship. TVA believes that this proposed project will have more flexibility in dealing with economic and environmental problems because the process selection considered a number of technical, economic, and environmental considerations. The project is further along than other efforts, having already completed a DEIS. In addition, TVA is in a unique position to work closely with the U.S. Environmental Protection Agency (EPA) to resolve environmental and regulatory issues (see Appendix A). Further, the technical demonstrations being supported by the U.S. Department of Energy (DOE) are using more complex or advanced technologies. They would not reach and resolve the commercial-scale problems using high-sulfur eastern coals to produce a variety of products until several years after the north Alabama coal gasification project demonstrates possible solutions.

4. Comment

Did the EIS consider the possibility of solvent refining available coal resources, and supplementing hydro, nuclear, and steam power generation through existing transmission lines as a possible alternative project goal?

Comment By

Julian A. Greer, 9/10/80 letter, page 1, paragraph 7; and 9/30/80 letter, page 1, paragraph 6.

Response

Please refer to Section 2.1.3 in the FEIS for a discussion of this issue.

5. Comment

Why was the production capacity of the plant set at the equivalent of 50,000 barrels of oil daily? How many synfuel plants does TVA intend to build and where will they be located? Are there plans to enlarge or expand the coal gasification plant and thereby increase the production capacity of the plant in the future? If so, have the environmental consequences of these plans been assessed in the EIS?

Comments By

National Environmental Health Association, 9/26/80 letter, page 1, paragraph 2; Natural Resources Defense Council, Inc., attachment to 10/1/80 letter, page 2, paragraph 2.

Response

The size of the proposed north Alabama coal gasification plant reflects the generally accepted understanding of a "commercial-scale" plant. There are significant economics of scale for synthetic fuels plants. Engineering studies sponsored by the Department of Energy and others suggest that the cost per unit of output decreases with increasing plant size for small plants but is fairly flat in the 25,000 to 100,000 barrel of oil equivalent per day range. The 2 candidate sites appear suitable for a nominal 25,000-50,000 barrel-per-day (BPD) oil equivalent plant. The north Alabama facility is expected to consist of 2-modules with a nominal capacity of 25,000 BPD oil equivalent. Should it be technically and economically feasible, the facility would be expanded to 4-modules (50,000 BPD oil equivalent) at a later date. There are no plans to expand the size of the proposed coal gasification plant beyond 4-modules or to build additional plants. The environmental consequences of constructing the full 4-module plant have been assessed in the FEIS.

6. Comment

The final EIS should elaborate on the relationship between the proposed coal gasification plant and TVA's efforts to solve the energy requirements of the area. This discussion should reveal how coal gasification relates to TVA's overall strategy with respect to conservation, renewables, and the direct combustion of coal, hydro, and nuclear power.

Comment By

Natural Resources Defense Council, Inc., attachment to 10/1/80 letter, page 2, paragraph 2.

Response

Please refer to Section 2.1.3 of the EIS for a discussion of this issue.

7. Comment

Although it appears that gas generated from coal gasification is cleaner at the combustion point than raw coal, there are potentially more hazardous waste problems at the conversion site of coal gasification plants than at the site of direct coal combustion. How do these risks compare in terms of cost and effectiveness of available control technologies? What are the other tradeoffs? Are additional data needed and, if so, will the proposed coal gasification plant provide these data? How will TVA balance coal gasification, liquefaction, direct combustion, and other conversion technologies?

Comment By

Natural Resources Defense Council, Inc., attachment to 10/1/80 letter, page 2, paragraph 3.

Response

The coal gasification technologies currently under consideration for the project, Koppers-Totzek (K-T) and Texaco, are not considered to present significantly different waste disposal problems than direct coal combustion. Both methods of coal utilization produce coal ash and slag. Direct coal combustion with flue gas desulfurization produces a sludge which must be disposed of properly to protect ground water. Coal gasification technology such as K-T produces fly ash with a higher percentage of unconverted carbon than conventional power plant ash. This would require proper handling to preclude the contamination of ground water. A gasification plant requires that most (99% or more) of the sulfur in coal be removed from the product gas. This removal level is substantially higher than the level of sulfur removal presently required for new direct coal burning plants (90%). TVA believes that in the balance, there is no significant difference between the coal gasification technology under consideration for this project or direct combustion of coal in terms of environmental impacts and current control technologies.

Although significant information is now available to determine possible environmental consequences of each of the alternatives, TVA is conducting detailed environmental studies to provide additional information regarding solid waste and wastewater characteristics and control methods needed to properly handle and treat the waste. Studies already conducted at gasification plants in Europe would provide information on wastewater treatment and solid waste disposal methods. It is anticipated that this facility would provide valuable information covering a range of subjects from waste treatment and disposal to technical and economic questions.

Appendix B of the EIS discusses the gasifier testing programs that were conducted at the overseas gasification facilities. Section 2.1.3 of the EIS describes TVA's activities in balancing a number of energy technologies to meet its legislated goals and objectives.

8. Comment

I do not believe that the energy produced by the proposed coal gasification facility will be a major contribution to efforts for controlling the energy crisis.

Comment By

Reed D. Hamman, 8/9/80 letter, paragraph 2; and 1/19/81 referral letter, paragraph 3.

Response

While the capacity of the facility compared to the nation's oil needs is small, the facility is large when compared to regional needs. We believe it provides other benefits as discussed in the response to question 3 above.

B. COAL GASIFICATION FACILITIES AND OPERATIONS

1. Comment

How can the environmental assessment process be conducted when the specific gasification process or combination of processes has not been selected?

Comment By

Sierra Club, 9/14/80 letter, comment 1.

Response

The environmental assessment process, when applied to a large project such as the proposed north Alabama coal gasification plant, must consider a number of potential environmental impacts. These impacts are not limited to areas generally regarded as impact areas, such as water quality or air quality, but must also include socioeconomic impacts or stresses placed on an existing community in the project area. These stresses might include shortages of water supply or classroom facilities due to the influx of a large construction force. In other words, the environmental assessment must be viewed from a broad perspective to ensure that potential significant impacts are identified and evaluated. When this is done for large projects, many of the impacts during construction and after operation has commenced would be the same regardless of the technology, so that it is quite possible to assess numerous impacts adequately without knowing, for example, whether the plant would use Texaco or K-T gasification technology.

The 2 processes that are presently being considered are substantially similar from an environmental perspective. They both utilize high temperatures; both produce similar solid wastes; coal handling is somewhat different, but both processes require grinding the coal to a fine mesh size; both produce similar product gases; and wastewaters are expected to be comparable. Given all these similarities, it is quite possible to assess the potential impacts from the gasification plant without having selected a specific gasification process. It would have been, nevertheless, well within the bounds of the environmental assessment process to have considered more than one technology even if they had not been as similar as those under consideration for this project. But more importantly is that the National Environmental Policy Act (NEPA) requires that environmental information be available to the public and the agency discionmakers before major decisions are made and before major actions are taken. TVA believes that process selection is a major decision justifying the consideration of possible environmental consequences.

2. Comment

Does the total projected water usage include the water required for the methanation step? If not, what are the potential environmental impacts when this additional water usage is incorporated into the projected total water requirement for the facility?

Comments By

Philip R. Owen, 9/20/80 letter, comment B30; U.S. Environmental Protection Agency, 10/1/80 letter, page 2, paragraph 1.

Response

The total project water usage shown in Table 2-7 for K-T and Texaco includes the water required in the methanation step. Figures 2-5 and 2-6 are flow diagrams of the proposed coal gasification plant. The water intake requirement shown for the facility includes the shift reaction and methane production for a 4-module facility. The proposed 2-module facility would require approximately half of this amount. Should methanol be produced onsite, the water requirements for the 2-module facility would need to be increased by approximately 2000 gpm to meet cooling water needs for the methanol production facility.

3. Comment

The proposed design and location of the water intake structure should be given in the final EIS. The design should be in accordance with Section 316(b) of the Clean Water Act.

Comment By

U.S. Department of the Army, Corps of Engineers, letter (date unknown), comment c; U.S. Environmental Protection Agency, 10/1/80 letter, page 3, paragraph 1.

Response

Section 2.3.6 in the FEIS contains a discussion of the alternative water intake structure designs and locations considered for this project. These options were evaluated by TVA biologists who specialize in aquatic resources. TVA believes that the selected design and location is in accordance with Section 316b of the Clean Water Act. A detailed discussion of the intake structure assessment is provided in Section J, "Aquatic Ecology and Fisheries," of this appendix in the response to comment 2.

4. Comment

The proposed design and location of the discharge structure should be given in the final EIS. Because of seasonal thermal and oxygen stratification at Lake Guntersville, the FEIS should include evidence that the selective discharge structure design and location will not have a significant thermal impact on the lake.

Comment By

U.S. Environmental Protection Agency, 10/1/80 letter, page 2, paragraph 6.

Response

Section 2.3.6 in the FEIS contains a discussion of the alternative discharge structure options considered for this project. Please refer to parts I, "Surface Water and Ground Water" and J, "Aquatic Ecology and Fisheries," of this appendix for a discussion of the environmental impacts of the selected discharge system.

5. Comment

During what times of day will construction and operation of the plant take place? Will these activities continue seven days a week?

Comment By

Patricia Hodges Abney, 9/24/80 letter, paragraph 4.

Response

During the initial construction phases, activities likely would be limited to daylight hours 5 days/week. Activities during this phase would include site excavation and fill work, foundation work, and erection of superstructures. Should the project schedule require that certain activities be completed under an accelerated schedule, the project could go to a 6-day work week with work at night. This assumes that work is available that could be done at nighttime under safe working conditions such as finishing the inside of buildings.

Once the plant becomes operational, it would be operated continuously 7 days/week.

6. Comment

During which times of the day and which days of the week will the coal be unloaded from the barges at the site?

Comment By

Patricia Hodges Abney, 9/24/80 letter, paragraph 4.

Response

It is anticipated that coal would be unloaded Monday through Friday, 16 hr/day during the first and second shifts. It is conceivable that operational constraints may require that barges be unloaded on weekends, but it is not expected that the weekend would be a routine operating period for the coal unloading dock.

7. Comment

What are TVA's plans for barge operations and docking facilities?

Comments By

Max W. Ingram, 9/25/80 letter; U.S. Department of the Army, Corps of Engineers, letter (date unknown), comment b; U.S. Department of the Interior, 10/7/80 letter, page 3, paragraph 5; U.S. Environmental Protection Agency.

Response

For information on barging operations, please see Sections 4.1.1.5 and 4.2.1.5 of Volume 1 and Section 4.1.5 of Volume 2.

The facility is expected to consist of 2-modules with the capability to expand to 4-modules at a later date. Provisions would be made at the coal dock that would allow expansion of the barge storage area to allow storage of 24 empty and 24 full barges. Initial construction of the 2-module plant would not require as large a storage capability. A separate fleeting site has not been planned. Return tows would be assembled from the empty barges located at the plant barge docking area as opposed to a separate fleeting site. Shipment of sulfur by barge would require a sulfur dock with the capability of mooring 4 barges. It is estimated that sulfur transport by barge would require 1 tow every 15 days. The additional barge traffic should not adversely impact navigation on the Tennessee River. Impacts to recreational boating should not be significant.

The preferred docking facility alternative is located to reduce dredging for the navigation channel in the productive overbank area. This minimizes the potential need for maintenance dredging along the channel to once every 5-10 yr. Guntersville Lake records indicate minimal siltation over the lake life.

In order to provide sufficient room for storage and movement of barges if the coal unloading facility were located in the cove to the northeast of the site, extensive dredging of a productive overbank area of Guntersville Lake would have had to been done. Even then, the area for barge movement and storage would be much less than ideal. The docking alternative was rejected on the basis of the extensive dredging which would be required in a productive overbank area. In addition, this alternative presented a number of engineering and navigation difficulties. Noise impacts of the various docking alternatives do not vary significantly, although the alternative of locating the coal dock at the secondary channel appeared to have the greatest noise impacts because of its relatively close proximity to the opposite bank. This alternative was also more expensive and presented greater safety impacts. For a discussion of aquatic ecological concerns and possible mitigation, please refer to Section 4.2.4 (Appendix G) and the response to comment 1 under Section J of this appendix.

8. Comment

Could the Monsanto barge facilities be utilized?

Comment By

Lee A. Woodward, 9/16/80 letter, page 2, comment 2.

Response

The option of locating the facility at the Monsanto plant does not eliminate or reduce noise and dust controls, obstructions to boating, etc. The cost savings and resulting reduction of dredge and fill requirements for the project is greatly outweighed by the additional costs (including double handling of coal) and environmental implications of transporting coal by truck and rail over 5 mi. Therefore, utilization of the Monsanto barge facility would not be preferable from economic and environmental viewpoints.

9. Comment

We have reviewed the document and offer the following comments as they relate to those activities subject to Corps jurisdiction:

a. Temporary mooring or barge landing facilities required during construction are not identified. If such facilities are planned, they will require Corps approval and should be addressed in the final EIS.

Comment By

U.S. Department of the Army, Corps of Engineers, letter (date unknown), page 1, paragraphs 2 and 3.

Response

A barge slip used for construction and subsequent operational needs is addressed in Section 2.3.6 of the FEIS and is shown in Figure 2-4. Impacts are addressed in the response to comment 1, Section J, "Aquatic Ecology and Fisheries."

10. Comment

Where is the location of the spoil areas?

Comments By

U.S. Department of the Interior, 10/7/80 letter; U.S. Environmental Protection Agency, 10/1/80 letter.

Response

Locations designated for dredge material, soil spoil, and rock spoil are indicated on Figure 2-4 of the FEIS. Spoiling of these materials within the areas designated will be in accordance with environmentally acceptable methods. Runoff control will be provided for dredge and soil spoil areas as indicated in the construction phase NPDES permit.

Please refer to Section 4.2.2.3 of Volume 2 and Section J, "Aquatic Ecology and Fisheries" of this volume for discussions of the water quality and ecological impacts of the proposed dredging and dredge spoil disposal.

11. Comment

Concern was expressed regarding the purchase of an additional 200 acres of land, the intended use of this land, and the possible donation of such land to private interests.

Comment By

Cleveland E. Owen, 6/17/81 letter, paragraph 3; and Philip R. Owen, 6/29/81 letter, comment 5.

Response

The additional 200 acres of land referred to in the DEIS supplement have been under TVA's control since the 1930's when Guntersville Lake was initialy formed and were not recently purchased by TVA for use in connection with this project. Should the project move forward, this land, along with the land owned by TVA's power program would be sold to the private entity, not donated. As indicated in the FEIS introduction, TVA would be reimbursed for all federal funds expended on the project.

This additional land will be utilized as storage area for excavated soil generated during site preparation. This soil would be used later for various construction needs such as dike construction. The area may eventually be used to dispose of waste ash or slag, but present plans call for storage of excavated soil in this area.

12. Comment

Having read recently about advances in hydraulic conveyor technology, I wonder whether TVA has looked at this alternative approach.

Comment By

W. K. Polstorff, 9/6/80 letter, page 1, paragraph 3.

Response

TVA anticipates that significant technical problems may be associated with slurrying coal from a barge facility on the Tennessee River to the Courtland plantsite. The problems arise from having to handle and/or treat large volumes of coal slurry water (the pipeline would be 5-1/2 mi long), erosion and corrosion potential in the pipeline, plugging potential in the pipeline, and the ability to meet moisture specifications in the coal prior to entering the gasifier (e.g., the K-T process injects dry coal into the gasifier). In addition, the economics of coal slurry technology has not been proven for short slurry distances.

13. Comment

When the Courtland site was evaluated, was the temporary docking facility located on the river approximately 3 miles from the site (near Mile 282) considered as a possible site for unloading barges?

Comment By

Julian A. Greer, attachment (1/30/80 letter) to 9/10/80 letter, paragraphs 4 and 6.

Response

TVA evaluated locating a docking facility near Tennessee River Mile (TRM) 282. (This location is approximately 5-1/2 mi from the plantsite.) In addition, TVA considered a dock location near TRM 283.5 at Spring Creek embayment. After dredging Spring Creek embayment, the barge unloading facility would be approximately 3 mi from the plantsite. This alternative was rejected on the basis of environmental impact to a sensitive area (Spring Creek embayment) and economics (the plant intake would be located at TRM 282 even if the barge facility were to be located at Spring Creek embayment; this would require acquisition of 2 land corridors from the Courtland plantsite to the Tennessee River).

C. PROCESS WASTES

1. Comment

It is difficult to assess the plant and its impacts on public health and the environment unless more information is available on wastewater treatment technologies and the expected characteristics of water discharges. The FEIS should contain a more thorough discussion of wastewater treatment of each process, incorporating the following factors:

a. a detailed discussion of the procedures (preferred and alternative) for removing pollutants from the wastewater, indicating the control efficiency of each procedure (per coordination with EPA-IERL);

b. a more precise estimate of the amounts and the expected characteristics of the raw wastewater and the effluent;

c. a discussion of the fate of priority pollutants within the individual treatment processes and in the environment;

d. a conceptual flow diagram indicating the different control technologies and the waste streams and discharge points requiring an NPDES permit;

e. a table or graph comparing levels of potential water pollutants with EPA acceptance criteria;

f. a discussion of potential health and environmental impacts of specific water pollutants that are associated with normal operations and with worst-case failure modes.

g. a determination of whether the various major wastewater streams (both treated and untreated) and treatment byproducts are potentially toxic, mutagenic, or carcinogenic.

Comments By

Kenneth C. Johnson, 9/21/80 letter, page 2, paragraph 2; Natural Resources Defense Council, Inc., attachment to 10/1/80 letter, page 3, paragraph 3; page 4, paragraph 1; page 6, paragraph 2; and page 14, paragraphs 1 and 2; Philip R. Owen, 9/20/80 letter, comment B34; and attachment 3 to 9/25/80 letter, page 1, paragraph 2; Tennessee Toxics Program, attachment to 8/25/80 letter, page 2, paragraphs 1, 5, 6, and 8; U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 2, paragraph 3.

Response

TVA has undertaken 2 testing programs to confirm the estimates and assumptions made in the FEIS relating to K-T and Texaco gasifier operating parameters while gasifying Eastern U.S., high sulfur coals. This information will be used to design the gasification system ultimately recommended by TVA for the proposed north Alabama coal gasification plant.

As part of these efforts, TVA is conducting environmental tests on each gasifier to support design and environmental permitting activities. Specifically, waste samples obtained during these efforts will undergo characterization, treatability, and bioassay studies. Results of these studies will be used to confirm TVA's present wastewater treatment conceptual designs discussed in Section 2.3.6 and Appendix B.

A listing of key environmental control decision items are found in Appendix A. In addition, an environmental study program that, among other activities, would include the assessment of the wastewater treatment system performance would be implemented as required by the NPDES permits. An outline of an environmental study program is given in Appendix A. Appendix B and Sections 4.2.2 and 4.2.4 of Appendix G present information on the potential water pollutants from coal gasification facilities and their possible impact on the environment. Section J of this appendix also addresses actions with regard to release of wastewaters.

2. Comment

The draft EIS indicates that there are no tars or oils formed in the K-T reactor. Is this correct?

Comment By

Tennessee Toxics Program, attachment to 8/25/80 letter, page 2, paragraph 4.

Response

Due to the high, relatively uniform reaction temperatures of the K-T gasification process about 93% of the carbon material in coal during steady state operation is converted to carbon dioxide (CO_2) and carbon monoxide (CO). The remaining carbon is lost in the fly dust. Tars and oils are produced when stratified temperatures occur in a reaction bed and volatile organics are stripped from the coal as hot product gases leave the reaction chamber. The gasifier initially would be brought to operating temperature using other fuels such as MBG or low-sulfur fuel oil. A discussion of tar and oil formation can be found in Section 2.3.2.4 in the FEIS. It is correct that the K-T reaction is free of tar and oil byproducts.

3. Comment

Page 2-29, Table 2-7. In the Lurgi system, tars are recycled to the gasifier. This is an experimental process since there are no commercial operations which recycle tars. Unless TVA has or will be obtaining specific data on recycle use, this may be a questionable approach. If the tars cannot be recycled and provisions have not been made for combustion or incineration, will the tars be disposed of as a hazardous solid waste?

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 4, paragraph 1.

Response

Based on the conceptual design work conducted for TVA, both the Lurgi dry-ash and slagging Lurgi designs called for tar recycle to the gasifier. We have no specific information on tar recycle other than this which came from the gasifier vendor. The problem of the existence of tars associated with the Lurgi process is one of the reasons TVA has identified the K-T or Texaco gasification technology as the preferred processes for the north Alabama facility.

4. Comment

The draft EIS indicates that of the 3 high temperature processes (B&W, K-T, and Texaco) which do not produce large amounts of toxic organics, K-T produces the least amount of hazardous organics.

What hazardous organics are produced from each gasification process? What amount of these could be recycled to the feed slurry to degrade in the reactor? How much would be expected to accumulate in low or cool spots in the system, thereby resulting in maintenance problems? How much would be expected to escape by leakage in gas or liquid streams?

Comment By

Tennessee Toxics Program, attachment to 8/25/80 letter, page 1, paragraphs 1 to 4.

Response

The organic compounds referred to in the draft environmental impact statement (DEIS) were low molecular weight organics that contaminated water used for cooling and cleaning product gases. None of the compounds are produced as byproducts or could be recycled to the gasifier. We would expect none of these compounds to accumulate in low or cool spots creating a maintenance problem. None is expected to escape as a result of leaks in gas or liquid streams.

As indicated in the FEIS, the B&W gasifier is not sufficiently developed to meet the project's present schedule. There are no commercial or semicommercial scale B&W gasifiers operating, and only estimated emission levels have been reported. It is, therefore, not possible to give more detailed information on this system. Information on the organic compounds present in the K-T and Texaco gasifier wastewaters is presented in Appendix B. Please refer to the response to question 1 above for a description of TVA's activities regarding gasifier waste characterizations.

5. Comment

Page 2-51, Table 2-9. It is considered imperative that a Biological Oxidation process can be used to remove dissolved organics from water effluent.

Comment By

Philip R. Owen, 9/20/80 letter, comment B33.

Response

Please refer to Section 2.3.6 and Appendix B of the FEIS for a discussion of the plant's conceptual wastewater treatment facility and associated effluents.

6. Comment

The DEIS indicates that, when practicable, process streams will be recycled to protect public and occupational health. How much of the process streams and which ones would be expected to be recycled? Since substances often accumulate at certain points in the system, recycling usually requires a "bleed point." Where is this expected to be in the system? What methods will be used for handling and disposal of substances "bled" from the system?

Comment By

Tennessee Toxics Program, attachment to 8/25/80 letter, page 2, paragraph 10.

Response

Section 2.3.6 and Appendix B of the FEIS contain a description of the conceptual wastewater treatment system. This discussion indicates which streams could be recycled, where "bleed points" or blowdown could occur, and the expected fate of the blowdown streams. Please also refer to the responses given to comment 1 above and to comment 2 under part R, "Public Health and Safety."

7. Comment

The estimated liquid effluents of the coal gasification plant given in the DEIS (Table 2-10) should reflect the expected discharge flow for the entire facility rather than for one module (1/4 of the plant).

Comments By

Philip R. Owen, 9/20/80 letter, comment B35; U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 2, paragraph 2.

Response

Table 2-10 in the DEIS did show effluents for only 1 module. This table was replaced in the FEIS with Tables B-18 and B-19 and other information on flow rates, wastewater treatment, and water distribution for the proposed facility that supplements Chapter 2 and Appendix B of the document. All discharges indicated in the FEIS, whether solid, liquid, or gaseous, are for a 4-module facility.

8. Comment

The DEIS (Table 2-10) indicates that 100,000 lbs/hr of service water with BOD of 50-150 mg/l and 150,000 lbs/hr of ash pile leachate with BOD of 10 mg/l represent part of the expected liquid effluents estimated from conceptual design studies. What compounds are expected to be present in each of these effluents? Will these effluents be pumped to the cooling tower? If so, is this an environmentally acceptable procedure?

Comment By

Tennessee Toxics Program, attachment to 8/25/80 letter, page 1, paragraphs 10 and 11.

Response

Information on the conceptual wastewater treatment system and the expected composition of various wastewater streams is given in Section 2.3.6 and Appendix B of the FEIS.

9. Comment

Page S-2, paragraph 4 states 'TVA prefers a high degree of detail regarding potential discharges and waste products. This level of detail is not presently available.' How then can this plant and its impact on the environment be analyzed at this time? When will the public be informed that the level of detail regarding potential discharges and waste products is presently available? Will construction of the Murphy Hill plant be held in abeyance pending receipt of the required detail? If construction will not be held in abeyance until such time, please inform every person in writing who furnished comments on this EIS of these questions and TVA answers.

Comment By

Kenneth C. Johnson, 9/21/80 letter, page 2, paragraph 2.

Response

Concerning questions related to TVA's capability to analyze potential impacts to the environment from the project at this time, the reader should refer to the response provided to question 1 above. As the FEIS indicates in various sections, existing data do not permit a definitive analysis of all potential impacts to a degree TVA normally prefers. However, existing data are sufficient to estimate potential impacts and to provide a clear basis of choice among available alternatives. Emissions to the air, wastewater effluents, and solid wastes would be managed consistent with permit requirements of the State of Alabama. State regulations require that the public have an opportunity to participate in the permitting process. In addition, with EPA's cooperation and advice, the north Alabama coal gasification plant design is expected to be environmentally acceptable.

10. Comment

The EIS indicates that ash will contain heavy metals, but does not indicate whether organics will be present. I believe that the EPA EP toxicity procedure should be used to test for organics in the ash.

Comment By

Tennessee Toxics Program, attachment to 8/25/80 letter, page 1, paragraph 9; and page 2, paragraph 7.

Response

TVA obtained samples of waste slag and ash during gasifier testing programs conducted in Germany (Texaco process) and Greece (K-T process) using design coal. (Refer to Appendix B for additional information on these testing programs.) The EPA extraction procedure (EP) Toxicity test would be applied to both ash and slag for metals determination. Since the EP is only good for 6 pesticides, the ash and slag would also be analyzed for the presence of organics by extraction procedures developed by EPA and TVA for solid materials. The results would be used to confirm TVA's appraisal of waste character.

11. Comment

Page G-69, 4.2.12.1, first paragraph. Fly ash waste, bottom ash waste, slag waste and FGD waste have been generally classified as nonhazardous pursuant to Part 261.4(b) of the Resource Conservation and Recovery Act (RCRA). However, this part, as presently written applies only to waste generated from industrial boilers and not from coal gasification processes. EPA will clarify this situation in a Regulatory Interpretative Memorandum (RIM). The FEIS should contain this document. This could require TVA to perform characterization study of these waste streams pursuant to Subpart C of RCRA.

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 4, paragraph 3.

Response

At this time, the referenced RIM has not been released by EPA. However, TVA is currently conducting tests on slag and ash from operational facilities in Europe to determine if these wastes could be classified as hazardous. (Please see Appendix B.) The disposal of slag and ash would be in accordance with applicable State and Federal regulations.

12. <u>Comment</u>

The DEIS does not provide enough data and analytical information on the expected characteristics of solid waste streams and leachates. More geological, hydrological, and engineering design information should be given in the FEIS that will detail control of leachate from waste disposal and its treating. This discussion should include information on the type of liners to be used for preventing soil, ground water, and surface water contamination.

<u>Comments By</u>

Patricia Abney, DEIS public hearing transcript, page 38, paragraph 4 to page 39, paragraph 1; Kenneth C. Johnson, 9/21/80 letter, page 2, paragraph 2; Natural Resources Defense Council, 10/1/80 letter, page 15, paragraph 5; Helen Nelson, attachment to 9/28/80 letter, page 1, paragraph 2; page 2, paragraph 2; James Nelson, 9/28/80 letter, comment 1; Philip R. Owen, 9/20/80 letter, comments A3 and B32; attachment 3 to 9/25/80 letter, page 1, paragraph 2; Tennessee Toxics Program, attachment to 8/25/80 letter, page 1, paragraphs 9 and 10; page 2, paragraphs 7 and 9; U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 4, paragraph 2.

<u>Response</u>

The options outlined in Section 2.3.6.11 of the FEIS encompass the range of available alternatives for solid waste disposal. Additional studies would be performed to define further the hydrogeological characteristics of the waste disposal area and to identify existing ground water supplies. TVA is conducting an environmental testing plan that includes:

a. slag characterizations

b. leaching studies

c. aquatic toxicity testing

d. mutagenicity/carcinogenicity testing

All of the slag for these studies was produced from the project design coal. These studies should further characterize the effects, if any, that ash/slag leachate would have on local ground water. As further information develops, a preferred solid waste disposal alternative would be selected, including foundation requirements, that appropriately protects ground water quality. TVA is fully coordinating this approach with the State of Alabama Department of Public Health. For more detailed information on leaching characteristics of the solid waste, please refer to Section 2.3.3 and Appendix B of the FEIS. In addition, please refer to the response to comment 6 in "Q. Solid Waste Disposal" for more information on methods for mitigating potential impacts from solid waste disposal.

D. SITE SELECTION

1. Comment

What sites were evaluated as possible locations for the coal gasification facility?

Comment By

Kenneth C. Johnson, 9/21/80 letter, page 3, paragraph 2.

Response

Section 2.2 "Site Screening Studies" describes the siting activities performed for the coal gasification project. Figure 2-1 in that section identifies the 15 sites considered for the coal gasification plant.

2. Comment

Please elaborate on the detailed environmental considerations evaluated during the site screening process and describe the criteria for rating each consideration of A through D as in Tables 2-2 and 2-4 of the DEIS.

Comment By

Kenneth C. Johnson, 9/21/80 letter, page 3, paragraph 3; and page 4, paragraphs 2 and 3.

Response

Tables 2-2 and 2-4 list a number of siting considerations that were used to evaluate possible sites for the proposed coal gasification plant. TVA rated each site as to its desirability for development based on criteria established for each evaluation category. Some of the site rankings were based on estimated costs, such as site development costs or fuel transportation costs (see Table 2-2 and 2-4 footnotes 11 and 15). Some of the other category rankings were explained in the table footnotes. All of these rankings taken together gave a general indication of the suitability of a given site for a proposed action. The following material is provided to expand on the criteria used to evaluate a site in a given evaluation category.

a. Socioeconomic, Recreational, Cultural, and Agricultural Resources

Construction of a coal gasification facility at any location may or may not significantly affect the socioeconomics of the surrounding communities. The level of significance associated with the number of inmoving workers is determined in large part by the size of the surrounding communities and the growth trends in the area. The urban services and facilities (water supplies, sewers, highways, school systems, utilities, recreation, etc.) of a large urban area or one that is expanding with proper planning would probably be able to absorb a reasonable population influx. Smaller towns or those with few services and facilities would more likely experience significant impacts. During the initial site screenings no labor force estimates were available, therefore, no detailed assessments of socioeconomic impacts were generated. Evaluations were based primarily on the potential for adverse socioeconomic impacts and compatibility with existing land uses. If a site area was sparcely populated, it was generally regarded as an area more susceptible to adverse socioeconomic impacts. The existing and, where available, projected land use in the site area and the general vicinity were characterized, giving a general idea of a facility's compatibility with its surroundings in the event it were developed. If it appeared that development of the facility was generally in line with existing or anticipated land uses and the potential for adverse socioeconomic impacts was low, a site area was rated high.

Features within or near the site areas having recreational, scenic, historical, and archaeological importance were identified from existing information. Of foremost concern were features listed on the National Register of Historic Places, Federal and State recreation areas, and areas of important scenic value. In addition, the occurrence of recorded archaeological sites was noted for confidential use in site assessments. Site ratings were based on the potential for a given proposed action to impact any of these recreational or cultural resources.

Assessments of the agricultural resources at each site were generally determined by interpreting existing soil survey information as published by the Soil Conservation Service, U.S. Department of Agriculture. The evaluation of prime farmland was in accordance with guidelines established by the Council on Environmental Quality.*

b. Natural Resources

Assessments and ratings for aquatic ecology and fishery resources in the vicinity of each site were based on readily available information concerning listed or proposed threatened and endangered species; the identification of critical, sensitive, unique, or productive aquatic habitats; and sport or commercial fishing areas. Good wetland habitat and the location of apparently unique or important wetlands as defined by Executive Order 11990 were identified by map reconnaissance and aerial overflights.** Terrestrial and upland wildlife resource assessments in the vicinity of each site were also based on readily available information concerning known occurrences of threatened and endangered species listed on either Federal or State lists, and the identification of existing or potentially good habitat for various species.

c. Environmental Considerations

Air quality assessments keyed on identifying possible air quality limitations due to site proximities to either Prevention of Significant Deterioration (PSD) Class I or nonattainment areas for any of the criteria pollutants, particularly sulfur dioxide (SO_2) or total suspended particulates (TSP). Due to the lack of design information and site-specific data, the air quality assessments performed were based on professional judgements and some general modeling results.

The potential impacts on surface and ground water quality that might occur due to coal gasification plant construction and operation at each potential site were assessed in light of readily

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*These guidelines were issued August 30, 1976, by memorandum from Russel E. Patterson to the Heads of All Federal Agencies, with the subject, "Analysis of Impacts on Prime and Unique Farmland in Environmental Impact Statements." Prime farmlands are those whose value derives from their general advantage as cropland due to soil and water conditions. Unique farmlands are those whose value derives from their particular advantages for growing specialty crops.

**Executive Order 11990 was issued May 24, 1977, and pertains to "Protection of Wetlands." The term "wetlands" as defined in the order means those areas that are inundated by surface or ground water with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction.

available information and professional judgement. Consideration was given to the overall water availability in conjunction with existing major users within a 20-mi radius; site drainage patterns; evaluations of the existing physical, chemical, and sanitary engineering properties related to surface waters; and evaluations of existing water quality standards and their implications to plant development.

d. Site Engineering Considerations

A number of site features were evaluated to determine a site's overall desirability from an engineering feasibility standpoint. These site-related features included the acreage and potential for development; site geology; site access; potential connections to a transmission line; water supply; and potential for flooding.

In order to assess the potential for site development, preliminary site layouts were prepared based on estimates of the gasification facility, waste storage, and support systems requirements for space. This included evaluating rail, barge, and highway routes to each site. Available geological information was used to make preliminary evaluations of a site's foundation conditions.

General assessments of each site's compatibility with the existing transmission system were made under the conditions of (1) 50-MW peak load, (2) up to 500-MW peak load, or (3) use of product gas for electrical generation and 1800 MWe capacity on the system. The assessments included determinations of impacts the additional load would have on existing transmission facilities with respect to both bulk and subtransmission supply problems.

Assessments of water availability at each site considered an assumed water consumption of 50 cubic feet per second (cfs) with either a continuous 10 cfs discharge or closed cycle, zero discharge. No assumptions for thermal or chemical discharge components were made nor were any modeling activities performed. Assessments were based totally on professional judgements and past operating experiences.

Flood profiles were determined for the 1% chance (100 yr) and 0.2% chance (500 yr) flood, TVA structure profiles where applicable, and TVA maximum probable or Corps of Engineers (Corps) standard projected flood elevations were used in evaluating each site.*

3. Comment

During the site selection process TVA should not consider land ownership as an advantage in evaluating sites, since the cost of the possible sites is insignificant compared to the cost of constructing and operating a coal gasification facility.

Comment By

Philip R. Owen, 9/20/80 letter, comment B24.

Response

While it may be true that the cost of land is small compared to the ultimate project costs, there are a number of advantages to TVA land ownership other than project costs. One advantage is the fact that siting the facility at TVA-owned locations would not require relocating private citizens. In view of the importance placed on an accelerated schedule it was believed that land ownership by TVA would be a positive benefit for the project.

Through TVA's ongoing siting activities a number of sites had been evaluated as possible locations for a major power producing facility. As a result of these studies some sites were purchased because they displayed characteristics desirable for a power plant site. TVA had accumulated environmental data on these sites which could be used to support assessments required for an environmental impact statement.

4. Comment

The EIS did not evaluate all alternative sites with detailed statistics and facts.

Comment By

Mildred Adams, 9/24/80 letter, paragraph 1.

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*This information was also used to provide assessments on possible impacts covered by Executive Order 11988 (May 24, 1977), "Floodplain Management." This order directs Federal agencies to avoid, to the extent practicable, the long- and short-term adverse impacts associated with the occupancy and modification of floodplains. In addition, TVA stipulates that the TVA structure profile elevation be used as the minimum acceptable level for all buildings where flooding damage would be significant on all land it owns or for which it has flowage easements.

Response

In the project siting activity, each of the 15 alternative sites were evaluated in a number of areas. As indicated in the response to question 3 above, some sites had been evaluated previously and more environmental information was available. As the site screening process progressed, an increasingly detailed level of information was gathered. There was, however, sufficiently detailed information available to evaluate each of the alternative sites. Please refer to Section 2.2, "Site Screening Studies," in the FEIS for additional information.

5. Comment

Before the final site is selected for the proposed coal gasification facility, TVA should re-evaluate whether it is necessary to locate the facility on a natural waterway.

Comment By

Philip R. Owen, attachment 3 to 9/25/80 letter, page 1, paragraph 2.

Response

TVA has evaluated the location of power plants on land which is not located on a waterway. It is found that locating a power plant on land with immediate access to a waterway is more economical as well as an operational advantage. These studies indicate that the proposed coal gasification plant, which is in many respects similiar to a power plant, should also be located on a waterway. Please refer to the economic site comparison given in Table 2-5.

6. Comment

The coal gasification plant should be located downstream from Murphy Hill. The relative ranking of the initial sites in the draft EIS (Table 2-2) seems to support locating the coal gasification facility at either Little Cypress or Saltillo.

Comments By

Max W. Ingram, 9/25/80 letter, paragraph 1; Philip R. Owen, 9/20/80 letter, comment B23.

Response

There were basically 2 phases to the siting process. The initial phase resulted in identifying 1 or more sites in each respective market area as identified in the FEIS. These siting results are given in Table 2-2. The second phase (Table 2-4) was used to identify the best available site in the desired market area (north Alabama). Neither Little Cypress nor Saltillo are in the desired market area. Murphy Hill was the best site in the north Alabama market area.

7. Comment

People would not need to move if the plant were located at any 1 of the 4 possible locations in Lawrence County. There are adequate facilities located on the river, including 2 sites that are owned by TVA and another that TVA has the option to buy.

Comments By

Jan P. Horne, 9/25/80 letter, page 1, paragraph 3; Howard Lloyd, DEIS public hearing transcript, page 44, paragraph 8 to page 45, paragraph 1; Grady Terry, DEIS public hearing transcript, page 116, paragraph 4 to page 117, paragraph 1.

Response

TVA has never owned a parcel of land in Lawrence County capable of supporting a facility of the magnitude of the proposed coal gasification plant (except for the Courtland site). In 1977 TVA undertook a power plant siting study for north Alabama that eventually narrowed the potential sites considered down to 3 sites--Town Creek, located at TRM 270.5; Westmoreland, located at TRM 272.5; and the Courtland site. It was concluded that of the 3 sites considered, Courtland was the preferred site. Further, there are no areas in the TVA lake land along Wheeler Lake that are capable of supporting the proposed facility.

8. Comment

If Yellow Creek Port Site has been compared with Murphy Hill at mile 364, or the embayment (U.S. Champion) at mile 283.5 at Courtland, Murphy Hill is isolated by distance from the raw material, as well as off center from booster station and pipeline transmission centers.

Comment By

Julian A. Greer, attachment (1/30/80 letter) to 9/10/80 letter, paragraph 3.

Response

TVA records indicate that the only dock of any size in the vicinity of TRM 283.5 is the Champion Paper Company dock located at TRM 282.1. TVA assumes that the demands of the proposed coal gasification plant on a docking facility would preclude the use of another organization's docking facility. A new dock would have to be developed if it were decided to barge the coal to this point on the river. The Spring Creek embayment located at TRM 283 near the Courtland site is considered to be a highly sensitive, productive environmental area. During the site evaluation process it was determined that the Spring Creek embayment should be avoided. This site is, therefore, not considered to be a viable location for a coal receiving dock. In addition, transporting coal by rail from the Yellow Creek port at TRM 364 would be substantially more expensive than by barge and would likely incur additional expense for the additional handling required. Please refer to the response to comment 10 below.

9. Comment

The coal gasification plant should be located at the mine location or at a site (such as Courtland, Saltillo, or Little Cypress) that is closer to the mine than Murphy Hill. This would alleviate potential solid waste disposal problems.

Comments By

Mercer Clayton, 9/24/80 letter, paragraph 4; Reed D. Hamman, 8/22/80 letter, page 1, paragraph 6 and 1/19/81 referral letter, paragraph 3; Dorothy P. Hard, 9/22/80 letter, page 2, paragraph 5 to page 3, paragraph 1; Charles and Dorothy Hellums, 9/12/80 letter, paragraph 3; Thomas A. King, DEIS public hearing transcript, page 113, paragraph 3; Cleveland E. Owen, 6/17/81 letter; Philip R. Owen, attachment (1/22/80 letter) to 9/25/80 letter, page 2, paragraph 1; 9/20/80 letter, page 13, paragraph 3, and comments B12 and B22; and DEIS public hearing transcript, page 71, paragraph 1; Ruth C. Owen, 9/22/80 letter, paragraph 1.

Response

Locating the proposed facility at another location, such as Courtland, would not alleviate potential solid waste disposal problems. As a matter of fact, the engineering assessment in the FEIS indicated that the Courtland site presented more problems for solid waste disposal than did the Murphy Hill site. Depending on the specific circumstances, mine disposal of solid waste may be feasible. Potential mine mouth locations evaluated in the site screening studies were rejected for economic reasons. Regardless of the plant location, solid waste would have to be disposed of in an environmentally acceptable manner. Additionally, while it is probable that most of the coal for the facility would be obtained from downstream supplies, it is possible that some of the coal would come from upstream sources.

10. Comment

When evaluating the Courtland site, did you consider transporting equal amounts of the 20,000 ton/day coal supply base by rail, highway, and barge?

Comment By

Julian A. Greer, attachment (1/30/80 letter) to 9/10/80 letter, paragraphs 3, 4, and 6; 9/30/80 letter, page 1, paragraph 3.

Response

When evaluating the Courtland site TVA evaluated 2 coal transportation options--100% transport by barge with a conveyor system to the plant from the coal dock and 100% transport of coal by rail. Rail transport, being about twice the cost of barge transport, was economically prohibitive. Coal transport by highways was not considered because it would be more economically prohibitive than rail transportation.

11. Comment

Did TVA consider obtaining the coal supply from Walker County when the Courtland site was evaluated?

Comment By

Julian A. Greer, attachment (1/30/80 letter) to 9/10/80 letter, paragraph 6; 9/30/80 letter, page 1, paragraph 3.

Response

High-sulfur coal not suitable for metallurgical applications or use in direct burning facilities would probably comprise a major portion of the proposed plant's coal supply. It is anticipated that coal will be obtained from a number of locations in the eastern U.S., possibly including Alabama. Walker County, Alabama, has not been specifically considered as a source of coal for the proposed plant.

12. Comment

The reason the Murphy Hill site was preferred for the coal gasification plant is that there is a seam of coal about 18 inches thick approximately 60 feet underground on Sand Mountain.

Comment By

Fred Weaver, DEIS public hearing transcript, page 28, paragraph 1.

Response

The availability of coal in the Sand Mountain area was not considered in the siting process. The reserves in this area, while potentially contributing to the plant's coal supply, are not sufficient to meet a major fraction of its needs.

13. Comment

The coal gasification facility should be located at a site that is more accessible by rail and/or highway and not so dependent on accessibility by water.

Comment By

Julian A. Greer, 9/10/80 letter, page 1, paragraph 4; attachment (9/10/80 letter) to 9/30/80 letter, page 1, paragraph 4.

Response

Based on TVA's experience at its coal-fired power plants, barging is the most economical method of transporting coal over long distances. Over the past 10 yr, the percentage of total coal that was shipped by barge to TVA power plants has increased from 15% to 46%. At times it may not be possible to ship coal by barge due to ice on the river, low water levels, or locks being out of service for maintenance. During these periods it is expected that the plant would operate on the 90-day coal supply which would be stored onsite.

14. Comment

The coal gasification facility should be co-located with an existing power plant.

Comment By

Philip R. Owen, attachment (1/22/80 letter) to 9/25/80 letter, page 2, paragraph 1.

Response

In TVA's site screening process, a power plant site, Paradise, was evaluated as a possible location for the facility. The site did not prove to be acceptable due to the presently existing impacts of the power plant. Please refer to Section 2.2 "Site Screening Studies" for a discussion of the Paradise site evaluations and to the response given to question 15 below for additional information.

15. Comment

The plant should be located in an area that is already industrialized.

Comments By

Jenny M. Helderman, 9/28/80 letter, page 1, paragraph 5; Philip R. Owen, attachment (1/22/80 letter) to 9/25/80 letter, page 2, paragraph 1.

Response

Industrialized areas were considered in TVA's evaluation of potential sites. As indicated in the response to question 14 above, an area that could generally be considered to be industrialized, a power plant site, was evaluated as a possible location for the proposed gasification facility. One of the major considerations associated with locating in an industrialized area is the existing air pollution levels. Under present air pollution regulations established by EPA, the air in an area can only be polluted to a certain level. Once this level is reached, no more emissions to the air would be allowed in the area without offsets. This is a constraint on the continued development of industrialized areas, and encourages one to move to areas where little or no industrial development has occurred.

16. Comment

TVA did not consider alternatives that would prevent the severe environmental impacts expected from locating the coal gasification plant at Murphy Hill.

Comments By

Joseph V. Olszewski, 9/26/80 letter, page 1, paragraph 4.

Response

TVA considered a number of alternatives, both for the plant site and the technology used at the facility. Please refer to Chapter 2, "Alternatives" for a discussion of the alternatives considered for the project. In addition, approximately 300 pages in the DEIS were used to evaluate environmental impacts and possible mitigation measures which would reduce potential impacts.

17. Comment

Because it appears that the Courtland site has better air pollution dispersion, deeper water for enhanced mixing of discharges, no extensive overbank areas, better noise conditions, and minimal impacts to vegetation, waterfowl, and wildlife, I believe that it would have fewer expected environmental impacts than the Murphy Hill site.

Comment By

Philip R. Owen, DEIS public hearing transcript, page 70, paragraph 3, to page 71, paragraph 3.

Response

TVA's environmental assessment based on a 4-module facility indicated that the Courtland site does have slightly better air dispersion characteristics in some respects, but the proximity of a PSD Class I area would complicate siting the proposed plant at Courtland. The differences between each site in wastewater discharge mixing is insignificant. Noise will impact more people at Courtland but may be considered more intrusive at Murphy Hill. TVA's assessments further indicate that with appropriate mitigation, the impacts to overbank areas could be reduced substantially. Courtland does present the least potential for adverse impacts to waterfowl and wetland wildlife. From solid waste and cultural resources standpoints, Murphy Hill is clearly preferable. In summary, TVA studies indicate that from a comparative standpoint the desirability of each site varies from environmental parameter to environmental parameter. From an overall environmental standpoint, the 2 sites are either equivalent or Murphy Hill is slightly preferable.

18. Comment

It was indicated that the EIS should address the possibility that the reduction in size to a 2-module facility could make another site economically and environmentally preferable to the Murphy Hill site.

Comment By

Alabama Department of Conservation and Natural Resources, Game and Fish Division, 6/22/81 letter, paragraph 2, and attachment, paragraph 1.

Response

The siting process for the proposed North Alabama coal gasification facility began about two years ago using a number of valid siting criteria. The EIS which documented the siting process has been undertaken in the very early stages of the project to evaluate potential environmental impacts early in the decision making process. As a result of the project's natural progression and development, changes in the project scope have occurred, but these do not warrant reevaluating possible sites with new siting criteria. The initial siting activities resulted in identifying a preferred site that has no environmental restrictions precluding its use. Land requirements remain the same since the project may expand to four modules at a future date if technically and economically justified. Further, marketing studies indicate that operating a facility in north Alabama is economically viable. Having already identified a site that is environmentally, technically, and economically viable, reassessing the range of possible sites would contribute little to the decision-making process.

E. PRODUCT GAS DISTRIBUTION

1. Comment

The Courtland site is located near most of the projected market area for the MBG product, whereas there is a relatively small projected market in the vicinity of the Murphy Hill site. The DEIS provides the same possible pipeline routings for distributing the product from a coal gasification plant located at either site. However, only 25 to 50 mi of pipelines would be required to serve most (80%) of the market area if the coal gasification plant were located on or near the Courtland site. The remaining 20% of the market could be served through existing natural gas lines using the MBG product or natural gas saved by converting other industries to MBG. If the coal gasification plant were located at Murphy Hill, approximately 100 to 150 mi of pipelines would be required to serve the major market area. The MBG product should be distributed to the major market area through the shorter pipeline routings, and the plant should be located on or near the Courtland site. In addition, it is suggested that the plant be either collocated with industry or located near the heaviest industrial users, thereby assuring a market and preventing a loss of energy from the MBG product during distribution.

Comments By

Reed D. Hamman, 1/19/81 referral letter, paragraph 3; James B. Kyser, 9/22/80 letter, page 1, paragraph 5; page 2, paragraphs 2 and 3; Philip R. Owen, 9/20/80 letter, comments B8, B9, B14, B21, and B26 to B29; and DEIS public hearing transcript, pages 68-71; Lee Woodward, 9/16/80, letter, page 1, comment 1A.

Response

In evaluating the Murphy Hill and Courtland sites a site-related variable cost analysis was done to compare the 2 sites. As part of this analysis TVA developed a hypothetical MBG pipeline route and market area that would be identical for each site. This allowed a comparison of the MBG pipeline capital costs with the plant located at either Courtland or Murphy Hill. All of the pipeline routings were hypothetical and, should, therefore, be viewed as illustrative examples rather than preferred choices. The estimated costs for this hypothetical pipeline indicated that the pipeline would be somewhat more expensive if the plant were located at Murphy Hill. The overall costs indicated, however, that the Murphy Hill site was more economical.

It is difficult and would be speculative to assess the various scenarios, such as the one suggested, involving fuel switching by existing industries. Although early siting studies and marketing activities focused on existing industries, current industrial interests indicate that the basic use patterns will be determined by a few large new chemical plants producing methanol, gasoline, and related synthesis gas chemicals. Plants would probably be sited using normal industrial siting processes, taking into account that MBG can be piped over tens of miles.

A similar situation exists with methane or SNG. As shown on Figure 2-7, an SNG pipeline from Murphy Hill to one of the gas transmission line terminals would be significantly shorter than that from Courtland. The actual pipeline routes will depend on which pipeline systems are served and the closest terminals. This will depend on a variety of business and economic considerations, many of which are external to the project.

Please refer to the responses given to questions 14 and 15 under Section D, "Site Selection" for additional information on collocating with existing industries.

2. Comment

The impact of the use of the product of this plant is inadequately assessed. Pipeline data has been studied only for the North Alabama area, yet page 2-19 indicates that this area can only use one-fourth of the plant's output. Since the gas produced by this plant must be used, the impact of such use must be addressed.

Comments By

Sierra Club, 9/14/80 letter, comment 2.

Response

As part of TVA's economic site comparison activities, a hypothetical pipeline and market area was assessed based on supplying about 25% of the total plant output of MBG as an industrial fuel source. Initial marketing estimates indicated that as much as 50% of the total plant output would go to producing SNG, 25% as a chemical feedstock, and the remaining 25% as an industrial fuel gas. At this time TVA is unable to specifically identify which industries would utilize the product gas from the proposed plant, and it would be speculative to do so. It is probable that MBG from the first 2 modules would be used as a chemical feedstock or methanated to produce SNG. However, there are no plans to transport product gases out of Alabama.

Use of MBG would probably involve a very small number of major users. The product could attract new industry to the region with associated impacts, and this is addressed in Section 4.1.4 of Appendix G, Section 4.5 of the FEIS and in the response to question 1 above. Secondly, should the MBG from subsequent modules be used by existing industries as fuel, it could either replace the use of natural gas, fuel oil, or electricity, or it could be used to increase the production capacity of the existing industry. Should MBG be sold to replace existing energy supplies it would require retrofitting existing equipment. Based on studies conducted for TVA this is not viewed as a major problem.

3. Comment

It was suggested that the project may want to consider serving the Triana, Alabama, area with the MBG product from the proposed coal gasification plant for a number of reasons enumerated in the reference letter.

Comment By

Top of Alabama Regional Council of Governments, 8/11/80 letter, paragraph 3.

Response

As indicated in the response to question 1 above, the final pipeline routing has not yet been determined.

4. Comment

The FEIS should include a discussion of the marketing strategy for the product gases. This discussion should address the selection of pipeline corridors and the preferred and alternative disposition of product gases. When potential pipeline routings and equipment are evaluated, some important design features and environmental factors should be assessed. The pipeline routings for product gases should maximize the usage of current rights-of-way, minimize pipeline length, avoid areas that are potentially susceptible to either a large degree of environmental damage (including critical wildlife habitats), or special hazards (including erosion or severe flooding). The pipeline equipment should utilize energy-efficient systems.

Comment By

U.S. Environmental Protection Agency, comments with 10/1/80 letter, page 5, paragraph 1; U.S. Federal Energy Regulatory Commission, letter (date unknown), paragraph 3.

Response

Please refer to the response to comments 1 and 2 above for information on marketing.

TVA sought to implement these various concerns when it was evaluating possible pipeline routes. Existing rights-of-way were used to the maximum extent feasible. In the hypothetical pipeline routings for product gases, environmentally sensitive areas or those areas presenting engineering hazards were avoided (please see Section 2.3.6.20 and Appendix C). As indicated in the DEIS, before pipelines would be constructed, the routes would undergo a more extensive evaluation and environmental review.

5. Comment

The draft EIS presents a possible pipeline routing for distributing the product from either the Courtland or the Murphy Hill site, but does not present much discussion on potential environmental consequences associated with the pipeline. Since a pipeline will be necessary for product distribution, the final EIS should contain a discussion of potential environmental consequences and proposed mitigation measures associated with the pipeline. In this discussion, please provide information on potential impacts to river water quality if a leak occurred in the pipeline at a river crossing.

Comment By

Philip R. Owen, 9/20/80 letter, comment B36.

Response

Possible pipeline routings for the product gas should be viewed as illustrative examples rather than preferred choices. The information given in Appendix C provides an adequate description of pipeline siting considerations, construction procedures, and the environmental effects of pipeline construction. Please refer to the response given to question 1 above for additional information on the pipeline routes and Section R, "Public Health," comment 10.

F. ECONOMICS OF PROJECT

1. Comment

I question the economic analysis of the alternative sites given in Table 2-3 of the DEIS. Please provide more detailed information on how these figures were derived.

Comments By

Bob DeYoung, 9/17/80 letter, paragraph 4; Kenneth C. Johnson, 9/21/80 letter, page 4, paragraph 3; Philip R. Owen, 9/20/80 letter, comments A4 and B26.

Response

As indicated in Section 2.2.3 of the FEIS, the summary of costs for pipeline construction and coal consumption considered a number of factors. Hypothetical pipeline routes were identified and cost estimates for constructing the pipelines were prepared based on the following assumptions:

a. All of the MBG from a 4-module facility would be sold to market areas (approximately 300 x 10^9 Btu/day) within and in close proximity to areas served by TVA power distributors.

b. Capital cost estimates for pipelines were from the plant to the market area (i.e., Muscle Shoals, Huntsville, etc.) and not to individual industries within the areas.

c. Operating and maintenance costs for pipeline distribution system were assumed equal for the alternative sites except for pumping stations.

d. Exit pressure of gas at the plant equals 500 psig and delivered pressure to market center equals 150 psig.

e. Pipelines should follow existing natural gas pipelines and/or TVA's transmission line rights-of-way.

f. Coal supply is from the western Kentucky and Illinois coal fields by barge delivery except that rail delivery was assumed for Little Cypress.

g. Cost estimates of pipeline construction to be yearly cash flows expressed in 1979 dollars.

The basic approach used was to assume that MBG from the first module would be delivered to the market centers nearest a given site. As additional modules came online the markets would be expanded to deliver the MBG. In this way a scenario was developed for each site that allowed pipeline construction costs (Table 2-3 in the EIS) to be estimated based on expanding the system over a period of about 4 to 5 years as subsequent modules came online. This allowed a comparison between the sites based on piping MBG and transporting coal.

2. Comment

Were the cost analyses for all of the sites evaluated in the draft EIS made available to the public?

Comments By

Jan P. Horne, 9/25/80 letter, page 1, paragraph 1; Kenneth C. Johnson, 9/21/80 letter, page 3, paragraph 2.

Response

TVA presented cost summaries in the DEIS comparing coal transportation and MBG distribution costs for 5 sites. In addition, estimates were prepared on the site variable costs for Murphy Hill and Courtland. Please refer to Section 2.2 "Site Screening Studies" to review these cost analyses.

3. Comment

The economic analysis comparing the Murphy Hill and Courtland sites should include the following factors in addition to those already given in the analysis in Table 2-5 of the DEIS:

a. expenses associated with transporting coal by barge including the cost of fuel for the barges in transit; the additional expense of maintaining and operating dams, locks, and riverways, due to coal transport; the value of electricity that was not produced because water was used for coal barge lockages instead of power generation; and costs to other river traffic awaiting the passage of coal barges through the Guntersville lock;

b. costs of dredging canals (including costs for each dredging option at Murphy Hill);

c. expenses associated with supplying electric power to each site (including the cost of constructing a 5000 DVA transformer near Murphy Hill);

d. fuel distribution expenses (including the costs of purchasing rights-of-way and building, operating and maintaining pipelines and pumping stations);

e. costs of all necessary road improvements and expenses for mitigating other potential socioeconomic and/or cultural impacts including additional funding for schools, fire departments, law enforcement and medical facilities, water supplies, and other community services in the vicinity of each site; and

f. credit for existing facilities, which may be useful if the gasification plant is located at Courtland.

Comments By

Phyllis Bates, page 2, comment 8; T. E. Bates, 9/26/80 letter, paragraph 3; Bob DeYoung, 9/17/80 letter, paragraph 4; and 9/25/80 letter, paragraph 5; Reed D. Hamman, addendum to 8/22/80 letter, paragraph 8; Jan P. Horne, 9/25/80 letter, page 1, paragraphs 1 and 2; and page 2, paragraphs 1, 2, and 3; Max W. Ingram, 9/25/80 letter, page 1, comments 3 to 6; and page 2, comments 7 to 9; Kenneth C. Johnson, 9/21/80 letter, page 4, paragraph 3; Thomas A.

King, 9/25/80 letter, page 2, comment 5; James B. Kyser, 9/22/80 letter, page 2, paragraph 3; C. R. and Elizabeth W. Lang, 9/25/80 letter, paragraph 4; Lawrence County Commission, 10/6/80 letter, page 1, paragraph 3; Philip R. Owen, 9/20/80 letter, comments A1, A4, B14, B28, B29, B36, B37, and B45; and page 13, paragraph 3; Ruth C. Owen, 9/22/80 letter; and 9/26/80 letter, paragraph 2 and 3; W. K. Polstorff, 9/16/80 letter, page 1, paragraph 4; H. L. Sutherland, 10/1/80 letter, page 2, paragraph 4; U.S. Department of the Interior, 10/7/80 letter, page 4, paragraph 3.

<u>Response</u>

a. The site-related variable cost analysis, Table 2-5 in the DEIS, contained the coal transportation costs which includes barge fuel costs. The Corps is responsible for maintaining the locks and riverways at no expense to the user regardless of the activity (recreation or business). Maintenance of locks and the riverway is not a project expense. TVA has not included the cost of lost hydroelectric production capability (approximately $31,439 annually at Guntersville Dam) in the cost estimates. Since the loss in energy production capability represents only 0.22% of the total annual power generation at this hydro plant, these costs are comparatively small. The cost to other river traffic awaiting passage is not considered to be a major item. Based on preliminary unofficial 1980 figures from the Corps, present lock usage occurs at an estimated rate of about 8 per day, representing about 19 percent utilization. Considering it would take about 2 to 2-1/2 hours to complete a double lockage for a tow transporting coal to the proposed facility, it is not expected to produce significant delays for existing river traffic at Guntersville Dam (please see Section 4.1.5, Appendix G, Volume 2).

b. Developing either site would require constructing a barge unloading facility. One of the initial options for use at the Courtland site was to construct a channel from the river to the site. This option was eliminated early in the project due to a preliminary estimated cost of $140,000,000. It was determined that a mechanical conveyor system would be more economical at the Courtland site.

Three coal receiving alternatives were considered at the Murphy Hill site. Dredging was required for each of the alternatives and was evaluated in the selection of a preferred coal receiving alternative.

c. Prior to initiating this project, TVA's Office of Power had determined that the power system needed a substation in the area of Murphy Hill. A substation is, therefore, not a requirement of the coal gasification project and not considered a project cost. In the final site ranking, both Murphy Hill and Courtland were rated equal in terms of their impact on the power system. Costs for electrical supply are considered essentially equivalent.

d. In TVA's site differential cost analysis, the cost for installing a MBG pipeline was included to determine the difference between the 2 sites given the same assumed market area. The estimates for this hypothetical pipeline indicated that pipeline costs were somewhat higher if the plant were located at Murphy Hill.

e. The site differential cost estimate (Table 2-5) used to support the selection of Murphy Hill as the preferred site for the coal gasification plant contained an estimate for road work of $7,675,000. Subsequent to publishing the draft EIS and in cooperation with the State of Alabama, the preliminary estimated cost of all road upgrading and rebuilding anticipated in the Murphy Hill site vicinity was increased to $19,979,700. The State of Alabama and TVA are still evaluating the possible road improvements. Given the revised mitigation strategy based on the proposed private ownership and the reduced scale of impacts, it is not possible to estimate costs of potential socioeconomic mitigation actions. Please refer to Section 4.1.4.4 of Appendix G for a revised discussion of mitigation.

f. It does not appear that there are any useful facilities at the Courtland Air Base.

4. Comment

It is more economical to locate the coal gasification plant at a site downriver from Murphy Hill. Siting the facility at the Courtland site would save $2 million in coal transport expenses. If the plant is located on the river at Courtland, a savings of almost $250 million could be realized in coal transportation costs over the next 20 yr. Siting the facility at a Kentucky site such as Little Cypress could save over $1 billion during a 20-yr interval.

Comments By

Rex B. Brown, 9/25/80 letter, comment 8; Mercer Clayton, 9/24/80 letter, paragraph 4; Bob DeYoung, 9/17/80 letter, paragraph 4; Charles and Dorothy Hellums, 9/12/80 letter, paragraph 3; Jan P. Horne, 9/25/80 letter, page 2, paragraph 4; Max W. Ingram, 9/25/80 letter, paragraph 1; Thomas A. King, 9/25/80 letter, page 2, comment 5; James B. Kyser, 9/22/80 letter, page 2, paragraph 3; Lawrence County Planning Commission, 10/6/80 letter, page 1, paragraph 3; Betty Ann Lloyd, 9/26/80 letter, comment 5; Howard Lloyd, DEIS public hearing transcript, page 45, paragraphs 2 to page 46, paragraph 2; Lena Lloyd, 9/16/80 letter, page 1, comment 1; Lillian C. Lloyd, 9/26/80 letter, comment 5; Susan Lloyd, 9/26/80 letter, comment 5; William P. Lloyd, 9/26/80 letter, comment 5; William P. Lloyd, Jr., 9/26/80 letter, comment 5; Anna McDonald, 9/22/80 letter, pages 2 to 3, comment 4; Philip R. Owen, 9/20/80 letter, comments A4, B3, B7, B22; page 13, paragraph 3; and DEIS public hearing transcript, page 71, paragraph 2; Ruth C. Owen, 9/22/80 letter; William B. and Adelaide A. Potter, 9/20/80 letter, page 2, paragraph 2; H. L. Sutherland, 10/1/80 letter, page 2, paragraph 4.

Response

The overall project cost estimates indicated that it is more economical to locate the facility near the MBG market area rather than near the coal supply. In this case, the preferred MBG market area is North Alabama. TVA's site variable cost analysis, Table 2-5, indicates that overall, Murphy Hill is the cheaper of the 2 sites. The Little Cypress site was eliminated because of its distance from the MBG market area and the resultant high cost for piping the gas.

5. Comment

If the coal gasification plant is located on a river site near Courtland, the cost for coal handling from the barge to the coal conditioners would be approximately equal with that given for the Murphy Hill site in the draft EIS (Table 2-5).

Comments By

Jan P. Horne, 9/25/80 letter, page 1, paragraph 3; Philip R. Owen, 9/20/80 letter, comment B28.

Response

We have not prepared any cost estimates for this situation; however, it is likely that coal handling costs for a facility located on the Tennessee River near the Courtland site would be about the same as those at Murphy Hill in this hypothetical situation. Please refer to the response to question 7 under part D. "Site Selection" for additional information.

6. Comment

The economic comparison of the Murphy Hill and Courtland sites in the draft EIS (Table 2-5) indicated that certain activities would be more costly at the Courtland site. Why is it more expensive for the construction facilities, the manager's office, and the activities associated with coal handling (i.e., architectural work, electrical work, central services, and common facilities) at Courtland?

Comments By

Jan P. Horne, 9/25/80 letter, page 1, paragraph 4; and page 2, paragraph 3; Cathy Owen, DEIS public hearing transcript, page 141, paragraph 5; Philip R. Owen, 9/20/80 letter, comment B29.

Response

The cost estimate (Table 2-5 in Volume 1) includes an entry entitled "Manager's Office-OEDC." This is a direct percentage (2.2%) cost of the total engineering design cost estimate covering incidental and overhead expenses for TVA's Office of Engineering Design and Construction. It is not a cost for an onsite office. Estimated expenses of the coal system are expected to be higher at Courtland due to the higher costs for a coal conveyor system from the river to the Courtland site.

7. Comment

It is stated that the economic life of the facility is 35- to 40-years yet the cost comparisons of the Murphy Hill and Courtland sites examined slag disposal costs for a 20-year period. Solid waste disposal should be examined for the entire life span of the facility.

Comment By

James B. Kyser, 9/22/80 letter, page 2, paragraph 3.

Response

It should be pointed out that the 35-40 yr economic life of the facility was an assumption used in the initial siting studies. This figure was in line with electric generating facilities and did not reflect current thinking in the chemical industry regarding plant life. This figure was used to estimate the cost of the pipeline networks identified in the initial site screening stages and coal transportation for the life of the plant. Please refer to the response to question 1 above. The economic life of the facility is 20 yr. The site (Figure 2-4 in Volume 1) is expected to accommodate 20 yr of dry ash and slag from a 4-module facility, unless engineering properties of the ash/slag or proposed waste disposal area are such that the waste cannot be stacked to the desired height. In such an event, other options (such as reducing ash content of the coal used, sale of slag, or acquisition of additional land) would be considered. At the present time, however, the north Alabama plant is expected to consist of 2 modules with the capability of expanding to 4 modules at a later date should it be technically and economically justified.

8. Comment

The cost estimates comparing the Murphy Hill and Courtland sites should be extrapolated and presented in outyear dollars.

Comment By

Philip R. Owen, 9/20/80 letter, comment B4.

Response

Because the plant construction would occur over a projected 6-8 yr period, TVA used a midyear of construction constant dollar analysis. This allowed the 2 sites to be evaluated on a common basis.

9. Comment

Questions were asked regarding the funding of such activities as mitigations for potential cultural or socioeconomic impacts (including the necessary road improvements) and the construction, operation, and maintenance of pipelines. Will electric rates or taxes go up to provide these funds?

Comments By

T. E. Bates, 9/26/80 letter, paragraph 3; C. R. and Elizabeth W. Lang, 9/25/80 letter, paragraph 5.

Response

Please refer to Section 4.1.4.4 in Appendix G for a more detailed discussion of mitigation strategies and funding.

The coal gasification project was established as a separate organization within TVA and was not funded by Office of Power revenues. Current funding is by Congressional appropriations. It is expected that the project will ultimately be owned and operated by a private entity and, therefore, be self-sufficient, relying on revenues from the sale of products and byproducts. It is likely that a private gas company would be responsible for constructing SNG pipelines. A variety of organizations could construct a separate MBG distribution line. Until such time as the product gas may eventually be used to generate electric power, Office of Power revenues would not be used to pay for coal gasification. The gasification program would probably be a large base load customer of the power system, helping rather than hurting electric ratepayers. Please refer to the response to question 12 below for additional information.

10. Comment

The Courtland site is nearer to the projected major market area than the Murphy Hill site. Therefore, the costs of distributing the product from the Courtland site would appear to be less, especially if shorter distribution pipelines were used. Possibly as much as $50 to $100 million could be saved by locating the plant at Courtland.

Comments By

T. E. Bates, 9/26/80 letter, paragraph 3; Max W. Ingram, 9/25/80 letter, comment 5; Thomas A. King, 9/25/80 letter, page 2, comment 5; Lawrence County Commission, 10/6/80 letter, page 1, paragraph 3; Philip R. Owen, 9/20/80 letter, comments A1, B14, B26, B28, B29, B36, and B45; William B. and Adelaide A. Potter, 9/20/80 letter, page 2, paragraph 2.

Response

TVA is presently evaluating a number of marketing and product options and is not in a position to indicate specifically where the major market lies. Pipeline routes and market areas should be viewed as illustrative examples rather than preferred choices. Please refer to the response to question 1 under Section E, "Product Gas Distribution" for additional information on this issue. TVA is not able to comment on the theorized cost savings indicated in the comment.

11. Comment

A number of comments were made on the economic feasibility of the proposed coal gasification plant and whether the product gas would be competitively priced with other fuels.

Comment By

Bob DeYoung, 9/25/80 letter; Julian A. Greer, 9/10/80 letter; Reed D. Hamman, addendum to 8/22/80 letter, and 1/19/81 referral letter, paragraph 2.

Response

During the first half of 1980, 3 leading architect engineering firms conducted extensive parametric conceptual designs of the proposed commercial coal gasification plant in northern Alabama. The results of these studies indicate that the initial plant gate MBG price would be in the range of $6.50 to $8.50 per million Btu in 1980 dollars, using utility-type financing. This required selling price would grow slower than inflation so that the projected price in 1980 dollars should drop to between $5.85 and $7.50 by the year 1997.

In early 1981, Kidder, Peabody & Company, a well-known financial institution, evaluated the economies of the project on the basis of a consortium of private entities. Kidder concluded that the project would offer an appropriate return to private firms capable of using potentially available Federal financial incentives. These analyses were based on medium-Btu gas, SNG, and methanol prices, which would be competitive today for marginal supplies and would increase with inflation.

12. Comment

One of TVA's goals is to demonstrate the economic feasibility of a commercial-scale coal gasification facility. If, however, this goal is not realized and the project has a deficit, how will this affect electric power rates? Will it affect taxes?

Comment By

W. K. Polstorff, 9/16/80 letter, page 1, paragraph 2.

Response

This project has not been funded with power revenues and would have no impact on TVA electric rates. The project plans to use commercial technology and studies to date indicate that the facility would be economical. It is expected that the project would be privately owned and operated and would have no measurable effect on taxes. In fact, the private entity would repay the U.S. government for the Federal investment in the project and would purchase the site from TVA.

G. SOCIOECONOMIC AND CULTURAL IMPACTS

LAND USE

1. Comment

The statement regarding 100 rural, farm, and lakefront homes is misleading. There is also no basis for using two miles as a cutoff. Since the potential lethal radius (accident situation) is three miles it would seem appropriate to address this range. Within three miles there are several rural, farm, and lakefront homes. There are also well over 100 within a two-mile radius (probably closer to 250).

Comment By

Philip R. Owen, 9/20/80 letter, comment 46.

Response

The description in the DEIS of housing within a 2-mi radius is incorrect. That description actually refers to a 2 kilometer (km) radius or 1.3 mi (also please see Section 3.2.10, Environmental Noise) and has been corrected for the FEIS. It is acknowledged that within a 3-mi radius there are probably several hundred homes. This discussion was meant to serve as a general description of the existing environment.

The "accident situation" mentioned is addressed in the FEIS, Section 4.3, Appendix G.

2. Comment

What are the effects of pollutants on farm crops and pastures in the area, including reduced yields and resulting effects on farm economies?

Comment By

Phillip R. Owen, attachment (4/7/80 letter) to 9/25/80 letter, page 3, item f.

Response

Based upon the available information, TVA concluded that at the emission levels stated in the DEIS, agriculture should be minimally affected. The levels which are even lower in the FEIS, are low enough to avoid detrimental impacts to nearby agricultural operations. For more information about potential effects from air pollutant emissions, please see the response to comment 15 under General Comments in Section "H. Air Quality" of this appendix.

3. Comment

We offer the following comments for your consideration: . . .

> Irreversible and Irretrievable Commitments of Resources, page 4-26.
>
> The total amount of prime farmland that will be altered or irreversibly affected should be given. If no prime farmland exists within the selected sites, it should be so stated.

Comment By

U.S. Department of Agriculture, 9/15/80 letter, page 1, comment 4.

Response

Please see revised Section 4.9, "Irreversible and Irretrievable Commitments of Resources", of Volume 1 of the FEIS.

RECREATION AND SCENIC RESOURCES

1. Comment

Your study has overlooked city recreation departments entirely.

Comment By

Scottsboro Recreation Department, 9/30/80 letter, page 1, paragraph 3.

Response

Please refer to the revised discussion of community recreation impacts in Section 4.1.4 of the FEIS, Volume 2.

2. Comment

The following statement paraphrases the comments made by persons listed below: The Murphy Hill region is very beautiful, characterized by numerous recreation developments. The proposed coal gasification plant would ruin this area for recreation.

TVA sold land on the right bank for recreation. The proposed plant would violate the people's trust in TVA to keep this area for recreation use.

Comments By

W. F. Floring, 9/26/80 letter, page 1, paragraph 3; Marion Gibson, 9/25/80 letter, page 1, paragraph 2; Ronald Green, 9/25/80 letter, page 1, paragraph 2; Reed D. Hamman, 8/22/80 letter, page 1, paragraph 6; Dorothy P. Hard, 9/22/80 letter, page 2, paragraphs 2 and 3; Jennie M. Helderman, 9/28/80 letter, page 1, paragraph 5; and page 2, paragraph 4; Charles and Dorothy Hellums, 9/12/80 letter, page 1, paragraph 3; Max Ingram, DEIS public hearing transcript, page 31, paragraph 4; Mary Ann Jenkins, 6/26/81 letter, paragraph 7; James D. and Sandra P. Jensen, 9/25/80 letter, page 1, paragraph 2; Marjorie B. Maples, letter (no date), page 1, paragraph 2 to page 2, paragraph 1; Patrick O. Matkin, 9/25/80 letter, page 1, paragraph 2; H. E. Monroe, 9/29/80 letter, page 1, paragraph 5; Helen Nelson, attachment to 9/28/80 letter, page 3, paragraph 2; James Nelson, 9/28/80 letter, page 1, question 4; Philip R. Owen, 9/20/80 letter, comment B41; 1/22/80 letter, page 1, paragraph 2; 4/7/80 letter, page 3, item "c"; W. K. Polstorff, 9/6/80 letter, page 1, paragraph 4; Inez E. Reese, letter (date unknown), page 1, paragraph 3 and page 2, paragraph 2, DEIS public hearing transcript, page 119, paragraph 4; and 6/30/81 mailgram; Bengie Rowe, 9/24/80 letter, page 1, paragraph 2; H. L. Sutherland, 6/11/81 letter, paragraph 2; William B. Tatum, 9/23/80 letter, page 1, paragraph 2; Warren Buford, 9/23/80 letter, page 1, paragraph 2; Lee A. Woodward, 9/16/80 letter, page 1, paragraph 4 and page 3, paragraph 1.

Response

The process of analyzing 15 alternative sites is described in detail on page S-4 of the DEIS. TVA has acknowledged in the DEIS that the Courtland site would present fewer and less significant recreational impacts; however, recreation and land use matters are only 1 of many factors taken into consideration in the site selection process.

Adverse impacts to the aesthetics of the immediate region are acknowledged in the DEIS (Section 4.1.1.2, Volume 1 and Section 4.1.2, Volume 2), but the level of impact has been determined not significant enough to warrant identifying another site as preferred for the following reasons:

a. TVA's experience indicates that industrial development and recreation/vacation home development may exist without significant impacts to the homes. The industrial development around New Johnsonville, Tennessee, on Kentucky Lake coupled with State park, commercial recreation, and nearby national wildlife refuges is one example. The Watts Bar Nuclear Plant and adjacent industrial park coupled with nearby resort and county park development is another example.

b. What recreation/second home development there is in the Murphy Hill region is located on the opposite lake bank more than a mile away. This distance should significantly diminish adverse visual impacts from the opposite shore.

c. TVA's initial design efforts on the proposed coal gasification plant have best utilized from a visual protection standpoint the natural features of the Murphy Hill site.

The lake side of "Murphy Hill" would not be disturbed to the extent practicable. It is expected that the forested area would provide a natural screen to the plant. Further, the plant is expected to have a low profile which better blends into the existing natural features. Certain areas of the shoreline would, however, have to be disturbed to provide access from the plant to the coal and sulfur docks, the barge slip, the intake structure, and the discharge structure (see Figure 2-4 in the FEIS). Plant color schemes, fencing, and lighting (including security) would be developed in accordance with the overall aesthetic design philosophy of the plant. Landscape architects would strive to minimize visual impacts even more by planting suitable trees, where possible, that would screen the plant from view and enhance the environment. In general, the natural topography of the Murphy Hill area would tend to minimize visual impacts of the plant.

d. The Murphy Hill site per se receives little, if any, recreational use although some small, undetermined amount of hunting may occur.

e. As indicated, the plant would conform to all applicable State and Federal regulations concerning emissions to the air, wastewater discharges, and solid waste disposal.

3. <u>Comment</u>

. . . I emphatically oppose the changes it will bring. . .the threat to water recreation by barge traffic.

<u>Comment By</u>

Jennie M. Helderman, 9/28/80 letter, page 1, paragraph 6; Mary Ann Jenkins, 6/26/81 letter, paragraph 4; H. L. Sutherland, 6/11/81 letter, paragraph 3.

Response

At no point on the Tennessee River system has commercial navigation development unduly interferred with recreational use of the lakes. Commercial navigation is confined to the deeper marked channels while smaller recreational boats have the flexibility to travel over most of the entire lake surface of Guntersville Lake. Only the shallowest embayments do not lend themselves well to recreational boating. At the dams, recreational boats are locked through with commercial tows when there is room, or separately after 3 commercial lockages or 1-1/2 hr. However, at Guntersville Dam, the small auxiliary lock is often available for recreational boats.

For more information on expected barging operations, please see Section 4.1.5 of Appendix G.

4. Comment

Concern was expressed regarding the visual impact of slag disposal.

Comment By

James B. Kyser, 9/22/80 letter, page 1, paragraph 4.

Response

The project plans to progressively reclaim (contour and revegetate, if possible) the solid waste disposal area throughout the plant life. Topography, existing vegetation and revegetation, if successful, would help minimize visual impacts. Further, the solid waste generated by a 2-module plant would be substantially less than that estimated for a 4-module plant, and visual impacts should be decreased.

5. Comment

The document should not state that "no significant impacts to recreational use of the Tennessee River would be expected" due to increased barge traffic. The increased barge traffic will have an impact on the recreational experience of fisherman fishing in areas adjacent to the river channel. If the plant is built at Murphy Hill, fish attractors placed in areas away from the river channel should be constructed as mitigation. These fish attractors should be constructed brush and placed in a number of areas on Wilson, Wheeler, and Guntersville reservoirs. It would be desirable if these attractors are permanently marked for the convenience of the public.

Comment By

Alabama Department of Conservation and Natural Resources, Game and Fish Division, attachment to 6/22/81 letter, paragraph 3.

Response

Potential impacts to recreational use of the Tennessee River are recognized and discussed in the FEIS. While two additional tows per day (one each way) will potentially interfere with sport and commercial fishing, and potentially increase shoreline erosion, the incremental increases of these impacts are difficult to estimate, and TVA does not anticipate that they will be significant. As pointed out in the DEIS, capital costs of the proposed project have been increased by locating water use facilities away from productive and wetland areas to the extent practicable. The 500 ± ft rip-rapped causeway extending to the barge unloading facility is expected to serve as a fish attractor, as are several of the other instream plant structures. Furthermore, the project is committed to routing and controlling barge traffic to minimize impacts, including routing loaded barges in from the south, using a barge puller system at the dock, and minimizing tugboat use as much as possible. An operational aquatic monitoring plan, approved by the Alabama Water Improvement Commission (AWIC) on June 23, 1981, is designed to detect (among other potential stresses) impacts due to barge activities. Following examination of the instream data from this program, mitigation will be instituted by the project if and as appropriate. Fish attractors in the area might be considered as appropriate mitigation.

TVA has already installed 9 marked fish attractors on Wheeler Lake, and is currently installing 6 attractors on Wilson Lake. None are currently planned for Guntersville due to the large quantity of natural vegetation in that lake.

As a result of private ownership, the plant will be subject to property taxation, thus providing the State of Alabama and Marshall County with the capabilities to expand local facilities at their discretion.

CULTURAL RESOURCES

1. Comment

What are the nearby historic structures?

Comment By

Kenneth C. Johnson, 9/21/80 letter, page 3, paragraph 5.

Response

Known historic structures in the vicinity of Courtland and Murphy Hill sites are identified in Section 3.1.3 "Cultural Resources," Appendix F of the FEIS.

MAGNITUDE AND DISTRIBUTION OF IMPACTS

1. Comment

They make no mention as to what is going to happen when these other 6,000 people finish the job and leave. There is no mention of how many permanent jobs are going to be left in this area with the plant being here.

Comment By

Hugh L. Sutherland, M.D., DEIS public hearing transcript, page 108, paragraph 1.

Response

Please refer to the revised work force estimate discussed in Section 4.1.4.1 (Construction Period) and to Section 4.1.4.2 (Operation Period) of Volume 2 of the FEIS.

2. Comment

They say we are going to have 6,800 at peak employment in the peak season. They are going to move in 6,900 so we are going to add it looks like a hundred extra people to our unemployment roll.

Comment By

Ruth Owen, DEIS public hearing transcript, page 136, paragraph 2.

Response

Please refer to the revised discussion of work force presented in Section 4.1.4.1 of Volume 2. Approximately 30% of the peak work force of 3,600 is expected to move into the 3-county area. These 1,080 employees are expected to be accompanied by 1,670 dependents, resulting in a total population influx of approximately 2,750 people.

3. Comment

We would like to request that the newly incorporated town of Langston be included in the impact assessment. Langston is located about four miles northeast of Murphy Hill, and we believe that we will receive a greater impact from the plant than any other community around, especially as far as traffic is concerned.

Comment By

Bill Lawhorn, DEIS public hearing transcript, page 111, paragraph 6 to page 112, paragraph 2.

Response

Langston is not included in the distribution of inmoving workers, despite its close proximity to Murphy Hill, primarily because of the community's small population. Past experience with TVA projects indicates workers tend to locate in larger communities even when a small community, such as Langston, is located near the site. Thus, although a few workers may locate in Langston, most of the impacts should be traffic-related and not related to inmoving workers.

4. Comment

There are some comments generally expressing concern over the potential adverse impacts on various community services and facilities, including the possibility of a boom town situation, and the amount of attention granted to these problems in the DEIS.

Comments By

Reed D. Hamman, 8/22/80 letter, page 1, paragraph 2; Mary Ann Jenkins, 6/26/81 letter, paragraph 6; National Environmental Health Association, 9/26/80, page 1, paragraph 3; Helen Nelson, 9/28/80 letter, page 3, paragraph 2; James Nelson, 9/28/80 letter, paragraph 3; Philip R. Owen, 9/20/80 letter, comments B10 and B17.

Response

The general nature of these 5 comments precludes any detailed responses related to specific impact areas. The FEIS acknowledges the potential adverse impacts on community services and facilities and presents detailed assessment of these impacts in Volume 2. Based on TVA's past experience with large power plant projects, the magnitude of anticipated impacts is not severe enough to be considered as a boom town situation, primarily because of the expected distribution of population among several communities. Please refer to Section 4.1.1.4 in Volume 1 of the FEIS for additional information.

5. Comment

A variety of cultural and socioeconomic impacts (including land use compatibility and the availability of housing, schools, and potential workforce) indicate that the coal gasification facility should be located at Courtland instead of Murphy Hill.

Comments By

James B. Kyser, 9/22/80 letter, page 1, paragraph 4; Philip R. Owen, DEIS public hearing transcript, page 71, paragraph 3.

Response

Socioeconomic impacts are only one of a number of factors evaluated when siting a facility. Please refer to Section 2.2 "Site Screening Studies" in the FEIS and to the response to question 2 under Part D, "Site Selection" of this volume of the FEIS.

6. Comment

A number of people expressed concern that recreational and/or residential property values in the site vicinity might be affected by the proposed plant due to the potential for visual, noise, and air pollution impacts.

Comments By

Jennie M. Helderman, 9/28/80 letter, page 1, paragraph 6; Max Ingram, DEIS public hearing transcript, page 31, paragraph 2; Anna McDonald, DEIS public hearing transcript, page 55, paragraph 5; H. E. Monroe, Jr., 9/29/80 letter, paragraphs 2 to 4; Philip R. Owen, attachment (1/22/80 letter) to 9/25/80 letter, page 1, paragraph 2; 9/20/80 letter, comment B41; W. K. Polstorff, 9/6/80 letter, page 1, paragraph 4; James H. and Judith B. Wilson, 9/18/80 letter, page 2, comment 6; Lee A. Woodward, 9/16/80 letter, page 2, comment 1D.

Response

As indicated in Sections 4.1.1.1 and 4.2.1.1 of Volume 1 of the FEIS, land values are not expected to decrease as a direct result of the plant siting.

7. Comment

It is difficult for us to perceive how these percentages (distribution of inmovers on page 4-3) were derived and also why Arab was not included, since our community is as close to the

Murphy Hill site as is the city of Boaz and access to Arab to and from the site is equivalent. We hope that such rather arbitrary calculations will not influence our ability to participate in the distribution of impact funds at the time of plant construction.

Comment By

LaMonte Davis, Mayor of Arab, Alabama, 12/10/80 letter, page 1, paragraph 3.

Response

A more detailed discussion of the estimation of the magnitude and distribution of inmoving workers is contained in Section 4.1.4.1 of Volume 2. These estimates are based on over a decade of TVA experience in monitoring the characteristics of workers at TVA power plant construction sites in addition to the consideration of certain area characteristics such as access. Arab was not included in the estimation of inmovers because of its poor access to the site which would involve, first, driving through Guntersville and then through Lake Guntersville State Park along a winding, hilly road. Workers should be more likely to move to a town located closer to the site than Arab, such as Guntersville, particularly when the town is on the same route. Although Boaz is located about the same distance from the site as Arab, Boaz is considered a more likely location for inmoving workers because of its location in the Albertville growth corridor and its relatively better access in terms of ease of travel.

The mitigation strategy discussed in the DEIS (page G-24) has been revised based on the proposed development concept (private consortium).

8. Comment

It was noted that a 2-module plant employing 3,600 will be constructed instead of the 4-module plant that would have employed 6,800. We agree that this will result in the substantial reduction of socioeconomic impacts. However, the impacts will still be significant and need to be mitigated for these areas in the final EIS, especially housing, schools, health care, and emergency services.

Comment By

Department of Health and Human Services, Public Health Service, Centers for Disease Control, Atlanta, Georgia, 6/19/81 letter, paragraph 2.

Response

TVA does not expect significant impacts on housing, schools, health care, and emergency services because of the relatively modest projected population increase and the anticipated distribution over a 3-country area. However, some temporary shortages of classrooms should occur in each county. As a result of the proposed transfer to private ownership, TVA would not implement its traditional mitigation process but would be responsible for any adverse impacts related to direct TVA involvement (during the site preparation phase). The private entity would determine if any mitigation efforts will be necessary on its part. Generally, the relationship of the project to local goverments would be similar to that of any other private industry. Thus, communities could accommodate potential growth from construction of the plant as they would for any private industry.

EMPLOYMENT

1. Comment

There are 4 general comments expressing concern over the need to hire local people for the project, including providing training to develop skills among the local labor force.

Comments By

Tom Chambers, DEIS public hearing transcript, page 23, paragraph 2 to page 24, paragraph 2; R. D. Gateley, 10/1/80 letter, page 2, comment 6; Reed D. Hamman, 8/9/80 letter, paragraph 1; Dean Matthews, Top of Alabama Regional Council of Governments, DEIS public hearing transcript, page 80, paragraph 3 to page 81, paragraph 1.

Response

Please refer to Section 4.1.4.4 (Mitigation) of Appendix G of the FEIS, Volume 2.

LOCAL GOVERNMENT BUDGETS

1. Comment

Concern was expressed on the absence of a discussion regarding the financial/fiscal impacts on communities from the project. Specifically recommended was a projection of revenue generation from each applicable tax assessment source (e.g., property, income, etc.) and a preliminary estimate of existing carrying capacity on utilization rates of the current services and facilities as well as the age, stability, and operating and maintenance costs. Finally, an identification of the debt/equity ratio of the communities and their ability to generate revenue was requested to indicate the need for mitigation.

Comment By

U.S. Department of Energy, Argonne National Laboratory, 10/20/80 letter, page 1, paragraph 3 to page 2, paragraph 1.

Response

The expected absence of rapid community growth and large capital expenditures related to the project precludes the need for a detailed examination of fiscal impacts. It should be noted that the discussion on local government budgets has been expanded to include information on police and fire protection and the general fiscal health of the communities.

Under the earlier development concept (TVA ownership), no large revenue increases were expected. Given the current development concept of private ownership, there is the potential for significant property tax revenue for Marshall or Lawrence County and the State of Alabama. Please refer to Section 4.1.4.1 for a discussion of this revenue.

HEALTH

1. Comment

Because our Section Center is closer to the Murphy Hill site, I would hope it, at least, would be included in your inventory of existing capacities and capabilities in Jackson County.

Comment By

Jackson County Rural Health Project, 9/26/80 letter, page 2, paragraph 1.

Response

The Section Center was not included in the assessment for the following reasons: it primarily provides dental services, few workers are expected to move into the Section area, and funding for the Center is expected to end in 1982, prior to the influx of any substantial number of people.

2. Comment

The socioeconomic impacts of the proposed project are well covered. However, in Part I, Section 4.2.1.4, it is stated that adverse impacts on public health services are expected in every county. Possible determinations for the solutions to these impacts should be discussed in the final EIS.

Comment By

Department of Health and Human Services, Public Health Service, Center for Disease Control, 9/26/80, page 1, paragraph 6.

Response

Please refer to the revised discussion on mitigation strategies included in Section 4.1.4.4 of the FEIS, Volume 2.

3. Comment

The following concerns were expressed over the health and medical services assessment: the estimates of occupancy rates for area hospitals are outdated or erroneous; the impact on specialist care was not addressed; recruiting doctors will be difficult because the increase in population of 8,000 is temporary and will reduce the attractiveness of the area for doctors to locate; and, that provision of adequate primary care will be totally impossible in the area.

Comments By

Marshall County Hospital Board, 9/30/80 letter, paragraph 2; Hugh L. Sutherland, M.D., 10/1/80 letter, paragraphs 2 and 3; and DEIS public hearing transcript, page 108, paragraph 2 to page 109, paragraph 3.

Response

The estimates of occupancy rates for area hospitals are from 2 reliable sources--the local Health Systems Agency and the latest edition (1979) of the American Hospital Association's Guide to Health Facilities, which consists of information provided by local hospitals. The FEIS is limited in scope to discussion of primary care needs (general practitioners, pediatricians, and obstetricians) and does not consider specialist care. A reasonably accurate assessment of specialist care would require detailed information not available at this time, such as patient location and patient flow. The temporary increase in population is not expected to have any adverse effect on physician recruitment, a current problem in the area. There are other more significant factors involved in physician recruitment difficulties, primarily related to the rural nature of the area. The FEIS acknowledges that there would be an additional strain on the provision of primary health care and that additional recruitment should be necessary.

4. Comment

When you add 6,000 people in this area, you are adding a minimum of 18,000 people, three people per each worker. That means that you need at least nine primary care physicians and probably another six or seven specialists.

Comment By

Hugh L. Sutherland, M.D., DEIS public hearing transcript, page 109, paragraph 2.

Response

Please refer to the revised discussion of peak work force and expected inmoving population in Sections 4.1.4.1 and 4.1.4.2 of Volume 2. Also, impacts on health services are discussed in Section 4.1.4.1.

TRAFFIC AND ROADS

1. Comment

Development of a TVA employee transportation system should be coordinated with the State Highway Department.

Comment By

U.S. Department of Transportation, attachment (State of Alabama Highway Department, 9/15/80 letter) to 9/25/80 letter, page 1, comment 4.

Response

TVA would coordinate the development of a TVA employee transportation system with the State Highway Department, should one be needed. However, it is likely that most of the work force would be non-TVA and could not participate in a TVA employee transportation system. Any similar efforts by the consortium would also be coordinated with the State.

2. Comment

All traffic impact mitigating measures should be coordinated with the State Highway Department.

Comment By

U.S. Department of Transportation, attachment (State of Alabama Highway Department, 9/15/80 letter) to 9/25/80 letter, page 1, comment 6.

Response

All traffic impact mitigating measures dealing with road improvements under investigation would be coordinated with the State Highway Department, as well as with appropriate local officials.

3. Comment

The impact statement on page 4-3 indicates that approximately 60 percent of the plant construction force would live in Guntersville, Albertville, and Boaz. The road connecting these cities with the plant site is a two-lane, narrow, winding, and mountainous road that runs through Lake Guntersville State Park. It would almost be imperative that the road be widened to a four lane to accommodate the tremendous increase in traffic on an already heavily traveled road due to the Monsanto plant. This could be done only at a tremendous cost and would require the acquisition of additional land from the State Park.

Comment By

Lee A. Woodward, 9/16/80 letter, page 2, comment E.

Response

TVA acknowledges that some traffic congestion is unavoidable during the construction period, particularly during peak employment. However, the temporary, short-term nature of the traffic impacts precludes justifying the cost of such improvements as adding additional lanes. It should be pointed out that highway capacity is dependent on several factors other than the number of lanes, such as lane width, percentage of trucks and buses, and average highway speed. Discussions are currently underway with the Alabama Highway Department regarding plans to improve the traffic capacity of that segment of S.R. 227 by improving and upgrading the road and roadbed rather than by adding any additional lanes. Additionally, the Monsanto plant has recently closed. Please refer to Section 4.1.4.1 of Volume 2 for a discussion of traffic impacts.

4. Comment

It is felt that the area of highway improvements, in particular the completion of the four-lane Highway 431 between Huntsville and Guntersville, should be discussed in the FEIS.

Comment By

William Murray, 9/21/80 letter, paragraph 2.

Response

A very small percentage of plant-related traffic is expected on Highway 431 and is not viewed as a major environmental impact. Please refer to the response for question 3 above for additional information on road improvements and to Section 2.3.6.20, Volume 1 of the FEIS.

SECONDARY DEVELOPMENT

1. Comment

If the coal gasification facility is built at Murphy Hill, then more industry may be attracted to the area. What kinds of industry might be expected to move into the area? The EIS needs to address the impacts of this industrial growth.

Comments By

Reed D. Hamman, 8/9/80 letter, page 1, paragraph 2; C. R. and Elizabeth W. Lang, 9/25/80 letter, paragraph 3; W. K. Polstorff, 9/6/80 letter, page 1, paragraph 4; William B. Tatum, 9/23/80 letter, page 1, paragraph 1; U.S. Department of the Army, Corps of Engineers, 10/9/80 letter, page 2, paragraph 2; U.S. Environmental Protection Agency, 10/1/80 letter, comments, page 5, paragraph 1; Buford Warren, 9/23/80 letter, page 1, paragraph 1; Lee Woodward, 9/16/80 letter, page 1, comment 1A.

Response

Please refer to revised Sections 4.1.4 in Appendix G and 4.5 in Volume 1 of the FEIS.

IMPACT MITIGATION

1. Comment

There are 4 general comments expressing concern over the potential financial strain placed on impacted communities because upgrading of certain public facilities and services may be necessary.

Comments By

C. R. and Elizabeth Lang, 9/25/80 letter, paragraph 5; Dean Matthews, Top of Alabama Regional Council of Governments, DEIS public hearing transcript, page 81, paragraph 2; Philip R. Owen, 9/25/80 letter, comment a; W. F. Polstorff, 9/6/80 letter, page 1, paragraph 3.

Response

Please refer to Section 4.1.4.4 (Mitigation) of the final EIS, Volume 2.

2. Comment

Concern was expressed by the Wakefield Community officials over the location of the program coordinator's office in Guntersville instead of Wakefield. Their desire for locating the coordinator in Wakefield is based on their belief that Wakefield will receive the greatest impacts of all the area communities.

Comment By

Wakefield Community Officials, 9/27/80 letter.

Response

The location of the program coordinator's office is not an indication of preference for one community over any other in terms of impact assistance. By virtue of its proximity to the Murphy Hill site, Wakefield would be subject to some nuisance-related impacts (i.e., traffic, litter, noise), should the proposed plant be constructed at this site. However, Wakefield is not expected to be adversely impacted by the presence of inmoving construction workers and their dependents, as expected for the larger communities in the area. TVA experience indicates that inmoving workers tend to locate in larger communities even when a smaller community is near the site, primarily because of the availability of various services and facilities. Thus, Wakefield should not need expansion of services and facilities to cope with a population influx, as other communities may require. Please refer to Section 4.1.4.4 in Appendix G for a revised discussion of mitigation strategies.

H. AIR QUALITY

"ACID RAIN" RELATED COMMENTS

1. Comment

Commenters expressed concern that SO_2 and NO_x emissions would exacerbate the acid rain problem and/or cause damage to Alabama, east Tennessee, and Georgia mountains. One commenter also asked how much of the SO_2 would be converted to hydrochloric acid.

Comments By

James Bates, DEIS public hearing transcript, page 84, paragraph 4; Wayne Garrett, DEIS public hearing transcript, page 117, paragraph 7 to page 118, paragraph 1; Tennessee Citizens for Wilderness Planning, 8/19/80 letter, paragraph 2; James H. Wilson, 6/24/81 letter, page 2, paragraph 2.

Response

The estimated emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) printed in the FEIS are substantially lower than those in the DEIS, due to later design information and more realistic assumptions. (Please see FEIS Chapter 4, Table 4-1.) Further, emissions from a 2-module plant should be substantially less than those from a 4-module plant.

The question of possible increases in rain acidity in the east Tennessee, Alabama, and Georgia mountains has not yet been settled, although research is in progress. TVA is not aware of "mounting evidence" that these mountains are being increasingly impacted by acid rain. Indeed, preliminary evidence seems to be conflicting.

For the emissions from a source to cause acid rain impacts at a given location, several conditions must be met:

1. There must be transport from source to receptor.

2. The combined effects of conversion of emissions into materials which can cause acidified rain, and removal mechanisms must allow a significant fraction of these materials to survive the journey.

3. The converted emissions must be deposited at the receptor (i.e., it must rain and wash the materials out of the air).

At present, there is no method for accurately, or even reasonably, estimating potential acid rain impacts. The atmospheric processes governing acid rain are too complex and not understood well enough. At best, a very simplistic assessment can be made which may, in a very general sense, indicate the possible magnitude of acid rain impacts. The following sets forth such an assessment.

In order to estimate possible effects of the proposed facility on a representative portion of the east Tennessee mountains, it was assumed that the transport wind speed was only 5 miles per hour (mph) or 2.24 meters per second (m/s), that there was no deposition or depletion enroute, and that the emissions were spread uniformly across only one 16-point compass sector (22.5°). If a distance range of 140 to 195 mi is selected (i.e., the closest and most distant portions of the Great Smoky Mountains National Park), the SO_2 quantity over 1 ft^2 is about 0.00000011 pound (11/100,000,000 lb). If precipitation of 0.5 inch per hour (in./hr) occurs over the area in question, and there is total conversion and removal of the SO_2 from the air with no neutralizing by ambient air, calculations of maximum pH (a measure of acidity) change may be calculated. The actual pH change depends on the initial pH of the rain as shown below.

Initial pH	Altered pH	Change
5.6	5.490	0.110
5.0	4.969	0.031
4.5	4.490	0.010
4.0	3.997	0.003

(Decreasing values indicate increasing acidity. A pH of 4.0 is ten times as acid as a pH of 5.0.)

The actual pH change is expected to be much smaller due to the conservative nature of the assumptions. The wind does not blow only in one direction, and the transport winds would be expected to be closer to 15 mph, spreading the plume downwind and decreasing its concentration to 1/3 or less of the calculated density. The plume likely would not be confined to one sector width at this distance, and the SO_2 in the plume would normally be depleted by about 50% at this distance from the source. Further, if the total removal occurs with 0.5 in./hr, as assumed, a heavier rain would further dilute the acid producing material, and a lighter rain would not be expected to wash all of it from the air.

An analysis of "cumulative impacts with other proposed facilities" is not appropriate due to the minute effect of this facility and lack of knowledge concerning such other facilities. The effect from other facilities would be essentially unaltered by emissions from the proposed coal gasification facility at Murphy Hill.

The effects of NO_x emissions on acid rain would be about an order of magnitude (10 times) smaller. At present there is not a method of utilizing coal on this scale that would contribute less to the acid rain problem than coal gasification with proper controls.

None of the SO_2 will be converted to hydrochloric acid (HCl).

2. Comment

Sulphur dioxide emissions and particulate matter (PM) can affect the acid levels of rain, and the relationship between this and potential impacts on cultural resources should be examined. Since the proposed plant is a demonstration plant, this will be a good opportunity to monitor these levels and effects on cultural resources.

Comment By

U.S. Department of the Interior, 10/7/80 letter, page 1, paragraph 5 to page 2, paragraph 1.

Response

TVA believes that any very slight increased acidity associated with the project would not have a measurable impact on cultural resources in the region. Therefore, monitoring for such minute levels and effects would not be practicable, productive, or justified on either a local or a regional basis.

3. Comment

Commenters expressed concern about acid rain occurrences; cited "reports by government agencies" about acid rain; or stated that no acid rain prevention method was given.

Comments By

Mildred Adams, 9/24/80 letter, final sentence; Phyllis Bates, letter (date unknown), paragraph 1, comment 5; Rex B. Brown, 9/25/80 letter, paragraph 1; Ms. Diane Davidson, 9/23/80 letter, paragraph 1; Betty Ann Lloyd, 9/26/80 letter, paragraph 2; Lillian C. Lloyd, 9/26/80 letter, paragraph 2; Susan C. Lloyd, 9/26/80 letter, paragraph 2; William P. Lloyd, 9/26/80 letter, paragraph 2; William P. Lloyd, Jr., 9/26/80 letter, paragraph 2; Marjorie B. Maples, letter (undated), page 1, paragraph 2; Dr. H. Michael Mauldin, William C. Reeves, Mrs. Janice P. Mauldin, Mrs. W. C. Reeves, Mrs. H. E. Mauldin, letter (date unknown), page 1, paragraph 4; Cleveland E. Owen, 9/4/80 letter, paragraph 1; Philip R. Owen, 9/20/80 letter, page 2, comment A2; Donald B. Popejoy, 9/29/80 letter, paragraph 2; James H. and Judith B. Wilson, 9/18/80 letter, page 1, paragraph 2, and page 2, paragraph 2.

Response

Concern has been expressed by government agencies and others about the effects of acid rain that may result from the increased use of coal to offset the need for imported petroleum. However, scientists disagree as to the extent of, cause of, and need for and possible means of minimizing acid rain impacts. Because of the high pollution control efficiencies possible with coal gasification (especially SO_2 control), generation of acid rain precursors is small in comparison to other methods of coal usage.

"HEALTH EFFECTS" RELATED COMMENTS

1. Comment

Commenters expressed concern that the amount of pollutants to be emitted might cause or aggravate health problems, especially upper respiratory problems, including asthma.

Comments By

Fancher Adams, letter (undated), paragraph 1; Royce M. Bynum, letter (undated), paragraph 1; Jack E. Farris, 9/26/80 letter, paragraph 2; B. D. Gateley, letter (undated), page 2, items 3 and 8; Dr. Michael Mauldin, et al., letter (undated), page 1, paragraph 2; Clayton Mercer, 9/24/80 letter, paragraph 3; Donald B. Popejoy, 9/29/80 letter, paragraph 1; William R. and Adelaide A. Potter, 9/20/80 letter, page 2, paragraph 3; Mrs. Pullan, DEIS public hearing transcript, page 54, paragraph 5 to page 55, paragraph 1; Billy Joe and Sue Rowan, 9/28/80 letter, page 1; and page 2, paragraph 1; William Talley, DEIS public hearing transcript, page 62, paragraph 5 to page 63, paragraph 3; W. George Taylor, 9/24/80 letter, paragraph 1.

Response

Later design information and more realistic assumptions have resulted in a substantial reduction of the expected emissions from the project. Conceptual design information indicates that about 3.5 tons per day (TPD) of SO_2, 2 TPD of NO_x and 0.3 TPD of (PM) may be emitted. (See response to Comments Relating to Quantities of Materials to be Emitted, comment 1.)

Expected ambient levels of pollutants are considerably below primary NAAQS define levels of air quality, with margin for safety, to protect the public health, operation of the plant is not expected to increase the frequency of upper respiratory problems of area inhabitants.

See also the response to comments concerning Polynuclear Aromatic Hydrocarbon/Polycyclic Organic Matter Impacts.

COMMENTS REFERRING TO "GRAVE DEGRADATION" OR "UNACCEPTABLE IMPACT" ON AIR QUALITY

1. Comment

Commenters expressed feeling that the project would cause "grave degradation" or an "unacceptable impact" to air quality.

Comments By

The Alabama Conservancy, 6/24/81 letter, paragraph 2; Phyllis Bates, letter (date unknown), page 1, paragraph 1, items 1 and 3; Rex B. Brown, 9/25/80 letter, paragraph 1; Betty Ann Lloyd, 9/26/80 letter, paragraph 1; Lillian C. Lloyd, 9/26/80 letter, paragraph 1; Susan C. Lloyd, 9/26/80 letter, paragraph 1; William P. Lloyd, 9/26/80 letter, paragraph 1; William P. Lloyd, Jr., 9/26/80 letter, paragraph 1; Marjorie B. Maples, letter (undated), page 1, paragraph 2, sentence 2; Dr. H. Michael Mauldin, et al., letter (date unknown), page 1, paragraph 4; Joseph V. Olszewski, 9/26/80 letter, paragraph 2; Francis Taylor, letter (undated), paragraph 2; Mr. and Mrs. James H. Wilson, 6/24/81 letter, page 2, paragraph 1.

Response

The DEIS indicated that offsite air quality levels (including those at lakeside locations) would be less than the primary and secondary NAAQS for all pollutants for which NAAQS have been set. In most cases, the levels were predicted to be considerably less than the applicable NAAQS. Further, these levels would be required to be less than those allowed by the PSD increments which have been established for 2 pollutants, SO_2 and particulate matter. Since NAAQS and PSD increment exceedances are not expected, "grave degradation" to air quality is not expected from operation of the proposed coal gasification facility.

COMMENTS RELATING TO QUANTITIES OF MATERIALS TO BE EMITTED

1. Comment

Commenters expressed concern about quantities of materials to be emitted. One commenter asked about Prevention of Significant Deterioration increment consumption.

Comments By

James Bates, DEIS public hearing transcript, page 83, paragraph 6 to page 84, paragraph 1; Ann Maples Brewster, 9/27/80 letter, paragraph 3; Rex B. Brown, 9/25/80 letter, paragraph 1; Mrs. Cain, 9/25/80 letter, paragraph 1; H. B. Cannon, Vice President and General Manager of Revere Copper and Brass, Inc., 9/30/80 letter, page 1; B. D. Gateley, letter (undated), page 1, paragraph 2, item 1; and page 2, item 7; Marion Gibson, 9/25/80 letter, paragraph 2; Ronald T. Green, 9/25/80 letter, paragraph 2; Reed D. Hamman, 8/22/80 letter, page 1, paragraph 1, subheading 2; Rilla Hodges, 9/21/80 letter, page 2, first full paragraph; Max Ingram, DEIS public hearing transcript, page 33, paragraph 1; James D. and Sandra P. Jensen, 9/25/80 letter, paragraph 2; Kenneth C. Johnson, 9/21/80 letter, page 4, last paragraph; C. R. and Elizabeth W. Lang, 9/25/80 letter, paragraph 3; Patrick O. Matkin, 9/25/80 letter, paragraph 2; Helen Nelson, attachment to 9/28/80 letter, page 2, paragraph 1; James Nelson, 9/28/80 letter, paragraph 2, item 2; Alfred P. Owen, 9/26/80 letter, paragraph 2; Mr. Philip Owen, DEIS public hearing transcript, page 151, paragraph 4 to page 152, paragraph 3; R. W. Plant, 9/25/80 letter, paragraph 2; Bengie Rowe, 9/24/80 letter, paragraph 1; Mrs. Arthur Stephens, letter (undated), page 1, sentences 1, 4, and 5; Hugh L. Sutherland, DEIS public hearing transcript, page 109, paragraph 1; Tennessee Toxic Program, attachment to 8/25/80 letter, page 2, item 3; Mrs. Eleanor Wersely, 9/29/80 letter, paragraph 1; and James H. Wilson, 6/24/81 letter, page 2, paragraph 1.

Response

The screening calculations in the DEIS were based on the limited amount of information available and several worst-case assumptions. The purpose of these calculations was to establish whether emissions from the proposed coal gasification facility would result in exceedance of primary or secondary NAAQS, or PSD increments. Primary NAAQS "define levels of air quality which the EPA Administrator judges are necessary, with an adequate margin of safety, to protect the public health" (40 CFR Part 50.2). Secondary NAAQS "define levels of air quality which the EPA Administrator judges necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant" (40 CFR Part 50.2). PSD increments quantify allowable increases in ambient levels of SO_2 and PM from baseline levels, provided that new levels do not exceed the applicable NAAQS.

Later design information and more realistic assumptions resulted in a substantial reduction of the expected emissions from the project. Additionally, the expected impacts from the proposed 2-module facility should be substantially less than those from the 4-module facility addressed in this FEIS. Product gas instead of coal would be burned for various plant steam requirements. Table E-1 presents a comparison of emissions estimated in the DEIS with the revised emissions presented in the FEIS.

For each pollutant, emission estimates are not expected to result in NAAQS exceedances or PSD increment exceedances.

Preliminary estimates of increment consumption, based on the information now available, are presented in the FEIS. When the specific plant design information is available, refined modeling would be performed. The results of this modeling effort would accompany the project's PSD permit application to the State of Alabama. These results can be considered as completed modeling results when they have been provided to the State.

AIR QUALITY AS A SITE SELECTION FACTOR

1. Comment

Commenters asked if the Murphy Hill site was selected because the environmental impact could be more adverse than at Courtland, or that less stringent controls would be required at Murphy Hill in comparison to Courtland. One commenter asked about impact "on the climate, the resultant increase in rain, acid rain, fog, decrease in the hours of sunshine. . ." Another stated "TVA should provide some rationale as to why there is concern about an area 22 miles from Courtland and is no concern about thousands of people who live within 22 miles of Murphy Hill."

Comments By

P. L. Horne, 9/25/80 letter, page 1, paragraph 2; Kenneth C. Johnson, 9/21/80 letter, page 3, paragraph 6 to page 4, paragraph 1; James B. Kyser, 9/22/80 letter, page 2, paragraph 2; Phillip R. Owen, 9/20/80 letter, page 3, item B11; Walter K. Polstorff, 9/6/80 letter, page 1, paragraph 2; and page 2, paragraph 1.

Response

Air quality was only 1 of several selection criteria (Please refer to the DEIS, Table 2-4, page 2-16 and to the response to comment 2 under D, "Site Selection", of this appendix).

However, the Murphy Hill site has fewer potential air quality restrictions to construction or operation of a coal gasification plant than the Courtland site. The primary concerns at Courtland

TABLE E-1

ESTIMATED POLLUTANT EMISSIONS
FROM A 4-MODULE FACILITY

Pollutant	Pollutant Source	Tons/day: DEIS 3780 TPD Coal Burn	Tons/day: FEIS Product Gas Burn	% of DEIS Value
SO_2	Gasification Plant	8.6	3.5	
	Auxiliary boiler	32.5	.01	
	Total SO_2	41.1	3.5	9
PM[1]	Plant Operations	3.1	0.3	10
CO	Gasification Plant[2]	-	8.7	
	Auxiliary boiler	1.9	0.2	
	Total CO	1.9	8.9	468
NO_x	Auxiliary boiler	56.7	2.0	4
Methanol	Gasification Plant[2]	-	16.8	-
	Total Pollutants	102.8	31.5	31

1 PM = particulate matter. PM was identified as total suspended particulate (TSP) in the DEIS.
2 The estimated CO and methanol emissions are from the acid gas removal (AGR) system CO_2 vents.

were the restrictions against even very small impacts on a Class I area, possible significant impacts on a nonattainment area, and the presence of some Class II increment consuming industry in the Courtland area.

Only very small air pollution impacts are permitted in Class I areas. These allowable impacts are much smaller than the NAAQS, and are not oriented to health or welfare concerns. Thus, the presence of the Sipsey River Wilderness Area (a Class I area) 35 km (22 mi) south of the Courtland site might more severely restrict allowable emissions of sulfur dioxide from a coal gasification plant at Courtland than at Murphy Hill.

Emissions, as estimated in the DEIS, were not expected to cause exceedances of NAAQS or the applicable PSD increments. Later design information and more realistic assumptions have resulted in a considerable reduction of those estimated emissions.

Emission controls can be expected to equal or exceed "Best available control technology" (BACT), and, in some cases, may approach "Lowest achievable emissions rate" (LAER) levels, regardless of the site selected.

The proposed facility would not be expected to cause either measurable increases in rain, acid rain, or fog, or measurable decreases in the hours of sunshine in the surrounding area at either site.

POLYNUCLEAR AROMATIC HYDROCARBON/POLYCYCLIC ORGANIC MATTER IMPACTS

1. Comment

Commenters expressed concern about the potential generation of polynuclear aromatic hydrocarbons. One stated "It is my impression . . . that a substantial problem exists with potential generation of polycyclic hydrocarbons no matter what the process. Ames test screening indicated that at least some fractions are potentially highly carcinogenic."

Comments By

Ms. Diane Davidson, 9/23/80 letter, paragraph 1, subheading 1; Philip R. Owen, 9/20/80 letter, page 2, item A2, sentence 1; Tennessee Citizens for Wilderness Planning, 8/19/80 letter, paragraph 1; Tennessee Toxics Program, attachment to 8/25/80 letter, page 1.

Response

Polynuclear Aromatic Hydrocarbons (PAH), also referred to as polycyclic organic matter (POM), are emitted as a result of the combustion of organic materials such as petroleum products, coal, and wood. Combustion of these organic materials at low temperatures appears to result in considerably higher quantities of POM emissions than during higher temperature combustion conditions. The preferred gasifiers, K-T and Texaco, are high temperature units. Either of these units should have minor emissions of POM, in comparison with other gasifier technologies and with alternate methods of coal usage.

The Ames test is simply a bioassay test for determining mutagenicity. No direct correlation has been established between the Ames test (nor any other mutagenicity test) and carcinogenicity. EPA does not use the Ames test as a basis for setting standards. Further, EPA has not determined that any standards are necessary for these compounds.

EPA is developing pollution control guidance for coal gasification and liquefaction. It is expected that this guidance would be more specific with respect to organic toxic compounds.

The gasifier would be designed and operated in such a manner as to make all emissions, including PAH, as small as practicably possible.

COMMENTS ON POLLUTANT DISPERSION MODELING AND TERRAIN EFFECTS ON POLLUTANT DISPERSION

1. Comment

Air Quality construction impact should address increases in highway traffic in the vicinity of the proposed site. This impact should be modeled by procedures approved by the Federal Highway Admistration and include a worst case analysis for carbon monoxide.

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 1, item 6.

Response

The analysis has been performed, and details are given in the FEIS, Volume 2, Section 4.2.1.1. The results showed that the estimated 1-hr CO concentrations from the expected increased traffic based on constructing a 4-module facility would not approach the present 1-hr standard of 40 milligrams per cubic meter (mg/m^3) or the proposed standard of 25 mg/m^3.

2. Comment

Commenter expressed concern about the rough terrain around Murphy Hill, and asked about air quality modeling of such terrain.

"The only model for air impacts in rough terrain which I am aware of is the VALLEY model recommended by EPA. This model, though it probably overstates the air impacts, should at least offer some insights into the effects of the rough terrain. And, if the VALLEY model does indicate satisfactory emission levels, there would be a much higher degree of confidence in the stack design."

Comment By

James A. Bates, 9/28/80 letter, page 1, paragraph 4; DEIS public hearing transcript, page 84, paragraph 2.

Response

For the DEIS, maximum ground level concentrations of pollutants, including SO_2, were estimated, using stated assumptions and the Gaussian equations from D. Bruce Turner's "Workbook of Atmospheric Dispersion" (see DEIS, page G-28). Terrain was considered only qualitatively.

Modeling for the FEIS was conducted with the Gaussian MULTIMAX model, in part because of its versatility. For example, it takes terrain into account, accepts multiple sources, uses actual meteorology, and makes ambient impact predictions for both short-term (1, 3, and 24 hr) and annual time periods. Estimates of ambient concentrations obtained by this model are presented in the FEIS, Appendix G.

The VALLEY model is less versatile, since it uses assumed meteorology and makes predictions only for 24-hr and annual time periods. However, a version of the VALLEY model was also used to estimate the impact of SO_2 emissions from the tail gas vent stacks associated with the proposed coal gasification facility. Estimates of worst-case 24-hr-average ambient SO_2 concentrations on the high terrain near the Murphy Hill site were obtained.

Stack height (m):	61.0
Stack diameter (m):	2.0
Exit velocity (m/s):	14.3
Exit temperature (K):	450.0
SO_2 emission rate (g/s):	36.6 (combined total for all modules)

This emission rate corresponds to an SO_2 removal rate of about 99.8%.

The model results indicate that under worst-case meteorology, the highest estimated concentration from that rate of emission would equal the 24-hr PSD Class II increment. Taller stacks and/or lower emission rates are expected to reduce these predicted concentrations to below PSD Class II increment values.

3. Comment

. Commenters expressed concern about whether the stack was tall enough to adequately disperse pollutants, the effect of terrain on pollutant dispersion, the potential need to evacuate the valley during stagnant air conditions, and the potential for smoke and smog formation.

Comments By

James Bates, DEIS public hearing transcript, page 84, paragraph 2; Joyce Bates (Mrs. James A.), 9/25/80 letter, paragraph 3; Max Ingram, DEIS public hearing transcript, page 34, paragraph 1; Philip R. Owen, 9/20/80 letter, items A2, B16, and B47; William R. and Adelaide A. Potter, 9/20/80 letter, page 1, last paragraph.

Response

The terrain at Murphy Hill would result in somewhat greater gaseous pollutant impacts from the coal gasification facility alone, compared to its impacts on the flatter terrain at Courtland. However, existing levels of air pollution are believed to be higher at Courtland than at Murphy Hill.

Stack and meteorological parameters would be the subject of detailed studies, including modeling, in order to optimize stack design. Ambient concentrations of pollutants are not expected to exceed the NAAQS and the applicable PSD increment.

Since product gas would be burned instead of the coal that was originally planned, little, if any, smoke (particulate matter) is expected from the stacks.

A smog problem is not expected to occur from operation of the coal gasification plant at the Murphy Hill site.

GENERAL COMMENTS

1. Comment

Page 2-33, 2.3.3.5, third full paragraph. Define what is meant by "fugitive emissions of carbon monoxide".

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, item 1.

Response

Coal gasification processes utilizing a pressurized lock hopper (e.g., Lurgi) to feed coal have the potential to emit small quantities of product gas containing high levels of CO when the lock hopper is depressurized and opened to add more feed coal. Since this gas is vented to the atmosphere without passing through a stack or chimney, it is termed a fugitive emission (please see Federal Register , Volume 45, August 7, 1980, page 52680).

2. Comment

Page G-31, 4.2.1.2.2, sixth paragraph. Elemental sulfur transfer and/or storage should be included in TSP emission and should be addressed in the Miscellaneous Source Section."

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, item 7.

Response

Sulfur is recovered in molten form (DEIS page 2-47, Section 2.3.6.8 Sulfur Recovery). Since it subsequently would not be in powder form, no significant amounts of PM are expected to be emitted from its transfer and storage.

3. Comment

Page G-27, 4.2.1.2, General Comment

Air Quality impacts from barges and tugs delivering the coal should be discussed."

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, item 5.

Response

The operation of the barge and tug system does generate a small amount of pollution. The PM emitted 1.1 lb/mi (pound per mile) for each unit of 23,780 tons of coal barged was quantified in the DEIS (page G-30, Section 4.2.1.2.2). The air quality impacts resulting from barge and tug operation are negligible due to the relatively low emission levels, and the time and space intervals over which they are emitted.

For information on expected barging operations, please see Section 4.1.5 of Appendix G.

4. Comment

31. Page 246, paragraphs 2, 3, 6, 7: Production of oxygen from air will obviously lower the oxygen content of air in the plant area and make less oxygen available for oxygenation of water in the lakes. This effect was not addressed in the EIS.

Comment By

Philip R. Owen, 9/20/80 letter, page 5, comment B31.

Response

This effect was discussed in Volume 2 of the DEIS, page G-35, Section 4.2.1.2.6. Since any nitrogen not utilized or sold is expected to be vented at a high level, and due to subsequent mixing, there should be no measurable reduction in the percentage of oxygen (O_2) in the air in contact with the surface water of the Guntersville Lake or any other body of water in the area of the Murphy Hill site.

5. Comment

More effective means of controlling particulate emissions from coal piles and handling are available than those discussed in the DEIS. For example, polymer coatings more effective than simple water spraying can be used to control dust from coal piles. More information is needed on the design of the coal handling systems to assure that enclosures and particulate-capturing devices are used to minimize emissions.

Comments By

James A. Bates, 9/28/80 letter, page 1, paragraph 5; Natural Resources Defense Council, attachment to 10/1/80 letter, page 17, paragraph 1.

Response

Particulate losses from the coal pile are expected to comprise only a small portion of the total PM associated with plant operation. Water sprays were mentioned, since they are reasonably effective, while at the same time costing relatively little to operate. In addition, use of water sprays does not adversely affect the gasification process. More effective controls appropriate to the specific processes, such as those mentioned, would be utilized to the extent they are necessary. It is anticipated that dust control hoods would be provided to minimize emissions from required transfer points, storage silos, and hoppers. Although design of the coal handling system has not been finalized, effective particulate control is one of the design criteria to be followed.

BACT would be utilized in the design of dust control systems as well as in the selection of control equipment. Such controls would be thoroughly reviewed by the State of Alabama and EPA during the air permitting process.

6. Comment

"The DEIS states (at page G-27) that TVA is considering washing the coal to remove sulfur and other problem impurities before shipping it to the gasification plant. NRDC strongly urges that coal washing be adopted. It would reduce the load on the gasification plant's sulfur removal systems. Moreover, it would result in significantly lower sulfur emissions from the auxiliary steam generating plant."

Comment By

Natural Resources Defense Council, attachment to 10/1/80 letter, page 16, section G, paragraph 1.

Response

If coal washing near the mine mouth is chosen, benefits include approximately 15-30% less sulfur content, and considerably less mineral matter. As stated, this could result in lower sulfur compound emissions, would reduce the amount of solid waste, and would lower transportation costs. Environmental costs of coal washing include air pollutant emissions from thermal dryers, and solid wastes disposed of in the vicinity of the coal washing plant. Since design changes have eliminated the burning of coal for auxiliary steam generation, the SO_2 emissions from this source have been virtually eliminated. The product gas which would be burned is expected to have about 1 ppm of a mixture of carbonyl sulfide (COS) and hydrogen sulfide (H_2S), which will yield negligible amounts of SO_2 upon combustion.

7. Comment

Commenters opposed the "stench of sulfur dioxide," or "smelling the fumes of the plant."

Comment By

Jennie M. Helderman, 9/28/80 letter, page 1, paragraph 6; Inez Reese, DEIS public hearing transcript, page 120, paragraph 4 to page 121, paragraph 2.

Respons:

According to the American Industrial Hygiene Association (Hygienic Guide Series, "Sulfur Dioxide"), "Sulfur dioxide can be detected by taste at 1/3 to 1 ppm--parts per million--and by smell at 1 to 3 ppm." The primary NAAQS for maximum 24 hr average concentration of SO_2 is 0.14 ppm and the secondary NAAQS for maximum 3 hr average concentration of SO_2 is 0.5 ppm. TVA expects that maximum concentrations of SO_2 in the vicinity of the proposed facility would be much below the primary and secondary NAAQS. It is not expected that any ground level detectable SO_2 odor would result offsite as a result of the gasification project operation, or that the proposed plant would present an odor problem to the area.

8. Comment

42. Page 4-4, paragraph 4.1.2.1: This paragraph indicates that potential emissions were based on a number of general assumptions. The assumptions should be included in the EIS and should be validated prior to finalizing the EIS.

Comment By

Philip R. Owen, 9/20/80 letter, page 6, item B42.

Response

The DEIS Volume 2, Appendix G, Section 4.2.1, discussed in greater detail the assumptions that were made. More detailed assumptions, based on improved conceptual design information, are used in the FEIS. This information has been developed by a respected architect-engineering firm with extensive capabilities in chemical process engineering. TVA believes that this information developed by experienced professional chemical or design engineers is adequate to assess environmental impacts. The ultimate validation of these emissions or assumptions cannot be completed until the facility begins operation and appropriate measurements are taken.

9. Comment

Commenter requested information relative to control equipment and emission standards for particulates, NO_x, and SO_2, as they relate to the auxiliary boiler.

Comments By

James A. Bates, 9/28/80 letter, page 1, paragraph 6 and page 2, paragraphs 1, 3, 4, and 5; DEIS public hearing transcript, page 82, paragraph 5 to page 83, paragraph 5.

Response

Since the DEIS was written, the amount of process steam needed has been reduced, and the fuel to be burned for auxiliary steam generation has been changed from coal to product gas. Burning of product gas is expected to produce negligible emissions of particulate matter.

As stated in the DEIS (Volume 2, Section 4.2.1.2.5, page G-34), the estimated amount of NO_x was conservatively large. Even this amount resulted in estimated concentrations less than the NAAQS. The reduced requirements for steam, in combination with the new source performance standard associated with coal-derived gaseous fuels (0.2 lb/10^6 Btu), results in an upper permissible emissions limit of about 2 TPD of NO_x. Boiler designs and associated controls have not been finalized, but one criterion is that the applicable NO_x emissions standard would be met. This should result in ambient levels considerably below the NAAQS for NO_x.

By burning product gas rather than coal to produce needed process steam, this would reduce the 32.5 TPD of SO_2 listed in the DEIS to about 5 lb/day of SO_2 from this emission source.

10. Comment

Commenter referred to DEIS estimates of SO_2 to be emitted, and to Mercke Index descriptions of SO_2 and hydrogen cyanide (HCN).

Comment By

Sylvester Boaz, DEIS public hearing transcript, page 20, paragraph 7 to page 21, paragraph 3.

Response

Design changes and more realistic assumptions have considerably reduced the expected SO_2 emissions (please see response to comment 1 under Comments Relating to Quantities of Materials to be Emitted in this section). The Mercke Index description of SO_2 refers to the pure substance. The expected ambient levels of SO_2 are small fractions of 1 ppm. In these concentrations, no significant impact is expected on public health or welfare. Ground level detectable SO_2 odor is not expected to result off-site as a result of the gasification project operation (please see response to comment 7 above).

As stated in the DEIS, Volume 2, page G-35, the product gas from a K-T gasifier may contain 300 ppm HCN, prior to clean-up. This is removed from the gas stream in the purification process. Therefore, HCN is not expected to be emitted to the atmosphere in quantities that could be harmful.

11. Comment

Across the river from Murphy Hill is land designated and sold by TVA for recreation use only. This area includes Preston cabin site, Pine Island cabin site, Girl Scout club site, Church of Christ club site, Ossa-win-tha Resort and TVA's own trailer and tent camping ground at Seibold Creek--also Riverbend Condominiums.

The prevailing winds constantly blow from Murphy Hill across lake to areas just mentioned. We are all concerned about pollution to air, water, noise, and light as well as effect to fishing, skiing, and swimming.

Comment By

Inez E. Reese, letter (undated), page 1, paragraph 3.

Response

Data from the meteorological tower at Murphy Hill does not support the statement, "The prevailing winds constantly blow from Murphy Hill across lake to areas just mentioned." These data were summarized in Figure 3.2.1-1 of the DEIS (Volume 2, page F-24). Percentages of the time that the wind, measured at 10 m elevation, blew from each of 16 compass sectors, in the October 1, 1978, to September 30, 1979, time period, are as follows:

Direction from which wind blew	Percent of time
N	6.25
NNE	7.88
NE	9.78
ENE	7.53
E	5.02
ESE	5.71
SE	10.25
SSE	5.24
S	6.25
SSW	5.48
SW	6.99
WSW	3.88
W	4.05
WNW	4.23
NW	7.95
NNW	3.51

The wind distribution at 110 m (DEIS, Volume 2, page F-25), representative of winds near stack top, shows the wind blowing toward the areas mentioned an even smaller percentage of the time.

12. Comment

Commenter expressed concern that toxic or hazardous chemicals might be carried to populated areas surrounding the facility, and stated, "Calculated concentrations of each toxic/hazardous agent at various distances from the point of origin should be compared with threshold limit values (TLV's) allowable by State and Federal regulations, including the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), and the Code of Federal Regulations (CFR).

Comment By

Philip R. Owen, attachment 3 to 9/25/80 letter, page 1, paragraph 1.

Response

An evaluation of possible air quality impacts from expected emissions to the air, including certain toxic or hazardous pollutants, was presented in the DEIS. Later conceptual design information and more realistic assumptions have substantially reduced the estimates of most of the expected emissions. This revised information for a 4-module plant is presented in Appendix B of the FEIS. Highest ambient concentrations are compared to the NAAQS, for those pollutants which are assigned NAAQS. Threshhold limit values (TLV's) are set at higher concentrations than NAAQS because they have been established for healthy workers who are exposed a maximum of 8 hr/day, 40 hr/week, or less. Therefore, TLVs are not applicable to substances found in the ambient air to which the public is exposed.

For other regulated pollutants that are expected to be emitted to the air, EPA "de minimis" emissions criteria are the basis for comparison. All potentially toxic/hazardous pollutants do not have standards promulgated for public exposure.

13. Comment

Commenter requested "copies of pertinent regulations governing each pollutant along with some descriptive data on the characteristics and hazards associated with each."

Comment By

Philip R. Owen, 4/7/80 letter, page 2.

Response

The material requested is too voluminous to include in the FEIS; however, Title 40, Code of Federal Regulations, subchapter C-Air Programs, includes most of the pertinent Federal air quality regulations. The Alabama Air Pollution Control Commission Rules and Regulations, Chapters 1 through 16, include pertinent State air quality regulations. Both of these are available at many public libraries.

14. Comment

"h. Physical maps which plot isopleths for noise levels, air pollution levels, (all pollutants, considering mean and extreme weather conditions), water pollution levels, and other data normally required in Environmental Impact Statements."

Comment By

Philip R. Owen, 9/25/80 letter, page 3, item h.

Response

Expected ambient air pollution concentrations for worst-case situations (extreme weather conditions) are included in Appendix G of the FEIS. Refined modeling for the PSD permit application would include isopleth analyses for determination of PSD increments.

15. Comment

Commenter requested, "Effects of pollutants on farm crops and pastures in the area, including reduced yields and resulting effects on farm economics."

Comment By

Philip R. Owen, 4/7/80 letter, page 3, item f.

Response

The effects depend on pollutant, pollutant concentration, and plant species. Among the air pollutants that are expected to be emitted from the proposed plant, the greatest potential for effects on vegetation would be associated with SO_2. For short term (1 to 3 hr) SO_2 concentrations less than about 650 micrograms per cubic meter ($\mu g/m^3$) or 0.25 ppm, no significant effect on farm crops and/or pasture is expected. The air quality impact analyses performed in connection with the FEIS show SO_2 concentrations are expected to be well below this level.

16. Comment

Commenter requested information on air pollutants to be presented in a chart with specified format.

Comment By

Philip R. Owen, 4/17/80 letter, page 1, final paragraph.

Response

Information about background levels, permitted concentrations, and the estimation of maximum concentrations resulting from plant operation for all pollutants expected to be emitted in more than "de minimis" amounts are presented in the FEIS (Appendices F and G). The referenced chart was not used directly since its use could be misleading and was not entirely appropriate.

For instance, PSD increments have been established for only 2 pollutants, viz. SO_2 and particulate matter. The increments listed (".002 mg/m^3 for SO_2 and .005 mg/m^3 for particulate matter") are annual increments for Class I areas. Since only Class II areas are significantly impacted, the applicable increments are:

Particulate matter (PM):	
Annual geometric mean	19 $\mu g/m^3$
Maximum 24-hr average	37 $\mu g/m^3$
Sulfur dioxide (SO_2):	
Annual arithmetic mean	20 $\mu g/m^3$
Maximum 24-hr average	91 $\mu g/m^3$
Maximum 3-hr average	512 $\mu g/m^3$

(Note: The Federal standards are stated in $\mu g/m^3$. 1 $\mu g/m^3$ = .001 mg/m^3).

17. Comment

No cost is detailed in the EIS for the purchase of air rights of residents in the near proximity as required by rules and regulations implementing PL 95-95, title 40 CFR part 51. Further no record has been uncovered showing the public was advised of a hearing covering redesignation of the area from a Class I to Class II as required by 40 CFR 51.

Comment By

P. L. Horne, 9/25/80 letter, page 2, last paragraph.

Response

There are no Federal or State of Alabama rules or regulations requiring any organization that proposes to build and operate a significant source of air pollutants to purchase "air rights of residents in the near proximity." According to 40 CFR, Part 51.24 (e), certain areas (international parks, national wilderness areas or memorial parks exceeding 5,000 acres in size, national parks exceeding 6,000 acres in size, and areas redesignated as Class I before August 7, 1977) were initially designated as Class I. All other areas were automatically termed Class II (although they could be redesignated). The Murphy Hill area has never been redesignated from its original Class II designation. The only Class I area in Alabama is the Sipsey River Wilderness area, located about 35 km south of the Courtland site.

18. Comment

There is one other aspect, however, that is not included in this presentation that I do want to address, and that is the--regardless of what Mr. Weinhold says--based on the study, the impact on those of us that live in the southwest quadrant from the plant.

According to TVA studies, the southwest and northeast quadrant will be provided the greatest influx of the pollutants of the plant, both when the winds are blowing and most certainly as Max Ingram has stated when there is a dead calm. TVA's study very nicely states that no individual lives within 2,000 meters of the plant. They are correct. 2,000 meters from the plant with a maximum doseage would be per their own tables--happens to be on the river.

What is going to happen 2,300 meters away where I live from the plant? No one is going to tell us on Pine Island that there is going to be that great a reduction in those pollutants.

Further, as the winds blow to the southwest, as they do about 40 percent of the time, hopefully they will be fast so that they can carry it to Guntersville. I don't want it on my property. The greatest degree of radioactivity will hit the Pine Island peninsula. Although it is not going to be a lethal dose, it is still going to hit the southwest quadrant at 2,000 meters, the center of the water, and carried an additional 300.

Comment By

Peter Horne, DEIS public hearing transcript, page 49, paragraph 2 to page 50, paragraph 1.

Response

The reference to "2,000 meters" (m) and "SW quadrant" are taken out of context (DEIS, Volume 2, Table 4.2.11-4, page G-58). These figures represent the location of maximum dose of radioactivity to a hypothetical exposed individual, based on a conservative modeling approach. With elimination of the proposed auxiliary coal burn, this source of particulate emissions (source of the trace of radioactive material giving rise to the "dose to maximum exposed individual") is likewise eliminated.

Onsite wind measurements (see FEIS, Volume 2, Section 3.2.1.1) indicate that winds at the 10 m and 110 m levels blow toward the southwest quadrant about 31% and 34% of the time, respectively. Pine Island appears to be northwest of the plant site, thus not in the southwest quadrant from the plant.

19. Comment

The summary of estimated air emissions from the proposed coal gasification facility in the DEIS (Table 2-8) should include all emission sources such as flares and incinerators.

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 1, paragraph 2.

Response

Tables B-10 through B-15 in FEIS Appendix B contain estimates of emissions from normal operations and startup flaring, respectively. Section 4.2.1.3, Appendix G, FEIS, Volume 2, contains a discussion of potential impacts of SO_2 concentrations resulting from flare operations and possible mitigation measures.

20. Comment

The final EIS should include a process flow diagram indicating various criteria air pollutant emission points and rates, and the efficiency of the control technology. A narrative discussion should accompany the diagram.

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 1, paragraph 3.

Response

Process flow diagrams, Figures 2-5 and 2-6, have been included which show the various emission points and rates. In addition, Appendix B has been revised to include a discussion of the expected air emissions from this facility. Information about sources of PM and expected control efficiencies is presented in Table B-10 in Appendix B of the FEIS. Also, potential SO_2 emissions are discussed in Appendix B, and their potential impacts are discussed in Appendix G.

21. Comment

The discussion of air pollution emissions in the EIS should incorporate information on the effects of startup and shutdown conditions on the process related emission rates.

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 1, paragraph 4.

Response

See Section 4.2.1.3, Appendix G, FEIS Volume 2, for a discussion of potential impacts from startup/shutdown flaring.

22. Comment

The DEIS should include a TVA commitment with EPA-IERL to develop control technologies to prevent the emission of toxic and carcinogenic organic compounds (especially polycyclic species).

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 1, paragraph 8.

Response

TVA is committed to working closely with EPA to determine the best available control technology (BACT) needed to control plant emissions (please see Appendix A). Results of overseas testing at commercial gasification facilities would be coordinated with EPA over the next few months. In addition, pollution control design decisions would be coordinated to help ensure selection of BACT.

23. Comment

Ambient SO_2 concentrations are expected to exceed National Ambient Air Quality Standards and PSD increments during the flaring operations. The Environmental Impact Statement Supplement does not satisfactorily explain how this problem could be handled.

Comment by

Mary Ann Jenkins, 6/26/81 letter, paragraph 3; The Alabama Conservancy, 6/24/81 letter, paragraph 3.

Response

Please refer to the response to comment 19 above where we have noted sections in the FEIS that address this issue.

I. SURFACE AND GROUND WATER

1. Comment

The discussion of the impacts of dredging and dredged spoil disposal has been insufficiently addressed.

Comments By

Natural Resources Defense Council, 10/1/80 letter, page 15, paragraph 6; U.S. Department of the Interior, 10/7/80 letter, page 4, paragraph 1; U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 3, paragraph 4.

Response

Please see the revised discussion of potential impacts from dredging and dredged spoil disposal in Section 4.2.2 of Appendix G and the response to question 5 under "J. Fisheries and Aquatic Ecology."

2. Comment

The discussion of erosion and siltation control measures should be expanded.

Comments By

Natural Resources Defense Council, attachment to 10/1/80 letter, page 14, comment 2; U.S. Department of Agriculture, Soil Conservation Service, 6/10/81 letter, comment 1; U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 5, paragraphs 4 and 5.

Response

As discussed in Section 4.2.2 in Volume 2 of the FEIS, the project would utilize "Best Management Practices" to control erosion and sedimentation because of stormwater runoff from disturbed areas. The practices which would be utilized are discussed in EPA's "Guidelines for Erosion and Sediment Control Planning and Implementation," EPA Environmental Protection Technology Series Report EPA-R2-72-015, August 1972. These measures include the use of diversion ditches, dikes, and holding ponds. Construction of holding ponds, and dikes to route surface water runoff to these ponds, will be the first major effort conducted as part of site preparation. Routine inspection and reporting on the effectiveness of runoff control measures would be conducted as required under the NPDES permit and problems identified would be corrected.

The construction runoff holding ponds would be designed to contain and treat the 10-yr, 24-hr rainfall event and would also be equipped with filters to effectively control the discharge of suspended solids. Discharges would be regulated by a manually operated valve such that water meeting NPDES permit limitations would be discharged.

3. Comment

More detail should be provided concerning spill containment.

Comments By

Philip R. Owen, 9/25/80 letter, page 1, paragraph 2; U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 5, paragraph 5.

Response

The SPCC plan would be prepared in accordance with the EPA guidelines for oil pollution prevention which are detailed in 40 CFR Part 112. All hazardous substances (as defined in 40 CFR Parts 116 and 117) and all hazardous wastes (as defined in the regulations pursuant to RCRA of 1976) would also be addressed in the SPCC plan. Spill control measures may include, but are not limited to, concrete berms around bulk storage tanks, regular inspection of storage tanks to detect any potential for leakage, the maintenance of oil and hazardous substance usage records, and regular training of employees in SPCC measures. Oil absorbent materials, containment booms, portable pumps, and other clean-up equipment would be stored onsite. Also, secondary containment of any spill would be provided by the 4 construction runoff holding ponds, each of which would be equipped with a manually operated valve which normally would be closed. All discharges would be inspected to ensure that no oil is discharged.

4. Comment

"The Alabama Water Quality Standards (AWIC Standards) seem to be TVA's benchmark (page G-37). If so, (a) how current are they, i.e., have they been upgraded and approved by EPA? (b) Which pollutants do they cover--the necessary ones? (c) Which use designations are in effect at the proposed site? (d) What will happen when EPA promulgates the final 65 criteria and/or requires States to adopt more protective standards for many of the effluents at issue?"

Comment By

Natural Resources Defense Council, Inc., attachment to 10/1/80 letter, page 14, paragraph 4, comment 1.

Response

As stated in Section 4.2.2.2 in Volume 2 of the FEIS, the EPA is in the process of developing guidance for the synfuels industry. The project would comply with all State and Federal water pollution control requirements. The AWIC's water quality criteria were approved by EPA on February 15, 1978. As stated in Section 4.2.2.2 of Appendix G, current regulations cover those pollutants for which there is a solid scientific basis for regulating for a given water use (see Table E-2). In response to (c), see the discussion of Surface Water Use in Sections 3.2.2A and 3.2.2B of Volume 2 of the FEIS. In response to (d), EPA has published water quality criteria for 64 of the 65 toxic pollutants (45 Federal Register 79318-79, November 28, 1980), and has evaluated a number of possible policy alternatives dealing with the adoption and application of water quality criteria for toxic pollutants. A proposed regulation pertaining to this subject was scheduled for release in the Federal Register in April 1981 (46 Federal Register 3408, January 14, 1981). At this time, we are unable to state how the AWIC would utilize these criteria in the formulation of water quality standards for specific stream uses in the State of Alabama. A comparison of EPA's recently issued criteria for the 64 toxic pollutants with the existing water quality in the vicinity of the proposed sites may be found under Surface Water Quality in Sections 3.2.2A and 3.2.2B in Volume 2 of the FEIS.

5. Comment

The range of DO values at Murphy Hill is very large (page G-39). Without knowing the distribution of these values it is not possible to assess the overall danger of exceeding standards (or for what portion of time standards will be exceeded)."

Comment By

Natural Resources Defense Council, attachment to 10/1/80 letter, page 15, comment 5.

Response

The sentence in question states that the overbank area near the proposed barge facility area exhibits wide diurnal fluctuations in dissolved oxygen concentrations and that these fluctuations ranged from 0.7 to 3.3 mg/l (the 4.3 mg/l figure was in error). The actual dissolved oxygen values ranged from 7.5 to

TABLE E-2. WATER QUALITY CRITERIA
ALABAMA

Parameter	Fish and Wildlife Value	Domestic Water Supply Value
pH	6-8.5	6-8.5
Temperature	≤ 86°F[a]	Rise above ambient ≤ 5°F
Dissolved Oxygen	≥ 5 mg/l[b]	≥ 5 mg/l[b]
Bacteria	≤ 2000/100 ml	≤ 4000/100 ml
Turbidity	≤ 50 JTU	≤ 50 JTU
Toxic Substances	Not to exceed 1/10 of 96-hr TLM	-

[a]Those river basins having been designated by the Alabama Department of Conservation and Natural Resources as supporting small mouth bass, sauger, and walleye shall not exceed 86°F (applicable to the Tennessee River in N. Alabama).

[b]Except under extreme conditions due to natural causes, it may range between 5 mg/l and 4 mg/l, provided that the water quality is favorable in all other parameters.

11.4 mg/l at 0.3 m depth, from 6.7 to 8.4 mg/l at 2.4 m, and from 4.3 to 7.6 mg/l at 4.6 m. This investigation was conducted in June 1975. As stated in the DEIS, however, dredging would be conducted during the cold months, if practicable, when dissolved oxygen levels are naturally highest to minimize impacts.

6. Comment

What does the DEIS mean by subsurface discharge? Does TVA consider deep well injection as a possible pollution abatement strategy?

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 3, paragraph 3.

Response

In the context of Section 4.2.2.3, the term "subsurface discharge" implies ground-water contamination by leaching of waste materials. Since Section 4.2.2 of Appendix G is entitled "Surface Water," the words "subsurface discharge" have been deleted from the text. The potential for groundwater contamination via "subsurface discharge" is discussed in Section 4.2.12, "Solid Waste Disposal" of Appendix G in the FEIS. The project is not considering deep well injection.

7. Comment

TVA promises to leave a 'portion' of the assimilative capability at the preferred site for future development (page G-39). There should be a detailed forecast of such development, and a commitment to leave a specific portion.

Comment By

Natural Resources Defense Council, attachment to 10/1/80 letter, page 15, comment 4.

Response

The discussion on page G-39 of DEIS Volume 2 has been revised to agree with the discussion on page 4-8 of DEIS Volume 1, in which the project has committed to "conduct assimilative capacity studies to determine the quantity of oxygen-demanding wastes" which the lake could assimilate without significantly affecting the potential for additional industrial growth in the area. Pending the results of these studies, TVA is not presently able to determine what portion of the existing increment would be left. It is expected that as large a portion of the increment as practicable would be left for future development.

8. Comment

Upgrading the access roads to the plant will likely involve obtaining a Section 404 permit from the Corps of Engineers for the stream crossings. The environmental impacts of the road upgrading, especially for stream crossings should be addressed in the impact statement. If these impacts are not discussed in the EIS, an additional environmental assessment will have to be submitted with the 404 permit application.

Comment By

U.S. Department of Interior, 10/7/80 letter, page 4, paragraph 3; U.S. Department of Transportation, attachment (State of Alabama Highway Department, 9/15/80 letter) to 9/25/80 letter, page 1, comment 8.

Response

Construction-related impacts would be minimized through the use of "Best Management Practices" for prevention of land erosion and siltation of surface waters (reference Section 4.2.2, Appendix G, Volume 2 of the FEIS). For information on the potential impacts of access road upgrading on aquatic organisms, please refer to the response for comment 4 under "J. Aquatic Ecology and Fisheries" in this appendix. In addition, a discussion of the impacts associated with the placement of fill is found in Section 4.2.4 of Appendix G.

9. Comment

Compliance with State (or even EPA) air and water pollution requirements is almost meaningless since . . . they do not have the necessary analytical techniques or standards for the more worrisome compounds.

Comment By

Tennessee Toxics Program, attachment to 8/25/80 letter, page 1, paragraph 5.

Response

The numerous environmental statutes and regulations establish standards and guidelines which address a large variety of pollutants, particularly those pollutants which have been determined to constitute a significant threat to human health, welfare, and the environment. Furthermore, TVA's environmental policy that compliance with applicable Federal, State, and local regulations and requirements is the minimum level of protection necessary would be reflected in the project. TVA would provide, if necessary, a greater degree of protection to enhance the quality of the environment. For example, the results of toxicity studies would be used to design waste treatment facilities.

10. Comment

The plant discharges might potentially impact water quality, especially as related to downstream water use and aquatic life.

Comments By

Alabama Water Improvement Commission, 11/13/80 letter, page 1, paragraph 1; Phyllis Bates, letter (date unknown) page 1, comments 1 and 3; Rex B. Brown, 9/25/80 letter, comment 1; Mrs. Cain, 9/25/80 letter, page 1, paragraph 1; Diane Davidson, 9/23/80 letter, page 1, paragraph 1; Jack E. Farris, 9/26/80 letter, paragraph 2; B. D. Gately, letter (date unknown), page 2, comments 7 and 8; Reed D. Hamman, 8/22/80 letter, page 1, paragraphs 1, 4, and 6; Betty Ann Lloyd, 9/26/80 letter, comment 1; Lillian C. Lloyd, 9/26/80 letter, comment 1; Susan C. Lloyd, 9/26/80 letter, comment 1; William P. Lloyd, Jr., 9/26/80 letter, comment 1; William P. Lloyd, Sr., 9/26/80 letter, comment 1; Marjorie B. Maples, letter (date unknown), page 1, paragraph 2; H. E. Mauldin, et al., letter (date unknown), page 1, paragraph 4; National Environmental Health Association, 9/26/80 letter, page 1, paragraph 5 to page 2, paragraph 1; Natural Resources Defense Council, attachment to 10/1/80 letter, page 15, comment 3; Helen Nelson, attachment to 9/28/80 letter, page 2, paragraph 3; James Nelson, 9/28/80 letter, comment 3; Joseph V. Olszewski, 9/26/80 letter, page 1, paragraph 2; Dr. Alfred P. Owen, 9/26/80 letter, page 1, paragraph 2; Philip R. Owen, 9/20/80 letter, comments A1, B38, and B39; attachment (4/7/80 letter) to 9/25/80 letter, page 2, paragraph 1, items a and c; and page 3, item h; Mr. and Mrs. William R. Potter, 9/20/80 letter, page 1, paragraph 3; and page 2, paragraph 4; Inez E. Reese, letter (date unknown), page 1, paragraph 3; Mrs. Arthur Stephens, 9/25/80 letter, page 1, paragraph 1; Frances Taylor, letter (date unknown), page 1, paragraph 2; Tennessee Toxics Program, attachment to 8/25/80 letter, page 2, paragraph 1; U.S. Department of Agriculture, Soil Conservation Service, 6/10/81 letter, comment 1; U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 2, paragraph 6; Eleanor Wersely, 9/29/80 letter, paragraph 1; James H. and Judith B. Wilson, 9/18/80 letter, page 1, paragraph 2; and page 2, paragraph 3.

Response

As stated in Section 4.1.2.2 of Volume 1 of the FEIS and as further discussed in Sections 4.2.2.2 and 4.2.2.3 of Volume 2, discharges from the plant will be regulated by the NPDES permit limitations. These limitations are issued such that State water quality standards are not exceeded. In addition, the permit limitations would be reviewed by EPA to ensure that the limitations are based upon the application of BACT. Therefore, downstream water uses (detailed in Section 3.2.2 of Volume 2) would not be adversely affected. These standards are intended to protect human health and aquatic life even after long-term consumption and exposure. After treatment to meet NPDES permit limitations, the effluent would be discharged through a multiport diffuser into the secondary channel as shown in Figure 3.2.2-2.

11. Comment

"During the summer months water temperature and dissolved oxygen levels in Lake Guntersville violate Alabama State Criteria. Variance procedures to allow thermal discharges into Lake Guntersville at this site should be detailed in the FEIS."

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 2, paragraph 5.

Response

During the TVA study period 1974-1975, data from Guntersville Lake in the immediate vicinity of the Murphy Hill site (TRM 369.4-370.7) showed that the lake did not exceed Alabama temperature or dissolved oxygen standards. Upstream from the site at TRM 388 during and after the study period, TVA data revealed that lake temperatures were at all times and dissolved oxygen levels were normally in compliance with State standards. Only during water quality surveys on August 26, 1975, and July 28, 1977, was the lake below the Alabama dissolved oxygen standard of 5.0 mg/l (measured at a depth of 5 ft). The concentrations observed during these surveys were 4.4 and 4.6 mg/l, respectively. Based on TVA's studies to date, it is not believed that a variance would be necessary to allow thermal discharges from the proposed facility.

J. AQUATIC ECOLOGY AND FISHERIES

1. Comment

More information is needed on the location of water use facilities (water intakes, wastewater discharges, and docking areas), especially with respect to productive aquatic habitats.

Comments By

Rex B. Brown, 9/25/80 letter, comment 6; Max W. Ingram, 9/25/80 letter, comment 10; Natural Resources Defense Council, Inc., attachment to 10/1/80 letter, page 15, comment C3; U.S. Department of the Army, Corps of Engineers, letter (date unknown), comment a; U.S. Department of the Interior, 10/7/80 letter, page 1, paragraph 3; page 2, paragraph 4 to page 3, paragraph 1; and page 4, paragraph 2; U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 2, paragraphs 3 and 6; page 3, paragraph 1; and page 4, paragraph 2; James H. and Judith B. Wilson, 9/18/80 letter, page 2, comment 4.

Response

Particular attention has been given to the protection of productive, unique, and/or sensitive habitats in the vicinity of the proposed project. Accordingly, the project committed in the DEIS to avoid productive areas to the extent practicable (p. G-45), to discharge treated effluent residuals into channel areas as opposed to overbanks (G-45), and to install what was determined to be best available intake technology for this facility (G-46). During preparation of the DEIS, it was determined that from a total environmental perspective, concept "B" was the most acceptable for the location of barging/docking facilities (p. 2-43).

Prior to completion of the DEIS, aquatic ecological field investigations were conducted in the vicinity of the proposed Murphy Hill site, including observations of fishing activity and interviews with sport and commercial fishermen. As a result of these investigations, it was determined that areas amenable to the growth of rooted and submersed aquatic vegetation (predominately Eurasian watermilfoil), primarily along the lake shoreline and in embayments, were the most productive (and valuable) habitats from the standpoint of supporting the lake fishery. Prime sport and commercial fishing areas in the site vicinity were also identified.

Subsequent to the release of the DEIS, TVA aquatic ecologists examined a series of practicable engineering alternatives for location and design of docking facilities (within the framework of concept "B"), discharge structures, and intake structures. The alternatives which minimize disturbance of the most productive identified near-field areas (spawning and nursery habitats and prime fishing locations) would be constructed, despite the fact that these environmentally preferred discharge and docking locations would be more costly. These alternatives are addressed in Section 2.3.6.

To the extent practicable, barge traffic on the overbank areas would be routed and controlled in such a way as to minimize impacts to sensitive areas. Subsequent to operation, portions of the aquatic community would be monitored as required by the draft NPDES permit and mitigation undertaken as appropriate.

2. Comment

The proposed intake structure location and design should be included in the FEIS. This design should be consistent with Section 316(b) of the Clean Water Act.

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 3, paragraph 1.

Response

Six intake designs were considered. In each design the intake pumping station was located about 400 ft inland from the lake proper and about 250 ft from a nearby embayment.

One alternative featured a pumping station fitted with 2 conventional vertical traveling screens (3/8-in. square mesh openings), with 3 pipes approximately 3600 ft long extending to the secondary channel. Fish protection would be afforded by low fish density in the vicinity of the pipe opening. This alternative was unattractive from the standpoint of cost (most expensive) and lack of confidence that fish would not congregate in the vicinity of the pipe openings.

A second alternative featured 3 pipes extending about 1300 ft from the pumping station to a point beyond the barge unloading dock in the overbank region. Two fine mesh (0.5 mm) screens would be operated continuously to transfer impinged larvae and larger fish into the nearby embayment via a fish return trough. Although this system was expected to provide adequate fish protection, advantages of withdrawing water from overbank areas via a pipe were doubtful.

Two other alternatives featured the use of horizontal traveling fine mesh screens in combination with either intake pipes or an intake channel. Insufficient lake water velocity to transport returned fish past the intake area made these 2 designs unattractive.

The remaining 2 alternatives were considered the most attractive for Murphy Hill. A fixed-screen shoreline intake featuring 6 cylindrical wedge-wire screens (0.5 to 2.0 mm openings) with low velocities at the screen face (<0.5 fps) mounted on a concrete wall would protect fish from entrainment and impingement. This alternative is attractive since no area of entrapment (pipes or channel) is created. Essentially all life stages of fish exposed to this intake would be able to avoid entrainment and impingement.

The second attractive alternative, which was selected (on the basis of cost comparison estimates) as the preferred design, featured an open channel, 2 vertical traveling fine mesh (0.5 mm openings) screens, and a system for safely returning impinged fish to the nearby embayment. The area surrounding the plant site is highly productive for fish. During early life stages species inhabiting this area typically remain in or near dense rooted aquatic plants (which would remain outside of the channel). Except for some spawning expected in the intake channel, few larvae should be impinged. Should large numbers of early life stages of fish be impinged, they would receive a high level of protection with this intake alternative. A combination of low intake volume (approximately 50 cfs), low intake channel velocity (<0.1 fps), and fine mesh traveling screens with return facility are expected to provide the most practicable protection for the fish community. It is also anticipated that the riprapped intake channel would provide new habitat, be attractive to adult fish, and subsequently provide an enhanced sport fishing area.

3. Comment

TVA needs to discuss in greater detail the potential for toxic effects (short-term and long-term) to fish and other aquatic life, including the safety and quality of fish as a food source.

Comments By

B. D. Gately, letter (date unknown), page 1, comment 2; National Environmental Health Association, 9/26/80 letter, page 1, paragraph 5 to page 2, paragraph 1; Natural Resources Defense Council, Inc., attachment to 10/1/80 letter, page 15, comment C3; Helen Nelson, attachment to 9/28/80 letter, page 1, paragraph 2; Philip R. Owen, attachment (4/7/80 letter) to 9/25/80 letter, page 2, paragraph 1, item 6; U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 3, paragraph 1; and page 2, paragraph 4.

Response

TVA is concerned about potential toxic effects, and protecting the quality of fish and wildlife resource which potentially could be affected by release of wastewaters from the proposed facility. In reponse to this concern, TVA stated in the DEIS (p. G-45) that it would undertake appropriate biological and waste characterization and treatability studies to support the wastewater treatment plant design, and would treat wastewater discharges to avoid adverse toxic impacts to aquatic life. TVA has initiated a plan (currently underway) for supporting treatment plant design and permit applications that involves wastewater characterization studies, wastewater treatability studies, and toxicity screening tests on wastewaters from 2 existing gasifier facilities (Texaco and K-T). The toxicity screening tests are being performed on (1) wastewaters from appropriate points within the existing wastewater process, (2) effluents from treatability experiments, and (3) leachates from solid wastes (slags, ashes, and sludges). State-of-the-art toxicity tests would be utilized and would be designed to detect chronic and acute toxicity to fish and invertebrates, potential for bioaccumulation, and indications of mutagenicity and carcinogenicity. Treatability studies would continue until such time as processes are developed which produce effluents without indications of toxicity. Based on the results of these studies and consultation with EPA's Industrial Environmental Research Laboratory, the project would install what is determined to be Best Available Control Technology (BACT) for the selected gasifier process. Treated wastewaters would be discharged into the secondary channel (approximately 3,250 ft offshore) in order to increase dilution and prevent minimal nearfield effects from reaching identified productive habitats (please see also response to comment 1 above).

Once the proposed plant is operational, similar (as appropriate) biological and health effects testing would commence. A continuous onsite biomonitor would have been installed and hold-up capacity would be provided for process wastewaters in case a treatment operation malfunctions or evidence of environmental perturbation is observed from the monitor.

A program to minimize the use and discharge of chlorine would be implemented as required under an NPDES permit. Chlorination for clam control would likely be restricted to critical periods of the year (June and October), and cooling towers would be shock treated individually for slime and algae (never simultaneously). Total chlorine would be dissipated to levels specified in the NPDES permit prior to mixing with process wastewaters.

4. Comment

Upgrading the access roads to the plant will likely involve obtaining a Section 404 permit from the Corps of Engineers for the stream crossings. The environmental impacts of road upgrading (especially for the stream crossings) and any onsite fill activities should be addressed in the impact statement. If these impacts are not discussed in the EIS, an additional environmental assessment will have to be submitted with the 404 permit application.

Comments By

U.S. Department of the Army, Corps of Engineers, 10/9/80 letter, and coordination meetings with TVA; U.S. Department of Interior, 10/7/80 letter, page 4, paragraph 3; U.S. Department of Transportation, attachment (State of Alabama Highway Department, 9/15/80 letter) to 9/25/80 letter, page 1, comment 8.

Response

The areas to be affected by road improvement and site-related water use facilities have been reviewed, and it has been determined that no threatened or endangered species or unique habitats would be impacted. Aquatic impacts would be temporary--resulting from direct displacement of some immobile organisms, increases in suspended solids and certain chemical species during fill and construction activities, and loss of minor amounts of natural habitat. Mobile organisms would avoid the area during the construction period. The newly created riprap habitat bordering the fill is expected to provide a diverse habitat, often superior to that which it replaced. Impacts would be minimized as follows: (1) dredge spoil would be disposed of in an upland area; (2) stone fill (in lieu of dirt) would be used below the mean high water level and above that elevation to the extent practicable; (3) any dirt fill would be vegetated or covered to minimize erosion; and (4) flows into and out of the affected backwater areas would not be altered significantly--and particularly would not be decreased. TVA has discussed improving a fishing access area, in conjunction with some of the road improvements being considered at South Saunty Creek, with the Alabama Department of Conservation and Natural Resources (Game and Fish Division), but no commitments have been made. An application for Sections 404 and 10 permits would be submitted for any dredge or fill activities in the area streams or lake.

5. Comment

Concern was expressed over potential impacts associated with dredging operations.

Comments By

R. B. Brown, 9/26/80 letter, comment 6; U.S. Department of the Army, Corps of Engineers, letter (undated) comments a and b; U.S. Department of the Interior, 10/7/80 letter, page 1, paragraph 4; page 2, paragraph 4.

Response

Ecological effects of dredging fall into 3 general categories: (a) displacement and disruption of habitat, (b) turbidity and sedimentation, and (c) resuspension and resolution of chemicals from sediments.

a. Benthic macroinvertebrates within the immediate area to be dredged would be lost from the system. Past experience has shown that recolonization occurs within a relatively short period of time (few weeks to a few months); therefore, there would not be a permanent loss of organisms from the area. It is expected, however, that prop wash from barge traffic moving in and out of the site vicinity would limit the extent of recolonization, particularly to those species which cannot adapt to periods of increased turbidity and unstable substrate.

   The area that would be dredged represents approximately 11% of the overbank habitat in the site vicinity. Of this 11%, 5% is highly productive habitat provided by aquatic weed growth.

   With the current project schedules, and the commitment that, to the maximum extent practicable, dredging would not be conducted during warm months of the year (due to potential problems with dissolved oxygen depletion) or during fish spawning seasons, dredging operations would span 2 to 4 years. This means that large numbers of macroinvertebrates would not be lost at one time. Therefore, ecological effects associated with this activity are going to be localized and short-term in nature and are not considered to be significant in terms of maintaining a balanced indigenous ecosystem.

b. The physical removal of sediment would result in increased suspended solids and turbidity along with a localized decrease in dissolved oxygen. Because of the high percentage of organics (due to decaying macrophytes) in the sediments, the depletion of dissolved oxygen could be locally significant with a resulting adverse impact to macroinvertebrate fauna. To minimize such impacts, the dredging operations would not be conducted, to the maximum extent practicable, during the warm months of the year.

   During the dredging operation there would be some transport of sediment to areas adjacent to the dredging site, which would result in smothering of some benthic macroinvertebrates. With currents (either wind-induced or water) there could be a significant transport of sediment over a larger area, with a resultant increase in the number of macroinvertebrates affected. In addition, increased turbidity would reduce photosynthetic activity in the immediate vicinity of the dredging. These impacts can be satisfactorily mitigated by use of a silt curtain around the actual dredging area. The project would monitor turbidity during dredging operations and would minimize the adverse impacts to the extent practicable.

c. The third potential ecological effect of dredging, and potentially the most significant since silt curtains would not eliminate this impact, is resolution of chemicals from the sediments. In order to estimate the extent of resolution of chemicals from the sediments to the water column, sediments obtained from Guntersville Lake near the Murphy Hill site were analyzed in a standard elutriate test (conducted in accordance with the procedures outlined in reference 1). Results of this test are given in Table E-3, along with applicable water quality criteria for the protection of aquatic life.

Analyses for pesticides were not conducted for the following reasons: (1) a survey of past pesticide use in the area disclosed that such use was minimal; (2) pesticide use in the past included minimal use of organochlorine materials (e.g., DDT, Lindane, Aldrin, Dieldrin, etc.). These materials were cancelled for agricultural use over 10 yr ago, and while they are persistent chemicals, it was determined that they would exist only at levels below detection. Elutriate tests conducted at comparable sites have not disclosed significant residue levels; and (3) currently recommended pesticides for crops grown in the Murphy Hill area are principally organophosphorus and carbamate derivatives which break down rapidly and are seldom found even in high-use areas.

The most critical parameter at this site in terms of meeting water quality criteria for the protection of aquatic life (i.e., requiring the largest mixing zone representing the worst-case conditions) is mercury. As shown in Table E-3, the criteria for mercury are very stringent. In fact, the criteria are below the analytical detection limit for standard cold vapor analytical techniques. This fact prohibits calculating precise dimensions of a mixing zone which would dilute the mercury concentrations to the 1980 EPA criteria. Therefore, evaluations are necessarily based on comparisons with literature references and/or other recommended criteria. Note that toxicity data for mercury are based on continuous exposure conditions. Such conditions would not exist during the actual dredging operation.

Mercury concentrations which have proven acutely or chronically toxic to freshwater organisms generally are greater than the maximum observed concentration of 0.5 µg/l in the sediment elutriate. However, because mercury is readily bioconcentrated and may be transferred through the food chain, it is important to determine the size of the area around the dredging operation which would contain concentrations of mercury at levels which could prove problematic through biomagnification. The recommendation criterion published by EPA in 1976 (0.05 µg/l) was determined in part by providing a margin of safety which was based on potential for magnification.

TABLE E-3
RESULTS OF STANDARD ELUTRIATE TEST
WATER QUALITY CRITERIA
GUNTERSVILLE LAKE, MURPHY HILL SITE

Parameter[c]	Elutriate Test Results: Background (Water)	Elutriate	EPA Criteria[a] (1980): 24-hr Average	Maximum	EPA Quality Criteria for Water, 1976[b]
Iron	<50	240-3800			1000
Manganese	<10	570-2500			
Copper	40	10-80	5.6	14	
Zinc	10-30	90-670	47	210[d]	
Nickel	<10	<10	65[d]	1250[d]	
Silver	<10	<10		1.7[d]	
Cadmium	<1	<1-2	0.015[d]	1.8[d]	
Lead	<10	<10-18	1.2[d]	92[d]	
Chromium	<5	<5	100		
Aluminum	<200	<200-2900			823
Barium	<100	<100			
Beryllium	<10	<10	11[d]		
Mercury	<0.2	<0.2-0.5	0.0006	0.002	
Arsenic	<2	<2		440	
Selenium	<1	<1-4	35	260	
Cyanide	<10	<10			5
Phenol	<2	5-12	1		

a. USEPA, "Water Quality Criteria," 45 Fed. Reg. 79.318, November 28, 1980.
b. USEPA, "Quality Criteria for Water," EPA 440/9-76-023, July 16, 1976.
c. All units are in µg/l.
d. Criteria calculated for 60 mg/l hardness.

Assuming a background concentration of 0.01 μg/l mercury and a criterion of 0.05 μg/l, a dilution factor of 11.25 is required to satisfactorily dilute the elutriate to the specified criterion. Using a mechanical suction dredge, approximately 3% of the total dredged material would be resuspended as fugitive spoil. Considering this material to be deposited in one disposal operation (worst-case assumption), a mixing zone similiar in shape to a conical frustum with the following dimensions would be required: bottom radius 150 ft, elevation 8 ft, surface radius of 532 ft, and a maximum projected surface area of 890,000 ft2. The size of this area is approximated to scale in Figure E-1. In practice, the fugitive spoil would not be deposited as a single mass but rather as numerous, much smaller units. Therefore, the actual size of mixing zones during the dredging operations would be small.

For additional information on potential impacts of water use facilities, please see the response to comment 1 above.

References

1. U.S. Army Corps of Engineers, Waterways Experiment Station. 1976. "Ecological Evaluation of Proposed Discharge of Dredged or Fill Material into Navigable Waters." Misc. Paper D-76-17. Vicksburg, Mississippi.

2. U.S. Environmental Protection Agency. 1976. Quality Criteria for Water. U.S. Environmental Protection Agency. Washington, DC. 501 pp.

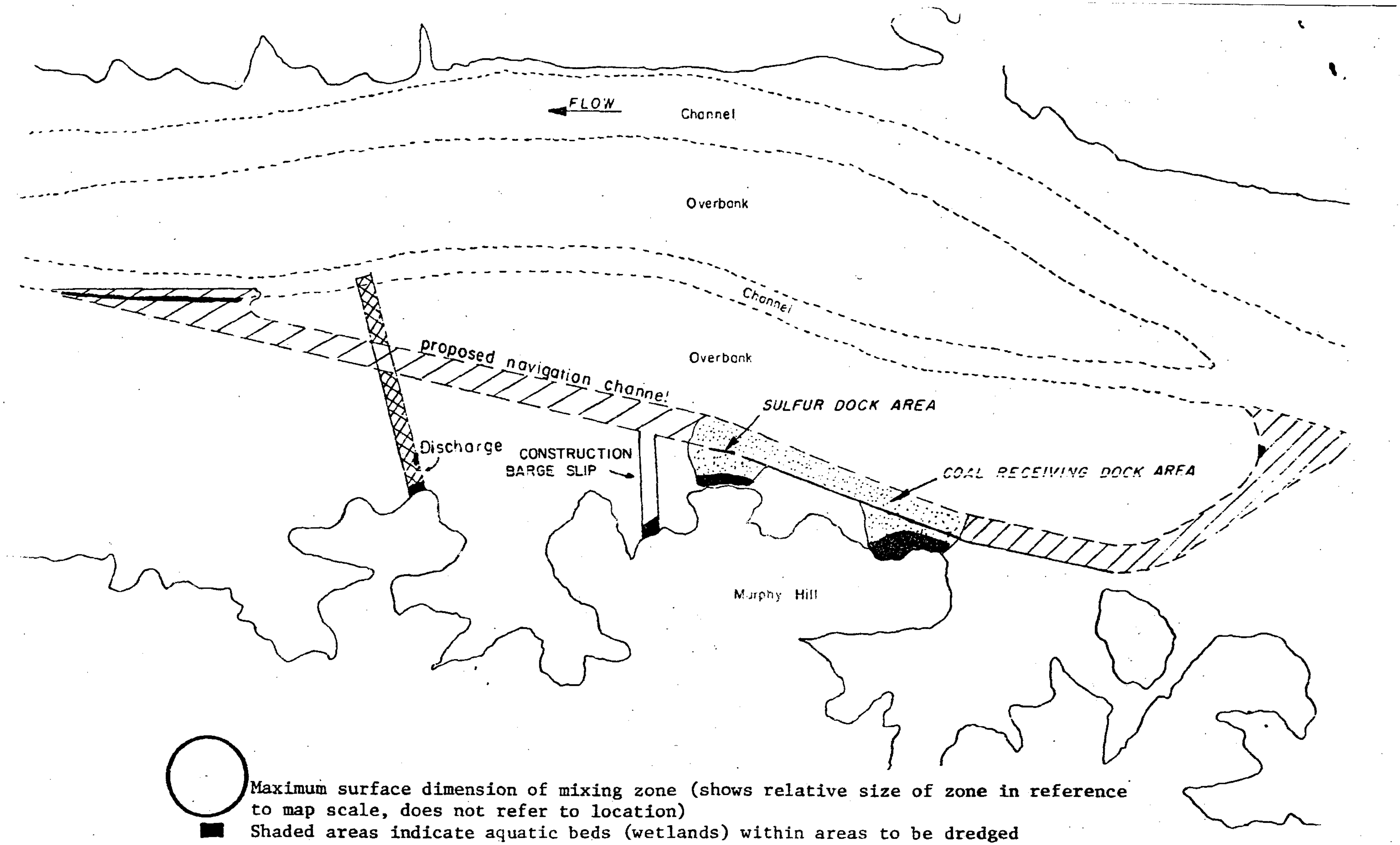

Figure E-1 Dredging sites, location of watermilfoil beds within dredging sites, and calculated mixing zone for dredge spoil elutriate at the proposed Coal Gasification Plant site, Murphy Hill, Alabama.

K. UPLAND VEGETATION AND WILDLIFE

1. Comment

It is stated that approximately two-thirds of the 1,190-acre site at Murphy Hill is forested; however, no further description of the forest habitats is given.

Comment By

U.S. Department of the Interior, 10/7/80 letter, page 3, paragraph 4.

Response

The information in Section 3.1.2 "Natural Resource," Volume 1, was revised in response to this comment.

2. Comment

The final statement should quantify and qualify wildlife habitat losses and provide means to compensate/mitigate those losses.

Comment By

U.S. Department of the Interior, 10/7/80 letter, page 2, paragraph 3.

Response

As discussed in Section 4.1.2.5 and Appendix G, Section 4.2.5, wildlife habitat losses would consist of approximately 950 acres of above average small game and deer habitat and 450 acres of fair to moderate wildlife habitat. Although construction would result in wildlife displacement and destruction in the immediate area of the plant site, with time, the wildlife population in the area adjacent to the site may be restored. Restoration of the wildlife population would be effected, if practicable, by establishing intensive wildlife management practices on available lands on Guntersville Lake. For example, it is anticipated that TVA, through its land use planning effort on Guntersville Lake, would provide land under long-term tenure to the State of Alabama for wildlife management.

3. Comment

We offer the following comments for your consideration:

1. Natural Resources, pp. 3-6 and 3-11.

   On page 3-6 of this section it is stated that 21 percent of the nonforested area is cultivated. However, the types of crops being grown should also be included. If these are high intensity-labor crops, there could be local impact due to the loss of production. For example, if major crops are soybeans, the local impact would be none to slight.

Comment By

U.S. Department of Agriculture, 9/15/80 letter, page 1, comment 1.

Response

Please refer to Sections 3.1.1 and 3.2.5 of Volume 2 of the FEIS.

L. THREATENED AND ENDANGERED SPECIES

1. Comment

The Department of Interior according to your impact statement ran a study here on the endangered species and found that Courtland only had three while Murphy Hill had 17. The change in air and water quality could upset the environment in a manner that could cause the gray or Indiana bat and the wintering bald eagle to no longer frequent the area. Habitat destruction is a major cause of the dwindling numbers of endangered species such as these.

Comment By

Max Ingram, DEIS public hearing transcript, page 33, paragraph 2; Mary Ann Jenkins, 6/26/81 letter, paragraph 5; and the Alabama Conservancy, 6/24/81 letter, paragraph 4.

Response

The Department of Interior study referred to is a listing of species either Federally listed or proposed for listing, which may occur in the project areas. This listing was provided by the U.S. Fish and Wildlife Service, at TVA's request, as required by Section 7C of the Endangered Species Act of 1973, as amended. The greater number of potentially occurring endangered species at the Murphy Hill site is due to the site's proximity to Guntersville Lake which potentially supports several endangered mollusks. The possible presence of these endangered species is discussed in Section 3.2.6 in Volume 2 of the FEIS and potential impacts are discussed in Section 4.2.6 in Volume 2 of the FEIS. It is the conclusion of TVA that plant construction and operation at either site would not jeopardize the future existence of any Federally listed, endangered or threatened species.

M. WETLANDS AND WETLANDS WILDLIFE

1. Comment

The EIS should also address positive actions that will be taken to preserve the spawning grounds and wildlife feeding grounds in the coves adjacent to the Murphy Hill property. These coves are a natural habitat for wild fowl and game fish.

Comment By

Philip R. Owen, attachment 3 to 9/25/80 letter, page 2, paragraph 3.

Response

Various sections of the EIS address such mitigative actions. The location of the various docking facilities has been further evaluated. It was determined that these facilities should be placed away from the coves and shoreline wetland areas to minimize possible impacts to all coves and wetland areas that surround the Murphy Hill site. All riparian habitat along the shoreline would be left undisturbed or replaced, to the extent practicable, to maintain a buffer zone between the plant and wetland areas along the shoreline. The project would spend an extra $4.5 million on design features to minimize impacts to coves and shoreline wetland habitat at the Murphy Hill site.

2. Comment

Citizen is concerned about the destruction of wetlands at the Murphy Hill site.

Comment By

Ann Maples Brewster, 9/27/80 letter, paragraph 2; U.S. Department of Agriculture, 6/10/81 letter, question 3.

Response

Of approximately 260 acres of wetlands on or around the Murphy Hill site, it is estimated that 15 acres would be directly impacted by the proposed project. Our studies indicate that the construction and operation of docks along the shoreline and overbank areas would affect the largest acreage of wetlands. Both the intake and discharge systems and the storage terminals for the coal gasification plant would be designed such that impacts as a result of these structures should be minimal. However, the preferred alternatives, which minimize, to the extent practicable, disturbance to the shoreline wetlands would be constructed even though these environmentally preferred docking alternatives are more costly. In addition, where practicable, these disturbed areas would be revegetated with woody species. These measures would ensure that impacts to wetlands would be minimal, and therefore comply with the policies and concepts of Executive Order No. 11990 and TVA's implementing procedures.

3. Comment

Citizen is questioning building a wooded buffer zone to provide habitat for roosting, perching, and nesting bald eagles.

Comment By

Lena W. Lloyd, 9/16/80 letter, paragraph 2.

Response

A wooded buffer zone would not be planted at Murphy Hill, but the existing (often wooded) riparian habitat would be preserved to the extent practicable along almost all of the shoreline around the Murphy Hill site. Where the wooded shoreline is damaged by plant construction, it would be revegetated to the extent practicable. All bald eagles found at Murphy Hill are migrant eagles passing through or wintering in the vicinity of the site during migratory or wintering periods. Eagles utilize the wooded shoreline zone for resting, roosting, and feeding perches. The wetlands at the Murphy Hill site provide feeding habitat for bald eagles which have been identified in the vicinity of the site during the winter season. Nesting by bald eagles on or near the Murphy Hill site has not been documented within the past 20 years and since nesting bald eagles are sensitive to human disturbance, we do not expect bald eagles to nest on developed portions of

Guntersville Lake. The presently existing wooded buffer zone would be protected, to the extent practicable, to provide habitat for many other species of wildlife including wintering bald eagles.

N. GEOLOGY AND SOILS

1. Comment

The statement that geological benefits exist at Murphy Hill is erroneous since geological disadvantages of the valley locations were not addressed.

Comment By

Philip R. Owen, 9/20/80 letter, comment B16.

Response

A geological advantage does exist at Murphy Hill as opposed to the Courtland site due to the presence of more suitable foundation rock. The proposed Murphy Hill site's location in Browns-Sequatchie Valley poses no geological disadvantages. Please refer to Section 3.2.9 "Geology and Soils" for a discussion of the characteristics of the site (Appendix F). Section 4.2.9 (Appendix G) discusses the impacts of the site geological features on the plant construction and operation.

2. Comment

Concern was expressed over possible ground vibrations in areas adjacent to the coal gasification plant at the proposed Murphy Hill site.

Comment By

Patricia Hodges Abney, DEIS public hearing transcript, page 39, paragraph 3 to page 40, paragraph 1; and 9/24/80 letter, paragraph 3.

Response

No noticeable ground vibrations are expected offsite from the operation of the coal gasification plant. Ground vibration that may be generated would be low in order not to cause structural damage to adjacent buildings or detrimental effects to the plant workers.

Ground vibrations are generally measured as particle velocity in inches per second (in/s). The Richter scale is used to represent a value of earthquake magnitude.

TVA has not actually measured ground vibrations from a coal gasification plant. Vibrations from a pile driving operation were 0.7 in/s particle velocity at a distance of 17 ft. U.S. Bureau of Mines studies recommend a maximum particle velocity of 2.0 in/s to prevent damage to a house measured at the house.

3. Comment

We offer the following comments for your consideration:

a. Natural Resources, pp. 3-6 and 3-11 . . .

"On pages 3-6 and 3-11 there is no explanation as to the kind of cropland being affected, such as soil types, prime farmland, etc."

b. Geology and Soils, pp. 4-11 and 4-19.

The major soils of the sites along with a general soil description of their physical characteristics should be included in this section. Also, the total prime farmland within each site should be given. Prime farmland is a valuable natural resource that should not be overlooked. Efforts to protect prime farmlands should be emphasized.

Comment By

U.S. Department of Agriculture, 9/15/80 letter, page 1, comments 1 and 2; and 6/10/81 letter, comment 2.

Response

For a discussion of the major soils on each site, please see the revised discussion in Sections 3.1.2 and 3.2.2 in Volume 1 and in Section 3.2.9 in Volume 2 of the FEIS. For more information on the existing prime farmland at each site, please refer to Sections 3.1.1 and 3.2.1 in Volume 1 and Section 3.1.1 in Volume 2 of the FEIS. Potential impacts to land uses are discussed in Sections 4.1.1.1 and 4.2.1.1 of Volume 1 and Section 4.1.1 of

Volume 2 of the FEIS. Prime farmland was one of the criteria used to evaluate each of the sites. Identifying Murphy Hill as the preferred location minimizes impacts on prime farmland. The site contains approximately 30% prime farmland, which is less than that contained in 10 other sites evaluated (6 of these 10 sites contained 60% or more prime farmland). Please refer to Section 2.2.3, "Site Area Screening", for more information.

O. ENVIRONMENTAL NOISE

1. Comment

Baseline data presented indicate ambient sound to approximately 22 plus dB with in the plant area. Present ambient levels taken at both Preston and Pine Island show levels approximately 47 dB at frequencies of 250 cycles and 500 cycles with peaks as high as 78 dB when tows are involved. Sound levels approximating those given in the EIS were not noted in the above ranges even when wind and water increments were extracted these dripping (sic) the level to approximating 38 dB.

Comment By

P. L. Horne, 9/25/80 letter, page 1, paragraph 3.

Response

Community noise is usually characterized by great variability. Differences of the magnitude cited are not unusual since measured sound is a function of the acoustical events occurring at the precise moment of measurement. The sound level values reported in the DEIS were based on 15-min tape recordings made at random times of the day.

To provide a more accurate value for the community sound now present on the lakeshore opposite the coal gasification plant site, a 48-hr sample of community sound was taken on November 30 and December 1, 1980. The average sound level for that 48-hr period was 52 dBA. Peak sound levels above 74 dBA occurred 0.01% of the time during the survey period. These values agree with the levels cited and represent current sound levels at that location.

2. Comment

The baseline noise level was not measured near my property.

Comment By

C. R. and Elizabeth Lang, 9/25/80 letter, paragraph 2.

Response

Baseline sound levels were measured at one location on Pine Island (see measurement location 5, Table 3-4, FEIS, Volume 1). Sound originating at the proposed plant site would reach every point on Pine Island with approximately the same energy. In other words, a person at any location on the island would hear about the same level of sound from a sound source a mile away. Thus, only 1 survey point would be needed on Pine Island to determine noise impacts.

3. Comment

Insufficient detail was given in the DEIS concerning construction noise.

Comments By

Mrs. Patricia Hodges Abney, 9/15/80 letter, paragraph 1; Bob DeYoung, 9/17/80 letter, paragraph 6; Max Ingram, DEIS public hearing transcript, page 33, paragraph 2; and Philip R. Owen, DEIS public hearing transcript, page 149, paragraph 4 to page 150, paragraph 1; 9/20/80 letter, comment B43; attachment (4/7/80 letter) to 9/25/80 letter, page 2, item e.

Response

TVA is continuously monitoring the noise generated at 3 nuclear plant construction sites. These monitoring data show that daily sound levels at plant boundaries average 50-60 dBA with an occasional hourly average as high as 75 dBA. Murphy Hill would have similar construction noise levels at the site boundary but when extrapolated to a 1-mi radius the levels should be 20 dBA lower.

4. Comment

Concern was expressed that noise pollution could be a health hazard.

Comments By

Mrs. Phyllis Bates, letter (date unknown), page 1, comment 3; Ann Maples Brewster, 9/27/80 letter, paragraph 3; Rex B. Brown, 9/25/80 letter, comment 1; Ilmars Dalins, DEIS public hearing transcript, page 105, paragraph 4; B. D. Gateley, letter (date unknown), page 2, comment 8; Thomas A. King, 9/25/80 letter, page 1, paragraph 5; Dr. H. Michael Mauldin et al, letter (date unknown), page 1, paragraph 2; Alfred P. Owen, M.D., 9/26/80 letter, paragraph 2; Donald B. Popejoy, DVM, 9/29/80 letter, paragraph 2; Inez E. Reese, letter (date unknown), page 1, paragraph 3; and James H. and Judith B. Wilson, 9/28/80 letter, page 1, paragraph 2.

Response

Our survey showed baseline average levels at a 1-mi radius around the plant to be between 50 and 60 dBA with short-term peaks near 80 dBA. Neither the construction nor the operational phase of the plant would appreciably increase these levels. As stated in the DEIS, sounds from the plant and from construction would occasionally be audible offsite but no health hazard would be caused by noise from the plant.

5. Comment

Noise will bounce between the hills and be unattenuated over the lake.

Comments By

Rex B. Brown, 9/25/80 letter, comment 7; Max Ingram, DEIS public hearing transcript, page 33, paragraph 2; Thomas A. King, 9/25/80 letter, paragraph 5; Philip R. Owen, 9/20/80 letter, comments B16 and B40; attachment 3 to 9/25/80 letter, page 2, paragraph 4; DEIS public hearing transcript, page 150, paragraph 2.

Response

The hills are not expected to be highly reflective due to their low slope. Sound energy would be largely absorbed when it strikes the hills. The unabsorbed energy would be reflected upwards, not back across the lake.

Sound would be attenuated somewhat less in traveling across the flat lake surface than it would traveling across an earth surface covered with vegetation. Excess attenuation due to surface characteristics is not assumed in project noise evaluations and in any case is very small compared to the decrease in sound level due to increasing distance from the noise source.

6. Comment

Insufficient detail was given in the DEIS concerning plant operational noise and barge traffic noise.

Comments By

Mrs. Patricia Hodges Abney, DEIS public hearing transcript, page 39, paragraph 2; letter (date unknown), paragraph 1; 9/24/80 letter, paragraph 3; Jennie M. Helderman, 9/28/80 letter, page 1, paragraph 6; P. L. Horne, 9/25/80 letter, page 1, paragraph 3 to page 2, paragraph 1; Max Ingram, DEIS public hearing transcript, page 33, paragraph 2; Philip R. Owen, 9/20/80 letter, comments B16 and B40; attachment (4/7/80 letter) to 9/25/80 letter, page 2, item f; attachment 3 to 9/25/80 letter, page 2, paragraph 4; and DEIS public hearing transcript, page 150, paragraph 2 to page 151, paragraph 3; Mrs. Arthur Stephens, 9/25/80 letter, page 1, paragraph 1; Hugh L. Sutherland, DEIS public hearing transcript, page 109, paragraph 4; and U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 5, paragraph 6.

Response

Potentially, the major noise generators in the plant would be:

Pressure Reduction Valves --Without controls, noise from valves with sonic pressure ratios could reach 130 dBA measured at 10 ft, and from both an environmental and an occupational standpoint, special care would be taken to ensure the installation of quiet valves and blowdown mufflers where needed. The valve noise must be controlled to 90 dBA in the immediate vicinity to meet occupational noise requirements. When measured at the site boundary the process noise level would be below the Federally recommended 65-dBA.

Air Separation Compressors --Preliminary design plans for the air separation plant call for high powered compressors which may generate as much as 130-dBA casing noise as well as 130-dBA air inlet noise. These compressors would be housed in a building designed for noise control and the intakes would have suitable mufflers. Again, the noise must be controlled to 90 dBA for occupational health purposes and would be below 65-dBA at the plant boundary.

Barges and Coal Handling --Barge unloading noise measured across the river (400 ft) from a similar type unloader showed an average sound level of 66 dBA with 80 dBA exceeded 0.01% of the time. When the 80-dBA value is extrapolated to the 6,000-ft width of Guntersville Lake, the barge unloading and coal-handling noise should be no more than 60 dBA at either Pine or Preston Island residential sites. At the present time the coal unloading facility is expected to be operated 5 days/week, 2 shifts/day (it is assumed this would be Monday-Friday, the 1st and 2nd shifts). Demurrage charges, maintenance downtime, and other factors could require that the barge unloading facility be operated more often than this, but these occurrences should be infrequent. The coal needed for operation would require an average of 5 to 6 tows per week in each direction, (each tow consists of 15-17 barges carrying approximately 1,500 tons). The same number of similar tows would be needed weekly to return empty barges to the coal-loading site. Since the coal needs of a 2-module facility would be about one-half of that estimated above, the barging requirements for the facility would be similarly reduced. The tows could travel on any day of the week (see Section 4.1.5 of Appendix G). Noise from passage of the additional tows would increase the baseline average noise on shore by less than 2 dBA, but the operation of the yard tug would be essentially continuous during coal unloading operations and may be intrusive. If such becomes the case, special muffling and engine enclosures may be necessary.

Other Sources --Transformers, cooling towers, ventilating fans, etc., should require no special treatment in order to be below 65-dBA at the site boundary. Flares, depending of their location and method of operation, may need special treatment to meet the 65-dBA value at the site boundary. If operational noise surveys show a need to reduce the level of any noise source, it is expected that additional measures would be initiated by the consortium.

7. Comment

How will TVA mitigate noise?

Comments By

P. L. Horne, 9/25/80 letter, page 1, paragraph 2; C. R. and Elizabeth W. Lang, 9/25/80 letter, page 1, paragraph 2; and Bob DeYoung, 9/17/80 letter, paragraph 6.

Response

The potential noise generators would include pressure reduction valves, high pressure gas vents, compressors, and the barge switching tug. While specific abatement procedures depend upon final design selection, those listed below are probable noise control measures:

(a) Install quiet valves where the pressure ratio causes sonic flow.

(b) Install discharge mufflers on high pressure vents.

(c) Acoustically house compressors to control casing noise and install intake mufflers to control intake noise.

(d) Control switching tug engine noise by muffling, engine room treatment, and good maintenance.

(e) Include noise level requirement in purchasing specifications in order to acquire the quietest suitable process equipment.

(f) Check criteria compliance by conducting a noise survey when any major change in construction or operational activity warrants or when a community complaint is received. If excessive noise is detected, it is expected that appropriate measures would be instituted by the consortium to control the source generating the excessive noise.

TVA expects to be involved in the design and site preparation activities for the proposed north Alabama coal gasification facility; however, the scope of work or level of activity has not been determined. As part of this effort, TVA anticipates reviewing the detailed design specifications to ensure that appropriate methods of noise control are utilized in the design. Mitigating noise impacts would be the responsibility of the private entity who assumes the financial responsibility for the project.

8. Comment

Concern was expressed that noise levels from the proposed facility would be unbearable to area residences and that the noise assessment should be expanded to include a comparison with acceptance criteria.

Comments By

Cleveland E. Owen, 6/17/81 letter, and Philip R. Owen, 6/29/81 letter.

Response

Table 3-4 and Figure 3-1 in Volume 1 show that current levels measured at sites five and six were 54-58 dBA with 68-74 dBA exceeded 0.1 percent of the time. Section 4.1.2.10, paragraph "Barge and Coal Handling," predicts the additional tows will increase the average levels by less than 2 dBA. Adding 2 dBA to the current noise levels given above will give a combined noise level. The Department of Housing and Urban Development criterion for residential land use gives an L_{eq} (average A weighted noise level) of 65 dBA (as indicated in the DEIS supplement), and even with the increased barge traffic, the Preston and Pine Island noise levels will be well within the criterion.

The Army Corps of Engineers has evaluated noise levels during construction and has established permissible noise levels during construction beyond the site boundary ("Construction Noise: Specification, Control, Measurement and Mitigation," Army Corps of Engineers, Construction Engineering Research Laboratory (CERL), Champaigne, Ill., CERL Technical Report E-53, 1975). The following permissible noise levels were given in the referenced report.

Activity	L_{eq} Beyond Site Boundary, dBA
Demolition	83
Excavation	78
Foundation	
Without pile driver	78
With Pile driver	83
Erection	71

TVA has estimated construction and operation noise levels which are below the acceptance criteria noted above. Please refer to Section 4.1.2.10 in Volume 1 of the FEIS and the responses to questions 3 and 6 above.

P. RADIOLOGICAL IMPACTS

1. Comment

The greatest degree of radioactivity will hit the Pine Island peninsula. Although it is not going to be a lethal dose, it is still going to hit the southwest quadrant at 2,000 meters in the center of the water and carry an additional 300.

Comment By

Peter Horne, DEIS public hearing transcript, page 50, paragraph 1.

Response

In the DEIS it was reported that doses to the worst-case individual from radioactive releases from the tail gas vent are predicted to peak at 2,000 m downwind in the southwest sector. However, the latest plant conceptual design information indicates that effectively no radioactive particulates would be emitted from the tail gas vent. Therefore, this radiological emission point has been eliminated.

Doses from atmospheric radiological emissions from the coal gasification plant are predicted to be highest in the northwest sector. Total doses from all plant activities are well below the Federal regulatory guidelines used for comparison purposes only. This is true for both atmospheric and liquid releases of radioactivity.

2. Comment

An incomplete radiological analysis was used to derive the conclusion that all doses received by an individual in the site vicinity would be below levels used as guidelines, if the plant were built at the preferred site. Although uranium-238 and its decay chain were addressed in the DEIS, thorium-232 and its decay chain were not discussed. The DEIS also did not address the long-term, low-level radiological and toxicological effects of solid waste disposal and fall-out. The waste slag contains radioactive and toxic substances and, therefore, should be subject to handling and disposal methods for hazardous chemical wastes. Public access to waste slag disposal areas should be denied forever. Serious potential health hazards may occur from ingestion and inhalation of radionuclides.

Comment By

Philip R. Owen, 9/20/80 letter, comments A3, B13, B32, and :8; DEIS public hearing transcript, page 157, paragraph 2 to page 158, paragraph 3.

Response

The contribution to radiation doses at Murphy Hill from the thorium-232 decay chain has been estimated. The principal source of exposure from this chain is expected to be radium-228, the decay product of thorium-232. It is estimated that radium-228, and hence the entire thorium-232 decay chain, would add only a few (less than 15) percent to doses calculated for the uranium-238 decay chain. Thus, total doses from both chains are predicted to be below the Federal dose guidelines used here for comparison purposes only.

Toxicological effects of inhalation and ingestion of radioactivity emitted in atmospheric and liquid releases from the coal gasification plant have also been addressed. Radionuclides evaluated include uranium-238, thorium-232, thorium-230, radium-226, radium-228, and lead-210. Maximum offsite ground-level air concentrations (northwest sector) are estimated to be about 10^{-4} $\mu g/m^3$ of uranium and thorium and about 10^{-12} $\mu g/m^3$ of lead in the form of lead-210. It is predicted that the worst-case individual living offsite might ingest on an annual basis about 1 μg of uranium and thorium combined per kg of body weight and about 10^{-8} μg of lead (in the form of lead-210) per kg of body weight due to plant activities.

While it is true that radioactivity contained in the slag produced by the gasification process is long-lived, levels are small and are not expected to result in significant environmental impacts.

Please refer to the response to comment 4 in Section "Q. Solid Waste Disposal.

3. Comment

Concern was expressed by the public regarding atmospheric radioactive emissions and their possible impact on health.

Comments By

Rex B. Brown, 9/25/80 letter, paragraph 1, comment 3; Mrs. Cain, 9/25/80 letter, paragraph 3; C. R. and Elizabeth W. Lang, 9/25/80 letter, paragraph 1; and Mrs. Arthur Stephens, letter (date unknown), paragraph 1.

Response

Maximum ground-level concentrations of radioactivity in the air at Murphy Hill due to atmospheric radiological emissions from the coal gasification facility are predicted to be far below 10 CFR 20 nonoccupational air concentration guidelines. Deposition of this radioactivity onto ground or water, termed "fallout," and buildup with time are therefore expected to be small also. Radioactive fallout would pose no significant environmental impact and is not expected to significantly affect the public health.

4. Comment

In comparing increased radioactive levels in bone marrow between Courtland and Murphy Hill, it appears that the total for Murphy Hill has not been properly totaled. What is the combined radioactive total from all activity at Murphy Hill and what is the direction and total contour of the fallout?

Comment By

C. R. and Elizabeth W. Lang, 9/25/80 letter, paragraph 4.

Response

Total doses from atmospheric releases of radioactivity at Murphy Hill are shown in Table 4.2.11-4 of the FEIS. These doses are below the Federal dose guidelines used for comparison purposes. Bone doses from liquid releases of radioactivity are given in Section 4.2.11, Volume 2 of the FEIS. These doses are also predicted to be below Federal dose guidelines.

The contour of radioactive fallout would tend to follow the wind rose with the winds at 10 m above ground level blowing more frequently into the northwest direction than any other direction. Fallout levels are not significant.

5. Comment

The DEIS (at page G-53) states that radioactive polonium may exit the Koppers-Totzek reactor with the product gas, and may plate out and accumulate on the inside surfaces of the waste heat boiler, the Venturi scrubber, or the packed tower. If this were to occur, would the accumulated radioactive material be sufficient to pose a hazard to workers or to the general public when the plant is operating under normal conditions? Would workers of the general public be at risk when such systems need to be serviced or cleaned out?

Comment By

Natural Resources Defense Council, attachment to 10/1/80 letter, page 16, paragraph 3.

Response

It is theoretically possible that radioactivity may plate out and accumulate on interior surfaces of certain plant equipment. TVA, however, does not have any data that indicates such an effect would actually occur. Should plating occur, it is not anticipated that any hazard to plant workers or the general public would arise due to the low levels of radioactivity present in the coal. It is expected that the private entity responsible for operating the proposed facility would develop a comprehensive health and safety program to ensure a safe and healthful work environment for coal gasification workers.

This program would comply with applicable regulations and standards and may provide additional protection against unforeseen hazards not covered by present regulations.

6. Comment

The use of radiological technology in industrial processes and instrumentation is ever-increasing. There has been no indication from TVA that the coal gasification process will use radioisotopes, however, it would seem likely that such technology would be required. The EIA should identify any processes or instrumentation that uses radioisotopes, and define protective measures that will be used to assure no public hazard in transportation, utilization, or storage. This evaluation should encompass both the construction and operational phases.

Comment By

Philip Owen, attachment 3 to 9/25/80 letter, page 2, paragraph 4.

Response

Use of radioisotopes (for example, as densitometers) in coal-fired facilities is relatively common. It is likely that radioisotopes may also be used for various industrial purposes in facilities which use emerging coal conversion technologies such as coal gasification. Radioisotopes have been used in industry for years and procedures for their use are well established. Transportation, use, storage, and disposal of such sources are carried out under Federal regulations and guidelines. We do not, therefore, anticipate any hazards to workers or the general public if such radioisotopes are used at the coal gasification plant.

O. SOLID WASTE DISPOSAL*

1. Comment

The EIS states that slag disposal facility will occupy 200 acres and have a depth of 130 feet. . .for a 20-year plant life. As stated earlier, the real plant lifetime is 35-40 years and solid waste disposal for 35-40 years must be allowed. Thus, the slag disposal will require either 400 acres or a depth of 260 feet! Since Murphy Hill does not have adequate area, it must be assumed that an honest estimate of slag disposal is 200 acres and 260 feet deep. All of this appears to be an attempt to hide the fact that insufficient space for the coal gasification facility exists at Murphy Hill.

Comment By

James B. Kyser, 9/22/80 letter, page 2, paragraph 1.

Response

As was indicated in an earlier response, the plant life is 20 yr as opposed to 35-40 yr. Please refer to the response given to

*Please refer to Section C, "Process Wastes" for additional responses related to solid waste disposal.

question 7 in part F. "Economics of Project" for additional information on this point. It is anticipated that at the end of 20 yr the facility would be retired and there would be no need for additional ash or slag disposal areas. The EIS has accurately reflected the situation regarding ash and slag disposal. Please refer to Section 2.3.6 of the EIS.

2. Comment

Page G-7, 4.2.12.2, fourth paragraph in Volume 2 of DEIS. The EIS should show the location of the disposal area for process generated hazardous waste and the conceptual engineering design for the storage area. The detailed engineering design for these storage areas should be approved by EPA Region IV.

Comment By

U.S. Environmental Protection Agency, attachment to 10/1/80 letter, page 4, paragraph 6.

Response

TVA anticipates that the generation of hazardous waste at the proposed facility would be relatively small with the greatest rate of generation during construction. There would be no hazardous wastes disposed of onsite. A facility for temporary storage of these wastes would be constructed in such a manner so as to contain spills of stored wastes. Since this facility would be relatively small and we anticipate this facility would fall under the small generator exclusion, TVA has not at this time prepared detailed conceptual designs. All State and Federal regulations would be followed in the design and construction of such a facility. A detailed engineering design for the solid waste facility would be prepared in coordination with the State of Alabama, and forwarded to EPA Region IV for review.

3. Comment

Please inform the public of. . .the solid waste to be disseminated per year and per twenty years.

Comment By

Kenneth C. Johnson, 9/21/80 letter, page 4, paragraph 4.

Response

If one assumed a nominal 4-module plant capacity of 20,000 TPD of coal containing 15% ash and a plant capacity factor of 90%, the amount of ash or slag produced would be 2,700 TPD or 985,000 tons/yr. Over a 20-yr life, the amount of ash or slag produced would be approximately 19.7 million tons for a 4-module facility. The present plans, however, now call for constructing 2 modules initially with the capability of expanding to 4 modules at a later date if technically and economically justified. A 2-module facility would be expected to produce about half of the ash or slag quantities estimated above.

4. Comment

Since the solid waste contains toxic and radioactive substances, the 3,000 tons of solid waste produced daily by the coal gasification facility should be handled as a hazardous chemical waste and public access should be controlled forever.

Comment By

Philip R. Owen, 9/20/80 letter, comments A3, B13, and B32.

Response

The EPA has established specific testing procedures, pursuant to its authority under RCRA, to be used when determining whether a waste material should be considered hazardous. TVA is conducting these tests on the slag and ash residue produced from gasifying design coal in Texaco and K-T gasifiers to determine whether the material should be considered hazardous. Preliminary results have indicated that wet ash collection would remove certain gases from the product gas stream, which may cause the wet ash to be classified as a hazardous waste. This potential problem does not arise if the ash is collected dry. While it is true that the solid waste may contain certain elements that, if in high enough concentration, could be toxic to living things, their mere presence does not render a substance toxic or hazardous. TVA is continuing its studies of the engineering and chemical properties of both wet and dry ash. It is expected that efforts to define the proper disposal requirements for the solid waste would be coordinated with the EPA and the State of Alabama. Please refer to Section 4.2.12 in Volume 2 for a discussion of environmental consequences of solid waste disposal. Section 2.3.6 describes the alternative solid waste disposal options presently being evaluated by the project.

5. Comment

Solid waste handling seems realistic although the Karst topography at Courtland may present a major problem. Hopefully, TVA will be able to develop end uses for the gasification slag before the useful plant life is expended.

Comment By

James A. Bates, 9/28/80 letter, page 1, paragraph 2.

Response

It is expected that a program to find uses for the gasification slag would be instituted before the plant life ends. Considerable effort has been expended by TVA to develop uses for power plant ash and slag. Experience gained through these efforts could potentially aid the private entity in developing uses for gasifier slag or ash.

6. Comment

Several persons were concerned that slag disposal at the Murphy Hill site might cause degradation of the ground water and lake.

Comments By

Patricia Hodges Abney, DEIS public hearing transcript, page 38, paragraph 4 to page 39, paragraph 1; Phyllis Bates, 9/24/80 letter, page 1, comment 2; Ann Maples Brewster, 9/25/80 letter, page 1, paragraph 3; Rex B. Brown, 9/25/80 letter, comment 4; Bob DeYoung, 9/17/80 letter, paragraph 7; Reed D. Hamman, page 1, comment 1; Rilla Hodges, 9/21/80 letter, page 1, paragraph 2; Max W. Ingram, 9/25/80 letter, page 1, comment 2 and DEIS public hearing transcript, page 33, paragraph 4 to page 34, paragraph 1; Marjorie B. Maples, 9/30/80 letter, page 1, paragraph 2; Dr. H. M. Mauldin, et al., letter (date unknown), page 1, paragraph 5; National Environmental Health Association, 9/6/80 letter, page 2, paragraph 1; Helen Nelson, attachment to 9/28/80 letter, page 1, paragraph 2; and page 2, paragraph 2; James Nelson, 9/28/80 letter, comment 1; Joseph V. Olszewski, 9/26/80 letter, page 1, paragraphs 2 and 3; Alfred P. Owen, 9/26/80 letter, page 1, paragraph 2; Philip R. Owen, 9/20/80 letter, comments A3 and B32; and attachment 3 to 9/25/80 letter, page 2, paragraph 1; Walter K. Polstorff, 9/6/80 letter, page 1, paragraph 5; and page 2, paragraph 2; Donald B. Popejoy, 9/29/80 letter, paragraph 2; Martha Pullan, DEIS public hearing transcript, page 54, paragraph 5; William C. Reeves, 9/28/80 letter, page 1, paragraph 5; Mrs. W. C. Reeves, 9/28/80 letter, page 1, paragraph 5.

Response

Solid waste disposal would be in full compliance with all applicable Federal and State regulations, which are designed to ensure that appropriate ground water quality is not significantly degraded. While it is true that some leachate would be formed in the solid waste disposal area, the project would provide mitigative measures as required to prevent contamination of ground water beyond the boundary of the solid waste disposal area. Extensive geophysical testing of subsurface material is being performed to ensure the structural integrity of the site. Similar geohydrological studies which account for permeability (testing to determine the rate of water movement) and exchange capacity (testing which determines the ability of soil to absorb pollutants) would be performed for soils in the site area. These tests, in conjunction with results from characterization and leachate testing of the gasifier ash and slag, would be used to determine a disposal design sufficient to protect the integrity of ground water beyond the boundary of the solid waste disposal area. Other measures which would be employed to protect both ground water and surface waters would include:

A. Location of storage area above 500-yr flood.

B. Compaction of ash and slag material.

C. Establishment of baseline ground water quality in the disposal area.

D. Quantify the water table, direction and magnitude of ground water flow, and, if appropriate, solute transport in the vicinity of the site.

E. Survey of area ground water users.

F. Establishment of a ground water monitoring program.

G. Diversion of surface runoff before it reaches the disposal site via stormwater ditches.

H. Control of disposal area runoff via reclaiming upper surface with cover soil, vegetation (if possible), berms, ditching, and collection/treatment, if necessary.

Please refer to the response for comment 12 in "C. Process Wastes." More detailed information on solid waste disposal is also presented in Section 4.2.12 in Appendix G of the FEIS.

7. Comment

We suggest that the final statement might include an assessment of the possibility of increased rates of solutioning in underlying calcareous rocks as a result of chemical composition and especially the pH of effluents, leachates, coal-pile runoff, and stormwater runoff.

Comment By

U.S. Department of Interior, 10/7/80 letter, page 2, paragraph 2.

Response

Chemical compositions of those leachates which might enter the underlying calcareous rocks might, depending upon many factors, pose a potential for increasing the rocks' porosity and rate of solutioning. This potential contamination would be among the various aspects considered in the project's groundwater protection program.

Ongoing waste characterization studies would be used to verify assessments presented in the FEIS. The design of the plant would minimize the potential for contamination of groundwater by coal pile drainage. Wastewater effluents, slag/ash leachates and stormwater runoff would be discharged, after meeting high levels of treatment as noted elsewhere in the FEIS, directly to the lake and would not pose a threat to ground waters.

8. Comment

There would be less potential impact on ground water quality from ash pile leachate at Courtland than at Murphy Hill since there is a central water system at Courtland and individual wells near Murphy Hill.

Comment By

Patricia Hodges Abney, DEIS public hearing transcript, page 38, paragraph 4 to page 39, paragraph 1; Rilla Hodges, 9/21/80 letter, page 1, paragraphs 2 and 3 to page 2, paragraph 1.

Response

Domestic water needs in the vicinity of the Murphy Hill site are supplied by ground water wells. Since all groundwater movement under the 20-yr ash disposal area is directly to Guntersville Lake, the ground water resources in this area would not be adversely impacted by leachates from the ash disposal area.

The public water supply system at Moulton, Alabama, supplies water for the Courtland residents and some surrounding areas. However, leachates from ash disposal at the Courtland site would move down gradient toward the Tennessee River and potentially could have an impact on many domestic wells between the site and the river.

9. <u>Comment</u>

The discussion on solid waste disposal in the DEIS supplement supports location of the facility as far as possible downstream to reduce the amount of water resources which could be damaged by leachate, dike failures, lining failures, etc.

<u>Comment By</u>

Philip R. Owen, 6/29/81 letter, comment 2.

<u>Response</u>

A number of factors are involved in protecting water resources from possible contamination, but selecting a location upstream or downstream from any given point does not necessarily reduce or increase the chances for water resources contamination. For instance, locating the facility downstream at Courtland would substantially increase the potential for groundwater contamination. Locating a solid waste disposal facility closer to the river downstream of Murphy Hill would still require that the disposal facility be adequately designed to protect water resources. While potentially impacted water resources from an upstream location may flow past a greater number of water users, the major siting criteria is the geological conditions of the disposal area. Properly designed disposal facilities should present no significant impacts on water quality. Regardless of the site, adequate measures will be taken such as properly designed dikes and liners, if needed, to protect water resources. Please refer to the response to question 6 above for a discussion of measures to be taken to provide for water resource protection.

10. <u>Comment</u>

If Murphy Hill or Courtland is selected as the site of the plant, we would recommend that construction be delayed until a suitable dry ash collection and disposal system can be developed. Even "an impervious lining" can develop a leak and cause environmental problems in a wet disposal system.

<u>Comment By</u>

Alabama Department of Conservation and Natural Resources, Game and Fish Division, attachment to 6/22/81 letter, paragraph 2.

<u>Response</u>

The disposal of ash products, either wet or dry, would require that an area be designed to safely contain the waste material. Engineering principles, experience, and judgment would be applied in the design of a disposal area to minimize the potential for breech of confinement which could jeopardize the environment. A monitoring program would also be established to provide early detection of any contamination of the groundwater system so that remedial action could be taken should an unanticipated event occur. Please refer to the response to question 6 above for additional information.

R. PUBLIC HEALTH AND SAFETY

1. Comment

The public expressed concern about the effects of emissions from the coal gasification plant on human health. These concerns were for respiratory disease, cancer, and birth defects (and the accompanying increased cost of health care) as well as chronic effects on health in general.

Comments By

Royce M. Bynum, 9/29/80 letter, paragraph 1; B. D. Gateley, letter (unknown date), page 1, comment 3; and page 2, comment 8; Jennie M. Helderman, 9/28/80 letter, page 1, paragraph 5; Philip R. Owen, attachment (1/22/80 letter) to 9/25/80 letter, page 1, paragraph 1; William Talley, DEIS public hearing transcript, page 61, paragraph 4 to page 64, paragraph 1; Tennessee Toxics Program, attachment to 8/25/80 letter, page 1, paragraph 3; and page 2, paragraph 2.

Response

The DEIS addresses the issues raised by the public regarding the potential for adverse health effects from the coal gasification plant. However, these discussions are presented in a number of areas throughout the DEIS. Particular attention should be given to Sections 2.3.3.5, 2.3.4, 4.1.2.12, and 4.3 and Appendix C of Volume 1. It is recognized that toxic chemicals may be produced by certain coal gasification technologies, and further, that the ash in coal may contain trace elements considered to be toxic to plants or animals at certain concentrations. Plans are presented and discussed for contolling these emissions (into air and water) to levels which do not adversely affect health. Emissions would be routinely monitored as required under appropriate permits to ensure that they do not exceed regulated limits.

Cost of health care is not anticipated to increase in the area because the plant is not expected to affect adversely the public's health.

2. Comment

If hazardous compounds (including organics) within the process streams are recycled, how will this affect public and occupational health? This estimation should consider that: substances often accumulate at certain points within a system; recycling often requires a "bleed point," and the substances which are "bled" from the system are subject to handling and disposal.

Comment By

Tennessee Toxics Program, attachment to 8/25/80 letter, page 1, paragraph 2; and page 2, paragraph 10.

Response

The major recycle stream in the facility would be the washer cooler water that is used to cool the gas and remove particulate matter from the gas stream. The particulate-laden water would be treated to remove particulate and then recycled to the washer cooler. It is expected that dissolved materials in this waste stream would build up. It is not, however, expected that this would impact public or occupational health. The blowdown stream, or material that is "bled" from the system would be treated as appropriate to remove pollutants to an acceptable level before being discharged. This treatment can be done with little or no worker exposure to the waste stream. The discharge of treated waste is not expected to impact public health. Please refer to the response to question 10 under "I. Surface Water and Ground Water" of this appendix for additional information.

3. Comment

Safety provisions should be included in the facility to minimize failures that could endanger the public or the environment. Experience shows, however, that in spite of man's best efforts, failures occur and emergencies arise that require real-time decisions and responses to limit deleterious effects. Training, equipment, and procedures for response to emergencies must be provided to ensure that these effects and hazardous environments will not reach populated areas.

Comment By

Philip R. Owen, attachment (1/22/80 letter) to 9/25/80 letter, page 2, paragraph 3.

Response

The subject of emergency procedures for the coal gasification plant was addressed in the DEIS, Volume 2, Section 4.3. It is expected that the consortium would implement such procedures.

4. Comment

The public safety and health effects of a failure in the synthetic fuel pipeline have not been adequately addressed, and mitigation techniques have not been discussed.

Comment By

Ilmar Dalins, DEIS public hearing transcript, page 105, paragraph 4; Philip R. Owen, DEIS public hearing transcript, page 67, paragraph 5 to page 68, paragraph 2; and 9/20/80 letter, page 1, paragraph 1.

Response

This subject is addressed in Volume 2, Section 4.3.2.1 of the FEIS.

5. Comment

The public safety and health effects of a significant plant failure have not been assessed. Occupational standards or ambient air quality standards could be used for the assessment. When the assessment is completed copies should be made available to the public for review.

Comment By

Philip R. Owen, 9/20/80 letter, page 8, comment B44; attachment 3 to 9/25/80 letter, page 1, paragraph 1.

Response

Public safety and health effects from a significant plant failure is assessed in the FEIS (Volume 2, Section 4.3), but using occupational or ambient air standards are inappropriate for the assessment. Occupational standards, for the most part, represent conditions under which it is believed that nearly all industrial workers may be repeatedly exposed day after day without adverse effects. Generally, exposure periods correspond to a typical industrial work shift, i.e., 8 hr daily, 40 hr weekly. Ambient air standards are designed to prevent adverse effects of chronic exposure to low concentrations of atmospheric contaminants even more restrictive since they take into account the greater variation in the public population than in the occupational population. Because a significant plant failure is a very infrequent occurrence the levels of interest for these failure assessments would be those causing severe, acute toxic effects among members of the public.

6. Comment

The occupational health and safety of the coal gasification plant work force was insufficiently covered.

Comments By

Natural Resources Defense Council, Inc., attachment to 10/1/80 letter, pages 15 to 16, section E; Tennessee Toxics Program, attachment to 8/25/80 letter, page 1, paragraph 2; page 2, paragraph 2; Department of Health and Human Services, Public Health Services, U.S. Center for Disease Control, 9/26/80 letter, page 1, paragraphs 3 and 4, and 6/19/81 letter, paragraph 3.

Response

Occupational health and safety was evaluated in the DEIS, although such considerations are not generally recognized as environmental issues. However, TVA recognizes that occupational health and safety is an important concern and anticipates conducting a design review to ensure that the proposed plant would be designed to minimize employee hazards. Since TVA does not expect to be involved in plant operations, the private entity would have responsibility for ensuring the protection of plant employees during this phase. It is expected that the design and operation of this facility would comply with all applicable regulations regarding occupational health and safety. Please refer to Volume 2, Section 4.3.3 for more information.

7. Comment

The EIS does not substantiate the statement (of the "Coal Gasification Project Draft Environmental Impact Statement" in Volume 2, Section 4.3.2.2 that selection of Murphy Hill will provide relatively lower associated risk to the public. In fact, Courtland has relatively lower associated risks.

Comments By

Anna McDonald, 9/22/80 letter, pages 2 to 3, comment 4; Philip R. Owen, 9/20/80 letter, comment B49.

Response

The statement to which reference was made states: "From the standpoint of reducing the potential risks to the public at large by selecting the site with the relatively lower associated risks, Murphy Hill is preferable over Courtland."

At the Courtland site, most of the town of Courtland (estimated 1980 population, 452) and about 200 rural residences lie within about a 2-km radius of the plant site boundaries. At the Murphy Hill site there are approximately 100 rural, farm, and lakefront homes within a 2-km radius of the proposed plant site as well as a transient recreation population. Should an accident occur at the coal gasification plant that might affect the public, one would expect fewer members of the public to be exposed to the accident hazard if the coal gasification plant were constructed and operated at the Murphy Hill site.

8. Comment

Concern was expressed about potential hazards to public health and safety posed by the product gas pipeline.

Comment By

Helen Nelson, attachment to 9/28/80 letter, page 2, paragraph 3; Philip R. Owen, 9/20/80 letter, comments B5 and B29; and DEIS public hearing transcript, page 67, paragraphs 1 to 3.

Response

This subject is addressed in Volume 2, Section 4.3.2.1 of the FEIS. Please refer also to the response to comment 7 above.

9. Comment

TVA should have a plan to identify all hazardous operations which will be conducted at the plant in order to ensure that design features will provide adequate safety and health protection for employees and the public.

Comments By

Philip R. Owen, attachment to 9/25/80 letter, page 3, paragraph 1; W. George Taylor, 9/24/80 letter, paragraph 4; Tennessee Toxics Program, attachment to 8/25/80 letter, page 2, paragraph 2.

Response

During the design phase of the coal gasification plant, a design and specifications safety analysis review would be conducted to further detail the potential for public and employee exposure to hazardous materials as well as other safety considerations. Process operating modes, including startup, shutdown, and emergencies, would be considered. Control options to protect the public, as well as employees, during any identified failure mode would be incorporated into the final plant design or into the standard operating and emergency procedures. All lines or equipment containing toxic gases, vapors, or liquids would be designed, constructed and maintained to minimize leakage.

A preventive maintenance and inspection program would probably be developed and implemented by the private entity to maximize equipment reliability.

10. Comment

The Draft Environmental Impact Statement indicates the product gas pipeline may cross the Tennessee River at two locations. Wouldn't the rupture of such a high-pressure gas pipeline beneath the river have a devastating effect on water quality?

Comment By

Philip R. Owen, 9/20/80 letter, comments A1 and B36.

Response

The components of the product gas in the pipeline will be approximately 60% carbon monoxide and 40% hydrogen. These gases would not pose a water quality problem due to their low solubility in the water (refer to Section 4.3, FEIS, Volume 2).

It should be noted that the project is not proposing to construct a MBG pipeline at this time. Should an MBG pipeline be constructed across the Tennessee River at some future date, it is anticipated the pipeline would conform to the requirements of the Department of Transportation Regulation, 49 CFR 192, "Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards." The pipeline would be buried beneath the original stream bed and backfilled for an additional measure of pipeline protection. Pipeline welds would meet pipeline safety specifications and the pipeline would be hydrostatically tested prior to use in order to verify maximum allowable operating pressures.

11. Comment

Health and safety effects of coal transportation must be addressed in the EIS.

Comment By

Philip R. Owen, attachment (4/7/80 letter) to 9/25/80 letter, page 3, item k.

Response

Additional barge traffic would result in no new public health and safety impacts other than the incremental increase in barge traffic, barge loading/unloading, docking/undocking, and dredging at the specific site area.

The National Safety Council occupational injury and illness incidence rates for employees engaged in transportation on rivers and canals during the period 1976-1978 was 4.14 recordable injuries or illnesses per 100 full-time employees with 1.89 of these cases involving days away from work or death. New coal transfer equipment and application of a modern safety program should result in lower accident rates at the coal gasification plant.

For more information on barging operations, please see Section 4.1.5 of Appendix G.

12. Comment

In view of projected use of the project as a model to develop standards for coal gasification plants, it is particularly important that public health considerations be discussed in greater depth. The toxicological implications should be discussed thoroughly so that intelligent and informed public choices are possible in the current energy situation.

Comment By

Margaret Pillow, Bendix Environmental Research, 9/24/80 letter, paragraph 2.

Response

The DEIS addresses the potential adverse health effects from the coal gasification plant. However, these discussions are presented in a number of sections throughout the text (Volume 1). Particular attention is provided in:

Section 2.3.3.5, Air Emission Characteristics
Section 2.3.4, Part C, Presence of Hazardous Compounds
Section 4.1.2.1 and 4.2.2.1, Air Quality
Sections 4.1.2.2 and 4.2.2.2, Surface Waters
Sections 4.1.2.11 and 4.2.2.11, Radiological Impacts
Sections 4.1.2.12 and 4.2.2.12, Solid Waste Disposal
Section 4.3, Public Health and Safety
Appendix C, Pipelines
Appendix H, Section J, comment 3

TVA recognizes that toxic substances may be produced by the coal gasification plant. Plans are presented and discussed for controlling these emissions (into air and water) to levels which do not adversely affect health. Emissions would be continually monitored to ensure that they do not increase to potentially harmful levels.

13. Comment

The toxic hazard potential of trace metals in effluents and wastes should be addressed in the EIS.

Comment by

Natural Resources Defense Council, attachment to 10/1/80 letter, page 6, paragraph 3; Margaret Pillow, Bendix Environmental Research, 9/24/80 letter, paragraph 1.

Response

Coal and coal ash contain varying amounts of trace metals, some of which are known to be toxic at certain doses. Based on experience in TVA coal-fired power plants, we do not anticipate that coal gasification plant workers would be overexposed to trace metals. Developing an occupational health and safety workplan for the coal gasification plant would aid in identifying health hazards.

Please refer to the responses to questions in parts "C. Process Wastes" (comments 1 and 9), "H. Air Quality" (comment 1 under "Health Effects" Related Comments and Comments Referring to "Grave Degradation" or "Unacceptable Impact" to Air Quality), "I. Surface and Ground Water" (comments 9 and 10), "J. Aquatic Ecology and Fisheries" (comment 3), and "Q. Solid Waste Disposal" (comment 4) of this appendix for information on potential environmental impacts associated with plant-related emissions, effluents, or wastes.

S. GENERAL POTENTIAL ENVIRONMENTAL IMPACTS

1. Comment

How would the potential environmental impacts (both short-term and long-term) expected from a coal gasification plant using either K-T or Texaco processes compare with the impacts caused by recent major accidents (such as Love Canal and Three Mile Island)?

Comment By

Kenneth C. Johnson, 9/21/80 letter, page 1, paragraph 3 to page 2, paragraph 1.

Response

The potential environmental impacts of the proposed coal gasification project would be much less significant than those of Love Canal and Three Mile Island. Please refer to Section 4.3, "Public Health and Safety" in Appendix G for a detailed discussion of the possible impacts on public health and safety.

2. Comment

General concern was expressed about unanswered questions regarding possible environmental hazards associated with the proposed site. It was believed that if the coal gasification facility were located at Murphy Hill, the environmental impacts in the site vicinity would be extensive and Murphy Hill should, therefore, not be the preferred location for the coal gasification plant.

Comments By

T. E. Bates, 9/26/80 letter, paragraph 1; Dorothy P. Hard, 9/22/80 letter, page 2, paragraphs 2, 3, and 4; Max W. Ingram, letter, paragraph 1; Howard P. Lloyd, 9/16/80 letter, paragraph 1; Philip R. Owen, attachment (1/22/80 letter) to 9/25/80 letter, page 1, paragraph 2; DEIS public hearing transcript, page 149, paragraph 4 to page 150, paragraph 1, and 6/29/81 letter, comment 2.

Response

TVA has, to the extent possible, assessed the potential environmental impacts of the proposed coal gasification facility. Approximately 300 pages in the EIS were dedicated to describing and assessing the potential environmental impacts. The assessment determined that if the plant is designed and operated as planned the environmental impacts would not be extensive. From an overall standpoint, recognizing that the desirability of each site varies from environmental parameter to environmental parameter, Murphy Hill is equivalent or slightly preferred to Courtland as a location for the coal gasification plant. As noted in the EIS, a high degree of detail regarding some environmental parameters is not available. With respect to those parameters, the EIS provides the data that is available and potential impacts are extrapolated from the existing data. As discussed in the EIS, TVA has undertaken an extensive testing program to confirm the analyses in the EIS and the results of this program would be utilized in the design of the plant's associated pollution control strategies.

3. Comment

Will TVA guarantee that this picturesque beautiful jeweled lake of beauty [Guntersville Lake] not be made a scarred area from extraction in the future of coal from strip mining this area for use in the coal gasification plant?

Comment By

B. D. Gateley, 10/1/80 letter, page 1, question 4.

Response

There are no coal reserves in the immediate vicinity of the preferred Murphy Hill plant site. Reserves do exist on the upper reaches of Sand Mountain which lies to the north and east of the proposed site (please see the responses to comments 11 and 12 under Part D. "Site Selection"). Some of these reserves could be mined and supplied to the plant. It is expected, however, that most coal would come from other locations throughout the Tennessee Valley and adjacent states (TVA's traditional coal buying market).

4. Comment

Will the land, water, and habitat 5 or 20 years from now be as good as before?

Comment By

Reed D. Hamman, 8/22/80 letter, page 1, last paragraph.

Response

Neither plant construction nor operation should have a long-term effect on water quality or land resources of the area. The only significant long-term impact to vegetation and terrestrial habitat would occur on the actual plant site area. Construction of the plant facilities would result in the loss of habitat for less mobile organisms. To prevent degradation of water quality, surface discharges from facility during construction and operation would be treated utilizing BACT and would be operated in conformance with NPDES permit requirements.

5. Comment

Finally, the coal gasification DEIS is thorough in its evaluation on immediate environmental impacts. However, the National Environmental Policy Act requires consideration of,

> The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity.

Your DEIS does not adequately address the long-term effects of your project or the coal gasification technology. Might there be future problems from storage of hazardous solid wastes for long periods, contamination of soil (possibly leading to contamination of ground water), washing of pollutants from the air, and effluents from the process on downstream residents and aquatic life?

Comment By

National Environmental Health Association, 9/26/80 letter, page 1, paragraph 5 to page 2, paragraph 1.

Response

TVA believes the assessment of long-term effects of the project provided in the EIS is adequate and appropriate for a project of this magnitude. This document is not intended to be a programmatic EIS wherein the overall environmental impacts that might be associated with implementing a given technology (such as coal gasification) on a national scale are assessed. TVA proposed only 1 commercial-scale coal gasification facility and does not intend to undertake a nationwide coal gasification program.

The Department of Energy issued a final EIS in September 1977 that presented "a generic assessment of the potential environmental impacts associated with the undertaking of a program to demonstrate the commercial viability of synthetic fuels." The program was called the Alternative Fuels Demonstration Program. Coal gasification (high- and low-Btu) and indirect coal liquefaction were included as part of this EIS. More specifically the EIS served to project "the impacts of a synthetic fuels industry of various sizes and composition that could ultimately be triggered by" [DOE's Alternative Fuels] program. It is believed that DOE's EIS adequately assessed the generic long-term effects of gasification technology.

Please refer to the response given to the comments in Sections H, I, J, and Q above for a discussion of the possible concerns associated with the washing of pollutants from the air, the potential impacts of plant effluents on downstream water quality and aquatic life, and the possible effects of solid waste disposal on soil and ground water. Further information on air quality, surface water quality, aquatic ecology and fisheries, and solid waste disposal may be found in Sections 4.2.1, 4.2.2, 4.2.4, and 4.2.12 respectively, of Appendix G.

T. GENERAL COMMENTS

1. Comment

One overall question we have with respect to the above document is: Is it supposed to include the operational aspects of the plant or only the construction aspects?

Comment By

Department of Health and Human Services, Public Health Services, Center for Disease Control, 9/26/80 letter, page 1, paragraph 2.

Response

The draft and final EIS addressed both the operational and construction impacts of the proposed coal gasification facility.

2. Comment

As you are no doubt aware, the heart of the requirements for publication of a DEIS or FEIS is the concept of full disclosure. It is in this way that the officials in a decision-making role, the public at large, and the courts (if need be) can be informed of the potential results of a major Federal action before construction proceeds. With respect to full disclosure, the presently offered DEIS falls far short of the existing law. There seems to be a thread running through the discussion that the coal gasification plant is a 'pilot plant' operation wherein the environmental effects will be determined after all construction is complete and operations are tested. This is totally unacceptable. The environmental impact must be determined before any decision is made even if an experimental program must be undertaken.

Comment By

The Alabama Conservancy, 9/29/80 letter, paragraph 2.

Response

The proposed coal gasification plant will not be a pilot scale operation. The facility will utilize full size commercial-scale technology and will have an initial plant capacity (10,000 TPD of coal) in the range generally regarded by industry to be a commercial operation.

Environmental assessment is not a one-time exercise but a continuing activity. The information presented in the FEIS is sufficient to support a decision to procede with plant construction and operation. Further, ongoing environmental reviews of the project would be part of the permit renewal process for this facility. In addition post-operational environmental data will be made publicly available. (Please refer to Appendix A.)

3. Comment

The draft EIS did not adequately address the overall impact of transporting coal from the source to the proposed plant site. The information on the number of barge tows and dam lockages required annually to deliver coal from the source to the proposed plant site also needs clarification. Please elaborate on the expected effects on the environment, the river traffic, and the maintenance and operation of the appropriate dams. In addition, please provide a detailed discussion of the location and condition of fleeting sites for empty barges enroute to the coal source. If new fleeting sites need to be constructed, what are the expected environmental impacts?

Comments By

Philip R. Owen, 9/20/80 letter, comment B37; Sierra Club, 9/14/80 letter, comment 3; U.S. Department of Interior, 10/7/80 letter, page 3, paragraph 5.

Response

Please refer to Sections 2.3.6.1 (Volume 1) and 4.1.5 (Volume 2) as well as responses in parts B, I, and J of this appendix for a discussion of the coal barging activities and requirements. The various environmental impacts of the barging operation have been described and assessed in the appropriate sections of the EIS. Further discussion on navigation impacts is provided in the response to question 17 below.

4. Comment

Throughout, the DEIS says this or that problem can be handled through such and such standard, permit, "best management practice," etc. The DEIS, and particularly the Final EIS, must contain commitments to take these measures.

Comment By

Natural Resources Defense Council, Inc., attachment to 10/1/80 letter, page 14, paragraph 3.

Response

Throughout both the draft and final environmental impact statements it has been indicated that "best management practices" as well as BACT would be used to control pollutants. TVA is committed to assuring that a clean plant is built that utilizes best management practices to control pollution, and measures which could further reduce impacts have been identified in the EIS. Further, referenced environmental standards, regulations, and permit requirements are legal requirements which must be complied with.

5. Comment

The discussion of public comments expressed during the scoping process needs clarification. Many people in favor of locating the coal gasification plant at Murphy Hill live 10 to 50 miles from the site and, therefore, are located outside of the main environmental impact area. Most of the property owners in close proximity to the Murphy Hill site oppose locating the plant at this site. How many people in each group commented during the scoping process?

Comments By

Kenneth C. Johnson, 9/21/80 letter, page 3, paragraph 4; James B. Kyser, 9/22/80 letter, page 1, paragraph 4; Philip R. Owen, 9/20/80 letter, comment B10.

Response

During the EIS scoping process, TVA developed the scope of contents of the EIS to include the general topics of public concern. Public responses were classified by support for or opposition to locating the proposed facility at either Courtland or Murphy Hill. Approximately 150 responses, including 76 letters, 55 telephone calls, 15 resolutions from local governments and organizations, and 4 petitions with 1,038 total signatures, were received from those who favored locating the proposed gasification plant at the Murphy Hill site. TVA received about 100 responses from those opposed to locating the proposed plant at the Murphy Hill site. These responses consisted of 45 letters, 52 telephone calls, and 3 petitions with 144 total signatures. Supporters of locating the proposed plant at the Courtland site had 88 total responses with 7 resolutions, 21 letters, and 60 telephone calls. Three telephone calls were received from those opposed to locating the proposed facility at the Courtland site. Multiple responses were received from some individuals in all of the above groups except for those opposed to locating the proposed plant at Courtland.

While reviewing the public comments, it was generally observed that many people in counties surrounding the Murphy Hill site favored the proposed action. Over 600 signatures were present on petitions that were identified as being from local union members and property owners supporting the proposed facility at the Murphy Hill site. Some of the opponents to this action identified themselves as owners of property located across the lake from the preferred site. Only these general observations could be made regarding the location of people commenting during the scoping process. No attempt was made during the EIS scoping process to categorize commenters with respect to proximity to either the Murphy Hill or the Courtland site. TVA considered all comments in defining the scope of the EIS irrespective of a commenter's geographical location. It should be pointed out that even though a person may be located outside of the immediate impact area or out of view of some proposed action, they may be located within the potential socioeconomic impact area of the proposed facility.

6. Comment

The EIS states that those opposing the location of the plant at the Murphy Hill site generally cited adverse impacts on aesthetic and property values as their major concerns. However, opponents also have expressed concern about potential impacts on air, water quality, scenic resources, noise levels, lifestyle, and other environmental parameters. The EIS should include more information on the concerns that were expressed by opponents during the scoping process.

Comments By

Kenneth C. Johnson, 9/21/80 letter, page 3, paragraph 4; Thomas A. King, 9/25/80 letter, page 1, comment 2; James B. Kyser, 9/22/80 letter, page 1, paragraph 4; Philip R. Owen, 9/20/80 letter, comments B10 and B17; DEIS public hearing transcript, page 154, paragraph 4 to page 155, paragraph 1.

Response

TVA reviewed all available public comments received during the scoping process and categorized these comments by the general topic of concern. As discussed in the introduction of the EIS, opponents of the proposed action commented on several topics including those mentioned in the above question. An individual response often contained more than one topic of concern. The most frequent comment, which was expressed in almost half of the responses from opponents to the proposed action, was that the aesthetic values might be degraded in the site vicinity. Decreased property values were discussed in 30% of the responses. Concern for increased water pollution, increased air pollution, adverse impacts to recreation, attraction of new industry to the area, increased environmental noise levels, and questionable economic feasibility of the preferred site was expressed in 29%, 24%, 21%, 17%, 12%, and 11% of the responses, respectively. All other topics mentioned were discussed in 10% or less of the responses.

TVA has discussed the above mentioned potential environmental impact areas in detail in both the draft and final EIS. Approximately 300 pages in the EIS were given to adequately address the environmental concerns identified by the public and TVA in the scoping process.

7. Comment

How much additional energy will be used over 20 years by not locating the coal gasification plant at the Courtland site or at another site downriver from Murphy Hill? This estimation should include: the amount of energy that would not be produced because the water is used for coal barge lockages instead of for power generation at Guntersville Dam; the quantity of fuel used to construct, operate, and maintain the additional pipelines and pumping stations required to distribute the MBG product from the Murphy Hill site; and the amount of fuel used to transport coal barges round-trip from the Courtland to the Murphy Hill site.

Comment By

Max W. Ingram, 9/25/80 letter, page 1, comments 3 to 6.

Response

The energy balance analysis (daily and 20-yr) for the proposed gasification facility is presented in Table E-4. The plant was assumed to consist of 4 modules and be in full operation 90% of the time during the entire plant life span. It is now proposed that 2 modules be constructed initially, with the capability of expanding to 4 modules at a later date if technically and economically justified. The analysis, however, presents energy levels for the different siting (Murphy Hill or Courtland), coal mining

TABLE E-4. ENERGY BALANCE FOR PROPOSED COAL GASIFICATION FACILITY

	Energy Balance[a]							
	Daily (Billion Btu)				20-Year (Trillion Btu)			
	Murphy Hill		Courtland		Murphy Hill		Courtland	
Activity	K-T	Texaco	K-T	Texaco	K-T	Texaco	K-T	Texaco
ENERGY CONSUMPTION BY								
Coal Mining Method[b,c]								
Surface	-3.3	-3.3	-3.3	-3.3	-24.1	-24.1	-24.1	-24.1
Underground	-4.6	-4.6	-4.6	-4.6	-33.6	-33.6	-33.6	-33.6
Coal Transport								
Rail[b,d]	-1.2	-1.2	-1.2	-1.2	-8.8	-8.8	-8.8	-8.8
Barge[b,e,f]	-4.2	-4.2	-3.3	-3.3	-30.7	-30.7	-24.1	-24.1
Barge Lockage[c,e-h]	-0.7	-0.7	-0.6[i]	-0.6[i]	-5.1	-5.1	-4.4[i]	-4.4[i]
Conveyor System	-	-	-0.2[i]	-0.2[i]	-	-	-1.5[i]	-1.5[i]
Subtotal	-6.1	-6.1	-5.3	-5.3	-44.6	-44.6	-38.8	-38.8
Operation of Facility								
Electric Power Imported[c]	-155.8	-58.2	-155.8	-58.2	-1138.1	-425.2	-1138.1	-425.2
Coal Feed	-455.6	-466.2	-455.6	-466.2	-3328.2	-3405.6	-3328.2	-3405.6
Subtotal	-611.4	-524.4	-611.4	-524.4	-4466.3	-3830.8	-4466.3	-3830.8
Total with:								
Surface Mining	-620.8	-533.8	-620.0	-533.0	-535.0	-3899.5	-4529.2	-3893.7
Underground Mining	-622.1	-535.1	-621.3	-534.3	-4544.5	-3909.0	-4538.7	-3903.2
ENERGY PRODUCTION BY FACILITY[j]	+330.8	+311.0	+330.8	+311.0	+2416.8	+2271.8	+2416.8	+2271.8
ENERGY EFFICIENCY:								
Plant Efficiency	54.1%	59.3%	54.1%	59.3%	54.1%	59.3%	54.1%	59.3%
Overall Efficiency								
Surface Mining	53.3%	58.3%	53.4%	58.4%	53.3%	58.3%	53.4%	58.4%
Underground Mining	53.2%	58.1%	53.2%	58.2%	53.2%	58.1%	53.2%	58.2%

Footnotes for Table E-4

a. Assumed that 90% of time plant is at full operational level, requiring approximately 20,000 TPD of coal. The present plans call for constructing only 2 modules now with a capacity of 10,000 TPD of coal.

b. Values calculated from information on Eastern Coal presented in Technology Characterizations Environmental Information Handbook, U.S. Department of Energy, June 1980, (DOE/EV-0072), assuming equivalent energy expenditure per ton for coal extraction and per ton-mile for transportation of coal.

c. Replacement value of electricity assumed to be 10,000 Btu/kWh.

d. Assumed coal transport distance of 70 mi by rail.

e. Assumed 6 barge tows required per week with one barge tow consisting of 15 barges with 1,500 ton capacity per barge.

f. Assumed hypothetical case transport distance of 384 mi to Murphy Hill site with lockages at Kentucky, Pickwick, Wilson, Wheeler, and Guntersville Dams or hypothetical transport distance of 296 mi to Courtland with lockages at Kentucky, Pickwick, Wilson, and Wheeler Dams.

g. Each barge tow assumed to have a double lockage per dam for each trip (original or return).

h. Values represent the amount of energy that was not produced because water was used for coal barge lockages rather than for power production.

i. Derived from estimates for power requirements of conveyor system at Cumberland Steam Plant, assuming transport distance to be approximately 30,000 ft for the Courtland site.

j. Values represent net product gas (total gas produced).

method (surface and underground), and preferred gasification process (Texaco and K-T) options.

At this time, the coal suppliers have not been determined and, therefore, the coal transportation distances are not known. To ensure that this analysis is conservative, worst-case transportation distances are assumed. Since some of the more distant coal sources may be expected to be in southern Illinois, the assumed average coal transportation distances were based on the estimated average distances between the mines in this vicinity and the proposed coal gasification plant sites. The coal was assumed to be transported 70 mi by rail to a barge loading facility on the Ohio River, approximately 14 mi from the mouth of the Tennessee River. Then the coal is assumed to be transported by barge to the plant site. The values for energy consumption during rail or barge transport of coal supplies were derived assuming that consumption increased directly with transport distance and shipment weight. The study also evaluated the amount of energy that was not produced because water was used for lockages of the coal barges rather than for electric power generation at hydro plants. The analyses included estimates of the energy required to operate conveyor belts for transporting the coal from the river to the Courtland site, although no estimate was included for constructing or maintaining this conveyor system. The summary also does not incorporate energy consumption estimates for construction of the facility and any associated pipelines or operation of these pipelines, since these values are expected to be negligible when compared with energy production during the life span of the plant.

As can be seen from the analysis, the major source of energy consumption is the operation of onsite facilities, including coal feed and consumption of imported electric power. The use of the underground mining method for coal extraction would result in a daily increase of about 1.3 billion Btu (or about 9.5 trillion Btu in 20 yr) over the net energy consumption with surface mining.

The additional energy consumption from transporting coal supplies to Murphy Hill rather than to Courtland would result mainly from increased barge fuel consumption. An additional 0.9 billion Btu or the equivalent of about 6,475 gal of No. 2 diesel fuel would be consumed by barges daily. This figure represents about 27% of the estimated daily barge fuel consumption for transporting coal to Courtland. There is a potential for a loss of less than 0.1 billion Btu daily (approximately 4,786 kWh of electricity) because of coal barge lockages through Guntersville Dam. This represents only about 0.22% of the total daily power production for the hydro plant. However, if the plant were built at the Courtland site approximately 0.2 billion Btu would be required to operate the conveyor system. When all energy consumption is considered for each site, an additional 5.8 trillion Btu for the plant life span (or 0.8 billion Btu daily) is consumed in transporting coal the additional distance to the Murphy Hill site. This represents less than 0.3% of the energy produced over the plant life span and is equivalent to the energy produced by the proposed facility in about 19 days of operation.

The expected overall energy efficiency of the proposed facility is about 53.2% to 58.4%. The major variation in overall efficiency is apparently attributable to the plant design with the Texaco process being about 5% more efficient than the K-T process. As indicated by the energy balance estimates above, there is very little variation in overall energy efficiency associated with the siting or coal mining options.

8. Comment

Construction of the proposed coal gasification plant at Murphy Hill would break the covenant in the transfer documents from TVA to private owners restricting the use of lands on Preston and Pine Islands to private residences and recreation. It would also violate TVA zoning restrictions.

Comments By

Thomas A. King, 9/25/80 letter, page 1, paragraph 1; Inez E. Reese, 9/29/80 letter, page 2, paragraph 3; William B. Tatum, 9/23/80 letter, page 1, paragraph 1; Buford Warren, 9/23/80 letter, paragraph 1.

Response

Construction of a coal gasification plant at Murphy Hill would not break any covenants in transfer documents from TVA for property on Preston and Pine Islands. Restrictions on the use of these lands transferred by TVA remain fully effective and continue to serve the purposes for which they were incorporated into the transfer documents. There are no similar restrictions in the use of TVA's Murphy Hill site. Nor would construction of the plant conflict with any TVA "zoning" restrictions. TVA does not have zoning restrictions as such. The site has been designated as preferable for industrial use in the regional land use plans and has been in TVA's power plant site inventory for several years. The construction of a coal gasification facility either by TVA or a private entity is consistent with such a designation.

9. Comment

TVA should evaluate the synthetic fuel products generated by the proposed coal gasification facility for conformity with the premanufacturer review requirements of the Toxic Substances Control Act.

Comment By

U.S. Environmental Protection Agency Region IV, attachment to 10/1/80 letter, page 4, paragraph 4.

Response

The constituents of the product gas and all of the byproducts which may be recovered for sale (or produced from the product gas) are listed on EPA's inventory of existing chemical substances. These substances and the inventory identification number of each are:

Chemical Substance	Identification Number
Carbon Monoxide	630-08-0
Carbon Dioxide	124-38-9
Methane	74-82-8
Hydrogen	1333-74-0
Argon	7440-37-1
Sulfur	7704-34-9
Gasoline	8006-61-9
Methanol	67-56-1
Synthetic Natural Gas	8006-14-2

Additionally, under EPA's proposed notification regulations, 45 Federal Register 2242-2348 (1979), byproducts need not be reported (see proposed Section 720.13(e)(2)).

10. Comment

If the proposed coal gasification facility cannot meet the requirements for interim status under Section 3005(3) of the RCRA, a RCRA permit will be required before construction can begin.

Comment By

U.S. Environmental Protection Agency Region IV, attachment to 10/1/80 letter, page 4, paragraph 5.

Response

Construction may proceed without an RCRA permit as long as no hazardous wastes are treated, stored, or disposed of during construction. TVA does not anticipate a need to handle hazardous wastes in such a manner during construction. If such wastes are generated they will be temporarily stored and transported in compliance with State and Federal regulations. This determination was confirmed in an October 31, 1980, letter from Sanford W. Harvey, Director, Enforcement Division EPA Region IV to TVA. Please refer to TVA response to comment number 2 under Q. "Solid Waste Disposal" above.

11. Comment

The Federal family should not be in partnership when deciding on environmental health and safety issues. The Environmental Protection Agency (EPA) should independently establish acceptance criteria and not be driven to jeopardizing the environment through political pressure from other governmental agencies or private industry.

Comment By

Philip R. Owen, 9/20/80 letter, comment B20.

Response

The Congress has provided EPA with the mechanism to accomplish the objective of independent review of Federal actions. Under Section 309 of the Clean Air Act (42 U.S.C. 7609), the Administrator of EPA is directed to review and comment publicly on the environmental impacts of Federal activities, including actions for which environmental impact statements are prepared. If after this review the Administrator determines that the matter is "unsatisfactory from the standpoint of public health or welfare or environmental quality," EPA can refer the matter to the Council on Environmental Quality (under 40 CFR Part 1504) to resolve or mediate such problems including bringing the matter to the attention of the President.

Furthermore, TVA believes that close coordination of a large construction project such as the proposed coal gasification facility with the various environmental protection agencies is not only essential from a management standpoint, but the best way of ensuring that environmental factors are given appropriate consideration and that environmental quality is protected.

12. Comment

"TVA has been unfair in that the site has not been definitely selected, yet TVA has put out all kinds of propaganda to lead the public to think it is a sure thing and therefore useless for them to object or protest."

Comment By

Mrs. Phyllis Bates, 9/24/80 letter, comment 7.

Response

TVA's press releases pertaining to the proposed coal gasification plant have stated that the Murphy Hill site is the "preferred" site. TVA has assessed and considered all comments on the draft EIS from other agencies and the general public. This is reflected in the final EIS. The final decision pertaining to, if, and where a coal gasification plant will be constructed will not be made until sometime subsequent to the release of the final EIS. In accordance with TVA's procedures, implementing the National Environmental Policy Act, 45 Federal Register 54,511-15 (1980), TVA will make publicly available its Record of Decision setting forth its final decision on these matters.

13. Comment

The environmental monitoring procedures that will be used during construction and operational phases should be described in the EIS. This description and the results of this monitoring should be available to the public.

Comment By

Philip R. Owen, attachment 2 (4/7/80 letter) to 9/25/80 letter, page 2, item i.

Response

Please refer to Appendix A for a description of the anticipated construction and operational monitoring plan for the proposed facility.

14. Comment

The final EIS should indicate that TVA will respond to any adverse effects associated with the coal gasification facility that are identified by environmental monitoring. This response may range between a decision to install adequate pollution controls or to change the mode of operation, and a decision to halt the project or not to pursue future use of coal gasification technology.

Comment By

Natural Resource Defense Council, Inc., attachment to 10/1/80, page 17, paragraph 4, to page 18, paragraph 1.

21. Comment

Interest was expressed as to what might be considered the economic and technical justifications for a further increase in 2-modules should an initial design of a 2-module plant be adopted.

Comment by

Etowah County Commission, 6/29/81 letter, page 1, paragraph 4 to page 2, paragraph 1.

Response

The most significant economic justification for constructing other modules would be the presence of a reasonable market for the additional product gas. Technical improvements could also reduce unit costs so that the plant could serve additional markets.

22. Comment

Concern was expressed that with the proposed change in sponsor for the facility, TVA should contracturally require the plant's operator to implement mitigation measures outlined in the FEIS and to select pollution control strategies developed by TVA and EPA.

Comment by

U.S. Environmental Protection Agency, 6/25/81 letter.

Response

Please refer to the TVA letter in Appendix A.

Response

It is expected that appropriate action would be taken in response to the results of environmental monitoring activities. TVA spent about $1.5 million on environmental monitoring activities in conjunction with technical evaluations of Texaco and K-T gasifiers using design coal. This information would be used to design appropriate waste controls for the facility. A comprehensive post-operational monitoring program will be implemented with results and evaluation of the results made available to the public, TVA, EPA, and the State of Alabama. Should post-operational monitoring identify the need for modifications in plant operation, it is anticipated that these would be undertaken.

15. Comment

Since the NEPA requires the activity taking the action to prepare the EIS, TVA and the Corps of Engineers should cease work on the EIS and the private consortium should prepare the EIS.

Comment By

Philip R. Owen, 6/29/81 letter, comment 1, paragraph 2.

Response

Federal agencies are subject to the requirements of NEPA, whereas private corporations and citizens are not subject to the environmental review requirements under NEPA. It would, therefore, be not only inappropriate, but unnecessary for the private consortium to prepare an EIS.

TVA has prepared this EIS because there are two federal actions which require NEPA review--(1) the transfer of government land and the Federal interest in the project to a private entity and (2) the Corps of Engineers (Corps) review and possible issuance of permits under Sections 10 and 404.

16. Comment

If it is true that the government investments in the project will be repaid with interest, then there is no need for TVA to invest any more effort or money in this project. It should be turned over to private enterprise and the government reimbursed for any funds expended on land or for any technical data and environmental studies given to private enterprise.

Comment By

Philip R. Owen, 6/29/81 letter, comment 1.

Response

Appropriated funds have been made available by Congress to allow the project to maintain its present schedule and to provide for its eventual transfer to a private entity in FY 1982 as proposed. If TVA decides to proceed with the project, it would undertake the initial activities required to commence the project such as the preparation and permitting activities. TVA plans to continue the project and then provide for an orderly transfer of the project to a private entity at a future date. The federal investment in the project including land, technical data, or environmental studies would be repaid by the private entity, the details of which are yet to be arranged.

17. Comment

Commenters were concerned about potential navigation impacts from the proposed facility. It was noted that navigational impacts at Kentucky Dam could possibly result in the expenditure of taxpayer's money and that impacts could be avoided by locating the proposed plant near the coal resources below the Kentucky Dam. In addition, the increased barge traffic could hinder industrial development along the Tennessee River.

Comment by

Mary Ann Jenkins, 6/26/81 letter, paragraph 4; Cleveland E. Owen, 6/17/81 letter, paragraph 2; Philip R. Owen, 6/29/81 letter, comment 3.

Response

A number of points should be emphasized to help illuminate the navigational impact assessment. The assessment TVA undertook was based on a worst-case scenario which assumed that all of the coal for a 4-module facility was delivered from some point on the Ohio River. As was pointed out in the DEIS supplement, some coal could come from western Kentucky (bypassing Kentucky Dam) or from east Tennessee and other areas upriver from the proposed plant, or from local Alabama sources, all of which would lower the number of lockages at Kentucky Dam. Also, some of the river traffic between the Ohio River and Kentucky Lake could be routed through Barkley Dam and the Tennessee-Cumberland Canal, thus bypassing Kentucky Dam. In addition, once coal supplies are secured, it would be the responsibility of the suppliers to ship the coal to the site which could involve more extensive use of rail than was assumed by TVA.

TVA's assessment of the barge traffic associated with the facility pointed out that under the assumed coal transportation scenario given above, Kentucky Dam would approach its maximum capacity. It is important to note, however, that the existing percent utilization of the locks annually at Kentucky Dam is estimated by the Corps of Engineers (Corps) to already be about 78%. In order to accommodate continued increases in the river traffic for shipping grain and other commodities or goods through Kentucky Dam, it could be necessary to increase the capacity of the locks at the dam. As a matter of fact, the possible need to expand the capabilities of Kentucky Dam is being evaluated by the Corps and TVA. Alternatively, other methods of shipment could be utilized. Please refer to Section 3.1.5 in Appendix F and 4.1.5 in Appendix G for additional information.

Finally, the increase in lock utilization at the dams as a result of operating the proposed facility is not expected to adversely impact industrial development along the Tennessee River. The navigational locks were initially placed on the river to promote industrial development on the Tennessee River by offering an economical mode of transportation for appropriate industries. Certain industries would be able to benefit more from barge transportation than others. The proposed coal gasification plant is a facility which could benefit from low-cost barge transportation to ship coal to the plant site and its development is consistent with the initial purpose for developing the navigational locks. While it appears that the facility uses a large amount of lock capacity, the facility would also provide a substantial number of jobs and would be equivalent to the development of a number of smaller facilities.

18. Comment

If we gasify coal, how much energy or Btu's are lost in the process? If the energy or Btu loss is significant, it would seem more efficient for the energy user to convert his operation to coal rather than convert the coal to gas as a short-term convenience. If we convert coal to gas, are we not perpetuating the mistake we made 20 years ago when we mistakenly placed our emphasis on petroleum resources as the major source of energy?

Comment By

Alabama Department of Conservation and Natural Resources, Game and Fish Division, 6/22/81 letter, paragraph 3.

Response

The two candidate coal gasification processes--Koppers-Totzek and Texaco have process efficiencies of 62.6% and 66.7% respectively. Considering other factors such as the fuel required to generate the imported electricity, barge transportation, and coal mining, the overall plant efficiencies are somewhat lower. Please refer to the response to question 7 above for efficiencies and Btu losses.

When coal is gasified the product can be used as a chemical feedstock (replacing petroleum or natural gas) methanated (replacing natural gas) or converted to a premium liquid fuel. The gas could also be burned in a boiler to produce process steam or heat. However, as is pointed out, the use of the product gas in this manner is less efficient than burning coal directly. That is why our plans focus on the use of the gas for higher valued applications where coal cannot be used directly.

Petroleum and natural gas became this country's basic source of energy for several reasons, one of the most important of which is their cleanliness and ease of use in transportation, residential applications, and as chemical feedstocks. In planning for the future these special needs must be accommodated. Conversion of coal to gas and liquid fuel offers one of the few means for meeting these needs with our abundant coal resources. The coal gasification plant has been proposed in order to help meet our country's need for premium energy and feedstock sources. Other sources of energy should be developed as well.

19. Comment

If the private sector is willing or eager to fund such a project as the north Alabama coal gasification plant, then why has a consortium of private individuals not initiated such a plant project in the past prior to TVA's project proposal? Also, there appears no mention of assurance or prospects of potential private funders in the supplement.

Comment by

Etowah County Commission, 6/29/81 letter, page 1, paragraph 2.

Response

Prior to the passage of the Energy Security Act (ESA), private industry could not and would not fund projects of this kind without government support and participation. Recognizing this, Congress passed the ESA last summer (1980) thereby providing Federal tax incentives for major energy projects and establishing the SFC. These incentives provided by the ESA, the $125 million that Congress appropriated to TVA for the proposed project, and the pending loan guarantee available through the SFC would be used by the private consortium to continue the proposed project. The private entity, however, would reimburse TVA for all Federal funds expended on the project. Without these benefits, it would be doubtful if private industry would participate in this project. It should be noted that TVA first expressed interest in the project in 1979 prior to any Federal incentives.

Kidder, Peabody & Company, Inc., the financial agent for the consortium, believes that a private consortium could be developed to fund, own, and operate the proposed plant and has applied to the SFC for loan guarantees on the behalf of the to-be-formed consortium. Presently, 2 firms (Santa Fe International and Air Products and Chemicals, Inc.) have expressed strong interest in joining the private consortium. Both TVA and Kidder, Peabody & Company are working to obtain the additional private firms needed to complete the consortium.

20. Comment

In reference to the discussion of a proposed 2-module plant over a 4-module plant, the supplement indicates that construction of a 2-module plant is considered to be preferable for economic reasons and would substantially reduce the project's impacts. A question of ambiguity arises surrounding the meaning in context of the project's impacts as to whether these impacts refer to the environmental or financial kinds or both. From information supplied in the supplement, the indication exists that a 4-module plant would be more economically feasible than a 2-module plant.

Comment by

Etowah County Commission, 6/29/81 letter, page 1, paragraph 3.

Response

The present thinking is to construct 2 modules initially with the capability of expanding to 4 modules at a later date, if technically and economically warranted. The economic evaluation, which indicated a preference for the initial 2-module approach, was based mainly on limitations in the near-term potential markets for the product gas. TVA believed that it would be more economical to have a 2-module plant that could sell its gas than to have a 4-module plant that had lower unit costs but could not sell its product. Another economic consideration favoring the 2-module approach was the limitation in the feasible size of the loan guarantee request that would be submitted to the SFC.

The project's impacts are of several kinds, including socioeconomic and environmental effects. The socioeconomic impact during construction would be reduced by limiting the amount of plant construction performed at any one time, and thereby reducing the peak construction work force required. In addition, an operational 2-module plant would also be expected to have approximately 50% of the coal barging requirements of, air emissions from, and solid wastes generated by, a 4-module facility.

21. Comment

Interest was expressed as to what might be considered the economic and technical justifications for a further increase in 2-modules should an initial design of a 2-module plant be adopted.

Comment by

Etowah County Commission, 6/29/81 letter, page 1, paragraph 4 to page 2, paragraph 1.

Response

The most significant economic justification for constructing other modules would be the presence of a reasonable market for the additional product gas. Technical improvements could also reduce unit costs so that the plant could serve additional markets.

22. Comment

Concern was expressed that with the proposed change in sponsor for the facility, TVA should contracturally require the plant's operator to implement mitigation measures outlined in the FEIS and to select pollution control strategies developed by TVA and EPA.

Comment by

U.S. Environmental Protection Agency, 6/25/81 letter.

Response

Please refer to the TVA letter in Appendix A.