OVERBURDEN CHARACTERIZATION: A TOOL FOR PLANNING RECLAMATION AND GROUND-WATER CONTROL PROGRAMS

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Texas Utilities Mining Company has conducted detailed overburden characterization studies at three surface lignite mines within the Wilcox Group in East Texas. The programs involved organization and classification of sediments into stratigraphic units having similar physical properties and, in many cases, similar chemical characteristics. Projection of identified units from continuous core locations to a large number of grid hole drilling sites was accomplished with cross sections compiled from borehole geophysical logs at the grid hole locations. Approximately forty distinct units were eventually identified, described and correlated in the overburden, interburden, lignite and underburden. At the completion of the overburden characterization projects, Texas Utilities Mining Company had a comprehensive and extensive computerized data base describing the physical and chemical characteristics of the overburden throughout the individual mine areas. The approach is cost effective and has resulted in substantial cost savings during both mining and reclamation activities.

INTRODUCTION

Texas Utilities Mining Company has undertaken a comprehensive program of overburden characterization at each of the company's active lignite mines. The surface mines are located within the Wilcox Group in the central and eastern portions of Texas (fig.1) and include the Big Brown Mine in Freestone County, the Monticello Mines in Titus and Hopkins counties, and the Martin Lake Mines in Panola and Rusk counties. In 1985 the combined production of lignite from these three locations was approximately thirty million tons. Mining activities during that year resulted in a need to reclaim approximately 2,000 acres.

The overburden characterization studies were designed to achieve the following objectives:

1. To identify the distribution and extent of potentially acid or toxic-forming strata in the overburden;
2. To describe the location of overburden strata that may be suitable for topsoil substitution;
3. To develop a geologic information base and data handling system that would enable the comparison of existing topsoils with the underlying overburden materials;
4. To develop overburden handling plans that would protect the hydrologic regime and facilitate successful reclamation; and
5. To provide data useful in the development of ground-water control plans.

A small-scale study of overburden characterization was initiated in 1982 at the Martin Lake Mine. Results of the pilot study were sufficiently encouraging to result in the establishment of comprehensive overburden characterization programs at all three active mine locations, beginning in 1984. Emphasis was placed on areas to be mined during the next five-year permit term, although at each site, the life-of-mine area was also investigated. For these projects, Texas Utilities Mining Company has drilled and run borehole geophysical logs at approximately 3,000 locations,

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collected more than 100 continuous overburden cores, and analyzed more than 3,500 overburden samples for the physical and chemical parameters identified by the Railroad Commission of Texas, the regulatory agency responsible for lignite surface mining in the state.

A brief discussion of the depositional history and processes which are responsible for the distribution of overburden sediments throughout the Wilcox Group helps explain why the physical and chemical characteristics of the overburden materials not only vary within the boundaries of a particular mine site, but also why they may change significantly throughout the Wilcox outcrop belt. The regional geology section is followed by a discussion of the overburden characterization process used by Texas Utilities Mining Company. After the procedures are presented, some of the specific applications of overburden characterization to reclamation planning and preparation of the ground-water control plans are discussed.

REGIONAL GEOLOGIC SETTING

In 1985, 88 percent (approximately 40 million tons) of the lignite mined in Texas was from the Eocene Wilcox Group (RRC, 1986). In central Texas, the Wilcox Group is composed of three separate formations (fig. 2). From oldest to youngest, they are the Hooper, the Simsboro and the Calvert Bluff. Most of the lignite in this area is found within the Calvert Bluff and Hooper formations. East of the Trinity River in northeast Texas and the Sabine Uplift area, the Simsboro becomes indistinguishable from thick fluvial sands of the Calvert Bluff and the Wilcox Group is subdivided into two informal generic units--the Lower Wilcox and the Upper Wilcox (Kaiser, 1986).

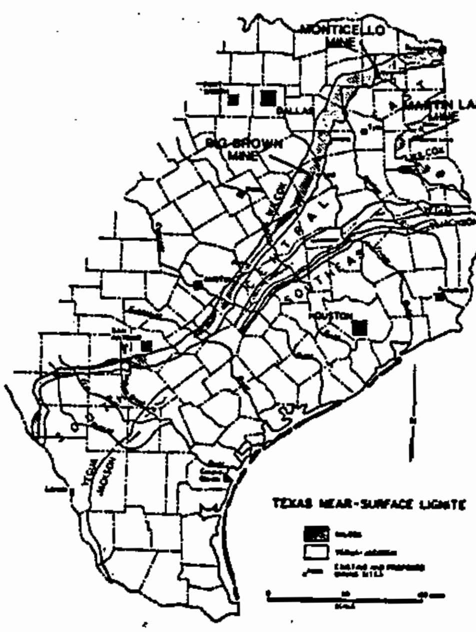

Figure 1.--Distribution of Texas near-surface lignite. (After Kaiser, 1978)

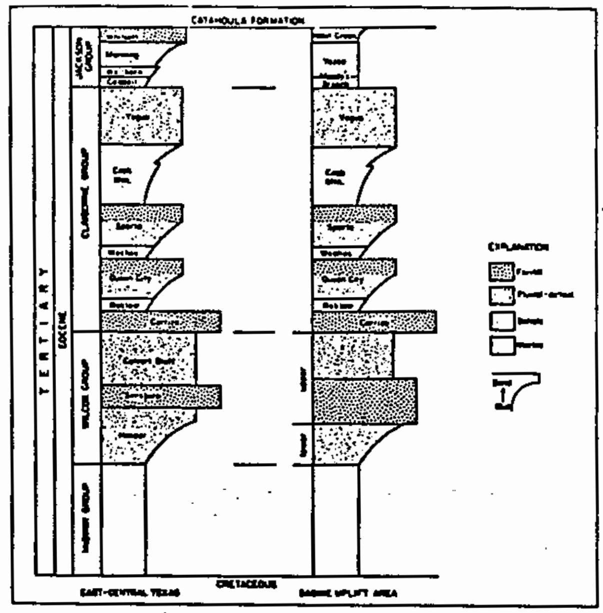

Figure 2.--Eocene stratigraphy in east-central Texas and the Sabine Uplift area (Kaiser, 1986).

The clastic sediments which comprise the formations of the Wilcox Group suggest a pattern of cyclic deposition in response to changing sea level elevation and migration of large sediment dispersal systems across the state. Formations with high sand content such as the Simsboro and Carrizo were generally emplaced by river dominated depositional systems. Low sand/high clay formations like the Midway and Reklaw represent ancient marine conditions. Depositional environments intermediate between marine and fluvial are deltaic or fluvial-deltaic which are represented by the lignite-bearing Calvert Bluff and Hooper formations.

Process-related sedimentary packages, or facies, which comprise the fluvial-deltaic environments include point bars, channel lag deposits, levees, overburden muds, crevasse splays, interdistributary bays, swamp and lacustrine deposits and distributary channels (fig. 3). These facies can be observed in highwalls, cores and geophysical logs and are distinguished on the basis of texture, geometry and vertical and lateral relationships with other units. Lignites are commonly found adjacent to the main channel complexes where low energy conditions prevailed. A modern analogue of the Wilcox lignite is found in the flood basins and delta plain environments of the lower Mississippi River.

There appear to be multiple source areas for Wilcox sediments. In central Texas, the major source of sediment influx to the Wilcox was a tributary system that fronted the ancient Rocky Mountains. Sediments in the upper and lower portions of the Wilcox east of the Trinity River are believed to have been deposited by ancient rivers that originated in the Ouachita Mountains to the north. A minor amount of sediment may have been derived from the Appalachian Mountains via the paleo-Mississippi River system (Ayers and Kaiser, 1986).

Major differences in the environment of deposition of the Wilcox across the state, together with the strong possibility of multiple source areas, help explain the variations observed in overburden properties along the Wilcox outcrop belt. The wide textural variation within individual mine areas reflects the different process-related sedimentary packages associated with formation of the lignite itself.

OVERBURDEN CHARACTERIZATION PROCEDURES

The overburden characterization program at Texas Utilities Mining Company involves the identification, description and mapping of overburden sediments that have similar physical properties and, in many cases, similar chemical properties. The various tasks of overburden characterization require the skills of geologists, geophysicists, ground-water hydrologists, soil scientists, hydrogeochemists and mine planners. Necessary information includes geophysical logs of exploration borings preferably located on a grid, continuous overburden cores, detailed laboratory analyses of core samples, surveyed elevations and coordinates of the grid holes, and a mine plan.

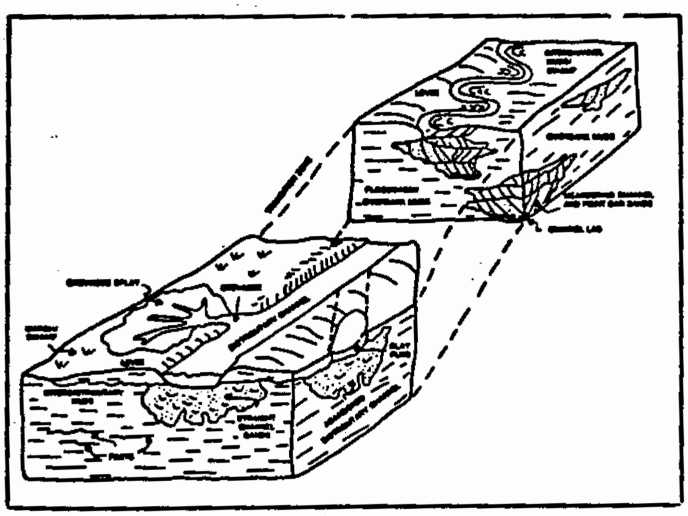

Figure 3.—Schematic diagram of stream deposition on lower alluvial plain.

The following information has been collected primarily from the Big Brown Mine near Fairfield in east-central Texas. At Big Brown the mineable lignites are within the Eocene Calvert Bluff Formation of the Wilcox Group. Most, if not all, of the methods to be described are applicable to any mine location where clastic sediments comprise the overburden.

Data Collection

During the period of August to October, 1984, Texas Utilities Mining Company drilled and geophysically logged test holes on 500-foot centers in areas to be mined in the next five years and on 1,000-foot centers throughout most of the remaining life-of-mine area. Approximately 840 grid holes were drilled and logged to about 20 to 25 feet below the deepest lignite to be mined. Total depths ranged from about 75 to 150 feet.

Geophysical logs were used to improve upon the subsurface descriptions recorded in the drillers logs. The downhole geophysical logs reflect and record changes in the electrical characteristics of the different sedimentary units as the tool is slowly brought up from the bottom of the test hole to ground surface. In this field program, the logs consisted of gamma ray, gamma-gamma density, and single-point resistance. The gamma ray tool measures natural radiation of gamma rays from certain elements that occur in varying amounts in subsurface formations. The log is a diagram showing the relative emission of gamma rays, measured in counts per second, plotted against depth below surface. In most of the Wilcox, the gamma-ray log accurately indicates the subsurface positions of clays and sands. Clays are indicated where the gamma-ray activity is high, sand where it is low. The gamma-gamma density log is made with an active source tool and is most useful for delineation of cemented sands, siltstones and lignites. The single-point resistance tool measures the electrical resistance of the path from the tool to an electrode at the surface. Usually, fresh water sands show high resistance and clays show low resistance.

Continuous cores were collected at nineteen sites within the seven thousand acre permit area for the purpose of characterizing the physical and chemical properties of strata down to and including the strata below the deepest lignite seam to be mined. The core locations were chosen after review of available geophysical and driller's logs and preparation of preliminary cross sections. Initially, a pilot hole was drilled to a depth of at least 20 feet below the expected depth of the core and geophysically logged to provide a guide for core description. After completion and plugging of the pilot hole, the drilling rig was moved approximately 15 feet to obtain the core. Core drilling was done with a Failing

1500 hydraulic rotary rig. Cores were collected with Shelby tubes to depths of about 10 feet. The remainder of the core was obtained with a five-inch diameter, ten-foot long Christiansen core barrel, with a three-inch diameter split inner barrel. Finally, the core hole was deepened approximately twenty feet and geophysical logs were run in the core hole before it was plugged.

In the field, core descriptions included dominant and subordinant lithologies, color (Munsell Soil Color Chart), grain size, roundness, sorting, matrix quantity and composition, major and accessory minerals, cementation, sedimentary structures, and bedding. The selection of individual samples for analysis by the laboratory was one of the most critical tasks of the overburden characterization process. It was extremely important that we be able to relate the physical and chemical analyses of the sampled interval to both the geologic description and to specific, identifiable stratigraphic packages on the geophysical log. Thus, both the field geologic description and the geophysical logs were studied before samples were selected for lab analysis.

Lengths of the individual core samples usually varied from about two to five feet. The cores were scraped clean of drilling mud to minimize sample contamination and to enable a good geologic description of the core. The cores were split lengthwise in the field and representative samples of the selected intervals were sealed in polyethylene bags and sent to the laboratory. Laboratory analyses were completed in accordance with procedures recommended by the Railroad Commission of Texas. For the Big Brown program, 587 overburden samples were analyzed for required physical and chemical parameters, an average of approximately 31 samples per core.

Data Analysis

The objective of the data analysis was to develop a classification system for characterization of the overburden materiala throughout the mine area. Fundamental to the classification system is the concept of a <u>stratigraphic unit.</u> For this investigation, a stratigraphic unit refers to a body of strata within the overburden, underburden, or lignite that has the following general characteristics: a characteristic textural composition or range of textural composition; a reasonably consistent and predictable stratigraphic relationship with the mineable seams in the project area; a recognizable gamma, density and/or resistance geophysical log; and a mappable thickness and geophysical extent.

Examples of stratigraphic units in terms of components of lignite depositional environments include point bars, channel lag, levees, crevasse splays, and floodplain/ overbank deposits. Examples of these units in terms of lignite mining include overclays, underclays, partings, water sands, and rider seams. In our overburden characterization work we have given a short, unique name to each of these units to facilitate computer processing.

The first step toward delineation of the stratigraphic units was to combine on a summary diagram the geophysical, geologic, textural and geochemical data for each core (fig. 4). These diagrams were useful in formulating an initial classification system. On these diagrams, it was possible to combine adjacent sample intervals which had similar physical and chemical parameters in that core and relate them to identifiable and characteristic geophysical log patterns at that location. The next step in the classification process was to assess the lateral continuity, extent and the vertical stratigraphic relationship of the preliminary units. This was done by preparing geologic cross sections connecting the continuous cores with one another. Grid hole geophysical logs between the cores were also incorporated into these multi-core sections. Using the characteristic geophysical log signature as a guide, the identified units and lignite seams were correlated from core hole to core hole.

Results of the initial correlations proved acceptable with regard to continuity of the preliminary units. Approximately 40 distinct units were eventually identified, described and correlated in the overburden, interburden, lignite and underburden. The next step involved a mora quantitative description of each preliminary overburden and interburden unit. Weighted average values were calculated for percent sand, percent silt, percent clay, pH and acid-base balance over the depth interval in each core where the particular units were identified. Graphs showing the range of weighted average values for selected parameters for the major overburden and interburden units in all cores where the unit was present were prepared. The graph of percent clay of selected units is shown in figure 5. Ranges of acid-base balance for selected units are shown in figure 6. Acid-base balance is equal to the neutralization potential minus the sum of potential acidity and exchangeable acidity.

The relatively close grouping of parameter values for most individual stratigraphic units in the graphs supported our hypothesis that the overburden characterization procedures developed in these studies would be useful in the identification and projection of unsuitable topsoil substitutes, particularly high sand, high clay and potentially acid-forming strata. When there were only a few samples of each unit available, conclusions were less clear. Also, wide ranges of values for some preliminary units required reclassification based on geographic location in the mine area or vertical position in the overburden. In addition, there appear to be other post-depositional factors that influence the chemical characteristics in some stratigraphic units and result in anomalous data. These include weathering processes, overburden thickness, overlying geologic formations, ground-water flow paths, and structural influences. We found it necessary to consider these factors during development of the stratigraphic unit classification system.

The final step in analyzing the data was to identify the stratigraphic units on each of the geophysical logs obtained during the grid drilling program. Many of the logs had been picked during preparation of the multi-core cross sections; however, it was still necessary to construct approximately 80 more working sections along grid lines to complete the task. On each of the 840 geophysical logs, the interval between the surface and the underburden was subdivided into the identified stratigraphic units. The top and bottom elevations of each unit on each log were incorporated into a data base file which also contained information such as hole number, location coordinates, ground surface elevation, and elevation of the water table.

APPLICATIONS TO RECLAMATION PLANNING

At the completion of the overburden characterization project at Big Brown, Texas Utilities Mining Company had a comprehensive and extensive data base describing the physical and chemical characteristics of the overburden throughout the mine area. In addition to the data base file in the computer, a grid hole catalog was prepared giving the pertinent locations, elevations and stratigraphic unit information for every grid hole location. An example page is shown in figure 7.

The data base has been applied to reclamation planning in several ways.

* The physical and chemical parameters of each stratigraphic unit were compared to current Railroad Commission of Texas suitability criteria for topsoil substitution and materials suitable for placement in the top four feet of leveled minespoil. This comparison enabled Texas Utilities Mining Company to continue mining in most areas without the need to strip, store and replace topsoil.

* The overburden characterization data were used for comparison with native soil conditions.

* The developed overburden data were used for identification of stratigraphic units which may be unsuitable for placement near the spoil surface. In areas where some selective handling might be required, the delineation and mapping of stratigraphic units enabled the reclamation and mine planners to rapidly assess the location, magnitude and extent of material requiring special treatment and was useful in planning appropriate overburden handling procedures.

* In areas where special handling is required, it is possible to prepare pit-centerline cross sections from the data base for use by the dragline operaters to identify the position of problem materials and carry out the agreed-upon handling practices.

* The overburden characterization study is useful for prediction of amendment requirements and thus provides information for planning of reclamation costs.

* The overburden data were useful in assessing the effect of mining on post-mine ground-water quality.

* This type of overburden characterization program provides the capability to evaluate the effects of alternate mining plans or equipment utilization scenarios in a relatively rapid manner. For example, it may be useful to know if the lower one-third of the overburden is consistently suitable for topsoil substitution. The data base can be queried to plot the occurrence of any unsuitable materials in

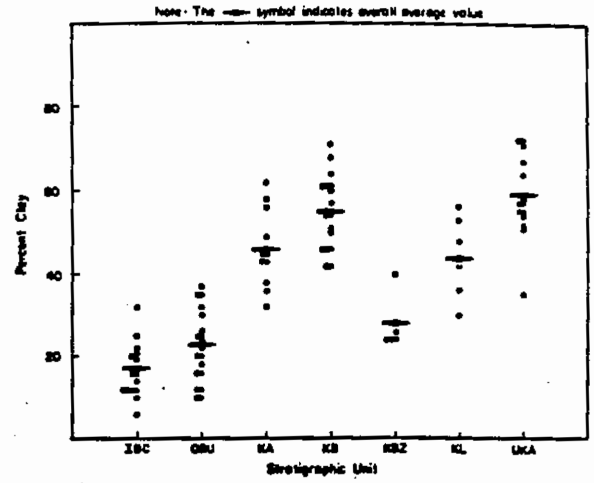

Figure 5.—Range of percent clay values.

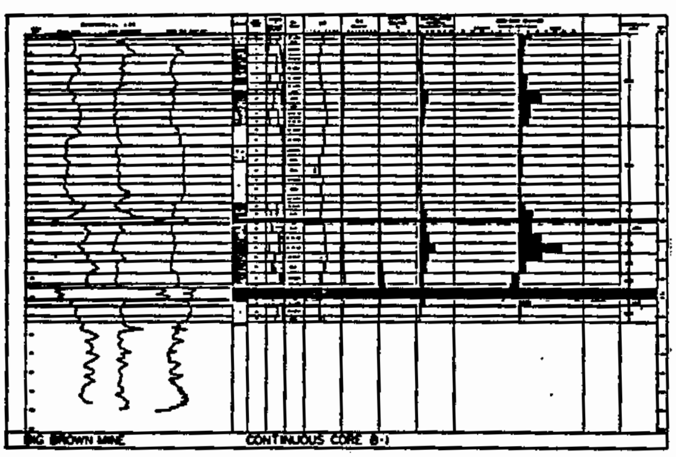

Figure 4.--Summary diagram.

this interval all across the mine area. This type of instant data analysis and presentation is useful for long-term planning.

APPLICATIONS TO GROUND-WATER CONTROL PROGRAMS

Information developed in the overburden characterization study can be extremely useful in assessing potential mine water problems, particularly the extent and magnitude of areas that require dewatering of the overburden. In the unconsolidated silts and sands of the Wilcox, shallow water tables can frequently create problems of water inflow as well as concerns about the stability of highwall and spoil piles. These areas can be identified well in advance of mining by combining information on water table elevations with top and bottom elevations of the sandier stratigraphic units. Plots of net saturated overburden sands or total saturated overburden thickness enable the mine planners to quickly assess potential mine water problems.

The overburden characterization data are also useful in formulating strategies for controlling ground-water. The geologic information in the data base is well suited for direct incorporation into computer flow models. Permeability data from aquifer tests conducted in particular stratigraphic units can easily be extrapolated throughout the area of interest. Boundary conditions resulting from thickening or thinning of permeable units can also be retrieved efficiently from the overburden characterization data base.

SUMMARY

Texas Utility Mining Company has conducted overburden characterization studies at three active lignite mines. The preliminary results suggest that each of the five initial objectives of the program was or is achievable. The lateral extent and vertical distribution of identified stratigraphic units can be mapped

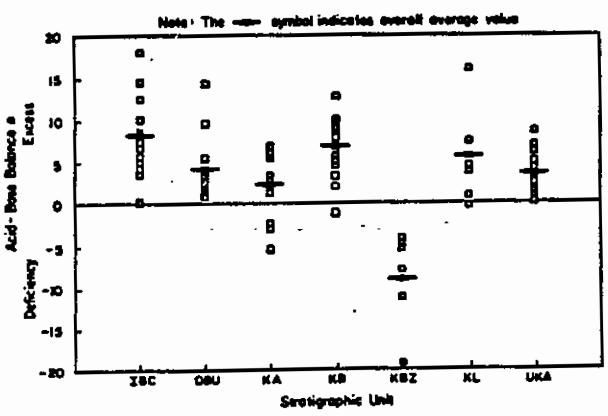

Figure 6.--Range of acid-base balance values.

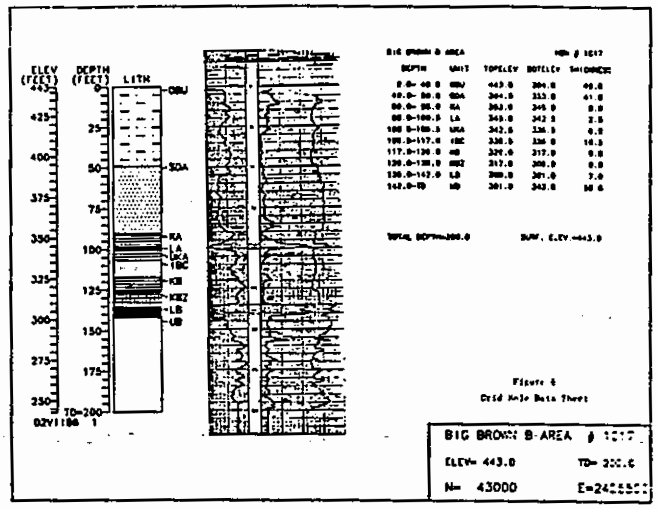

Figure 7.--Grid hole data sheet.

using geophysical logs as the basis for correlation. The approach is appropriate for identifying the distribution and extent of potentially acid/toxic forming strata. We have learned that the type of information required to characterize the overburden in this manner is equally useful and necessary for mine planning, that the characterization process can be completed before mining begins, and it appears that this method will help mining companies obtain successful reclamation while minimizing the amount of top soil stripping, stockpiling and replacement.

We have learned that the reliability of the overburden characterization methodologies and the reproducibility of the results are improved if (1) there is an adequate number of geophysical logs appropriately spaced in the project area, (2) the logs are carefully run and of consistent quality, and (3) there is sufficient laboratory physical and chemical data from core samples to characterize units that have identifiable geophysical log signatures. The quantity of geophysical log data and overburden core samples necessary for reliable characterization varies among different mine sites and depends to a large extent on the complexity of the local geologic framework.

The ability to locate and use suitable topsoil substitutes is important for mines in all parts of the country. However, it is especially important for Gulf Coast lignite mines where annual reclamation activities extend to thousands of acres. We believe that the pre-mine overburden characterization techniques described in this paper have effectively resolved significant water control problems as well as difficulties in reclamation and environmental protection. We know the approach is cost effective and has resulted in substantial cost savings during reclamation. In addition, the procedures are efficient and safe.

LITERATURE CITED

Ayers, W.B., Jr. and W.R. Kaiser. 1986. Regional depositional setting, resources, and quality of lignite in the Wilcox Group of East Texas and the Jackson Group of East and South Texas, p. 69-114. IN Geology of Gulf Coast Lignites, Coal Geology Division field trip, the 1986 annual meeting of the Geological Society of America. Environmental and Coal Associates, Houston, TX.

Kaiser, W.R., 1978. Electric power generation from Texas lignite. The University of Texas at Austin, Bureau of Economic Geology Geol-Circ 78-3.

Kaiser, W.R., et al. 1986. Geology and ground-water hydrology of deep-basin lignite in the Wilcox Group of East Texas, p. 3-10. The University of Texas at Austin, Bureau of Economic Geology Special Publication.

Railroad Commission of Texas. 1986. Coal surface mining operations, report on activities January through December, 1985: Austin, Texas, Railroad Commission of Texas, Surface Mining and Reclamation Division.