SECTION 1

INTRODUCTION, UNITS, CONVERSIONS, AND PREPLANNING

1.1 INTRODUCTION

Studies of coal overburdens and minesoils in relation to environmental quality have progressed to the point that needed appraisals can be made with confidence if adapted and calibrated procedures are followed in the field and the laboratory. This manual contains such procedures. They are described in a step-by-step manner that should assure consistency of results. These procedures include everything from identification of common rocks and minerals in the field through interpretation of analytical results.

When a manual is to be used by many different disciplines, many terms must be defined for a particular purpose or misunderstandings result. Insofar as the application of this manual is concerned, essential rock, soil, chemical, physical, and engineering terms have been defined. Outside of the manual, other meanings may be attached to these terms.

This manual consists of four major sections: Section 1 introduces the manual and contains the advance planning approach; Section 2 contains all procedures and clues to be used in the field; Section 3 is strictly laboratory methods; and Section 4 is a combination of both field and laboratory weathering methods.

Each section is subdivided into specific groupings of closely related material. In turn, these subsections are subdivided into individual procedures. They are numbered so that cross referencing within and between sections, subsections, and procedures can be done easily and specifically.

If one part of a procedure is referenced (i.e. see 3.2.2.2), the first number indicates the section and the second number indicates a specific grouping. The third number indicates a particular method while the fourth number refers to a certain part of that method.

An example of the numbering system is as follows:

Section 3.2.2.2

Sample Processing and Laboratory Analysis (3)
Chemical Methods (2)
pH (2)
Comments (2)

1.2 UNITS AND CONVERSIONS

To Convert	To	Multiply By
acre	hectare	0.4047
centimeters	inches	0.3937
feet	meters	0.3048
gallons (U.S. liq.)	liters	3.785306
grams	pounds	0.002205
grams	kilograms	0.001
hectare	acre	2.471
inches	centimeters	2.540
kilograms	grams	1000.0
kilometers	miles	0.6214
lb/acre	ppm	0.5
liters	gallons (U.S. liq.)	0.2641794
liters	milliliters	1000.0
miles	kilometers	1.609
milliliters	liters	0.001
millimeters	meters	0.001
meters	feet	3.281
meters	millimeters	1000.0
ounces	liters	0.02957
pounds	grams	453.6
ppm	lb/acre	2.0
section (1 sq. mile)	acres	640
°F	°C	5/9 (°F-32)
°C	°F	(9/5 °C) + 32

1.3 PREPLANNING TOTAL MINING OPERATION

1.3.1 Acid-Base Account

In the humid areas of the United States, the toxicity associated with acid results largely from the oxidation of iron disulfides. This process takes place when earth disturbance activities such as mining (Temple and Koehler, 1954; Hill, 1970) and highway construction (Miller et al., 1976) expose iron disulfides to the atmosphere. Since the public in the United States has supported legislation that acid-toxic or potentially toxic materials (a source of pollution) will not be left exposed, the need for a basis to evaluate overburden materials arose.

Acid-base accounting is a dependable criterion by which overburden materials can be evaluated. An acid-base account consists of two measurements: (1) total or pyritic sulfur and (2) neutralization potential. The accounting balances maximum potential acidity (from immediately titratable sources plus sulfuric acid equivalent calculated from total sulfur) against total neutralizers (from alkaline carbonates, exchangeable bases, weatherable silicates or other rock sources capable of neutralizing strong acids as measured by the neutralization potentials).

The total or pyritic sulfur content (see 3.2.4) accurately quantifies potential acidity of materials when all sulfur is present as a pyritic mineral. When gypsum is found in an overburden sample or the materials are weathered, sulfur occurs in the form of sulfates. Samples high in organic carbon usually contain organic sulfur. When part of the sulfur occurs in nonacid-producing forms, the maximum potential acidity as calculated will be too high. It is for this reason that such calculations are referred to as maximums and that in doubtful cases appropriate acid and water leachings should be made to rule out those forms of sulfur which do not produce acid (see 3.2.6). Then from the stoichiometric equation of pyrite oxidation, the maximum potential acidity can be calculated in terms of calcium carbonate equivalent. Overburden material containing 0.1% sulfur (all as pyrite) yields an amount of sulfuric acid that requires 3.125 tons of calcium carbonate to neutralize one thousand tons of the material. The neutralization potential (see 3.2.3) of overburden materials, the second component of a net acid-base account, measures the amount of neutralizers present in the overburden materials. This measurement is found by treating a sample with a known amount of standardized hydrochloric acid, heating to assure complete reaction, and titrating with a standardized base. The result is then expressed in calcium carbonate equivalents. When balanced against acidity from the total sulfur measurement, a net acid-base account can be made.

From the acid-base account, potentially toxic material is defined as any rock or earth material having a net potential deficiency of 5.0 tons of calcium carbonate equivalent or more per 1000 tons of material. The 1000 tons is based on the assumption that an acre plow-layer contains 2 million pounds of soil. Regardless of the acid-base account, materials which have a pH of less than 4.0 in a pulverized rock slurry in distilled water are defined as being acid-toxic.

The choice of the deficiency of 5 tons of calcium carbonate equivalent per 1000 tons of material as the division between toxic and non-toxic material obviously is arbitrary. However, when applied to the large number of samples studied during the past several years of minesoil research at West Virginia University, it corresponds to other supporting laboratory information about these samples as well as to extensive field experiences with minesoils developing in the different rock types. If rock or soil samples were defined to be toxic at much lower calcium carbonate equivalent deficiencies than 5 tons per 1000 tons, we would be declaring many of our native soils to be toxic. On the other hand, with deficiencies much greater than 5 tons per 1000 tons, toxic concentrations of plant-available aluminum and pH values below 4.0 often develop rapidly.

Rock type is incorporated with the acid-base account because it is useful to categorize the materials which comprise coal overburdens. Knowledge of the rock types can provide an estimate of the texture and base status of a future minesoil, as well as stability of rock fragments. For example, sandstones containing moderate amounts of pyrite and lacking sufficient neutralizers become active acid producers when exposed to the atmosphere.

The properties previously discussed are represented graphically in Figure 1. There are two zones of acid-toxic materials (the 16.2 to 17.1 m and the 20.7 to 21.6 m depths) indicated by pH values of less than 4.0. Both zones contain enough sulfur to continue to overwhelm the small amount of neutralizers present. Thus, these materials have the potential for remaining acid-toxic unless large amounts of neutralizers (50 and 80 tons calcium carbonate equivalent per 1000 tons of material, respectively) are added. In addition, there is a zone of potentially toxic material at a depth of 13.4 to 16.2 m and two zones below the 23 m depth (underlying the first coal and overlying the bottom coal), which are defined by a calcium carbonate deficiency of more than 5 tons per 1000 tons of material even though the pH is above 4.0.

Non-toxic zones, which exhibit varying amounts of excess neutralizers, exist from the surface to a depth of 13.4 m, from the 17.1 to 21 m depth, and from the 24.4 to 25.4 m depth. These materials can be removed and replaced in sequential order, selectively blended before replacement, or totally blended before replacement. Other methods of handling the overburden materials would include utilization of the limestone, after crushing, as a source of neutralizers to be blended with the potentially toxic materials.

The acid-base accounting method provides a useful tool for evaluating overburdens in the humid areas of the United States, since it is useless to look for plant toxicities from elements such as aluminum, boron, etc., until the acid problem is eliminated.

1.3.2 Geologic and Pedologic Considerations

The decision of management to open and operate a strip mine is based on numerous considerations involving mining engineers, geologists, agronomists and other reclamation specialists. Initial considerations of prospective stripping areas include accessibility, proximity to markets, uniformity,

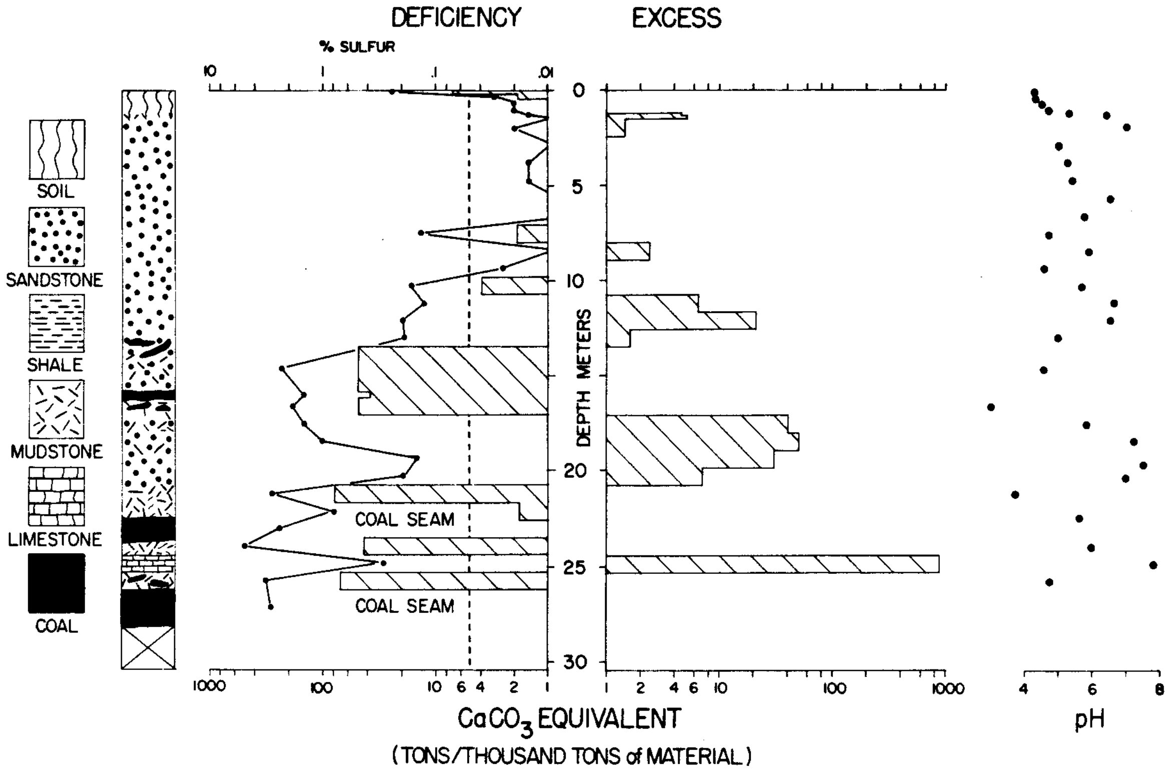

Figure 1. Acid-base account of the Kentucky no. 11 and no. 12 coal overburden.

thickness, quality and quantity of coal seams, and physical and chemical characteristics of the overburden materials for use in reclamation. In recent years the prospect of successful reclamation of mined lands resulting from selective placement of non-toxic, nutrient-rich overburden materials has become increasingly important in the decision to locate and develop new strip mines.

Coal-bearing overburden bedrock in the Appalachian and Midwestern coal basins commonly consists of a complex series of mudrocks and sandstones interbedded with generally thinner, more regular beds of limestone, carbolith, coal, and coal undersoil. The predominate mud and sand rock stratigraphic units often change rapidly in short distances (laterally and/or vertically) as compared with the chemical (limestone) and organic (coal) deposits. Usually, the rock units are mixtures in varying proportions of the common sedimentary rock types. In addition, trace amounts of heavy minerals occur in all sedimentary rocks. Of these minerals, chemical studies of overburden materials are most concerned with concentrations of the potentially acid-forming heavy metallic minerals, mostly iron disulfide, called pyritic minerals.

The immediate and maximum acid-making potential of the rock types in the overburden, is assayed by determining: (1) pH of the pulverized rock paste;

(2) total or pyritic sulfur; and (3) neutralization potential. The first determination gives the present condition of the rock types and the second and third determinations forecast the potential net acid-base account of the overburden materials (see 1.3.1).

Recognition of gross lateral rock changes indicates major physical and mineralogic differences and suggests the presence of more subtle changes that may be measured in an acid-base account of the overburden. In practice, the physical character, mineral composition, and net acid-base account provide information needed for desired mixing or placement of overburden materials. Highly toxic overburden necessitates disposal by proper blending, sandwiching, or burial with neutralizers. Non-toxic materials require proper treatment guided by experience and adapted chemical tests.

Advance determination of the physical and chemical character of the overburden materials may mean the difference between economic success or failure of a mining operation. Planned removal and direct placement of materials with known properties can prevent mistakes that require re-handling or costly reclamation practices.

A three-step approach is suggested for the study of overburden materials during the investigation of the feasibility of development of a strip mine. The three steps may be stated as follows:

1. Geological and soil reconnaissance.

2. Regional study of physical and chemical properties of soil profiles and rock units of overburden materials as well as underlying coals.

3. Detailed analyses of appropriate samples to determine important physical and chemical characteristics of soil horizons and rock units of the overburden at promising sites.

Geological and soil reconnaissance in the area of interest consists of a review of information from private, state and federal sources. Available information is generally confined to modern standard soil surveys, 7.5 minute topographic maps, county geologic reports, physical and mineralogical descriptions of rock units, chemical analyses of coals, and location of underground mines, surface mines and coal prospects. Collection and analysis of selected dominant soil profiles and rock units of prospective overburden materials in the area of interest may offer early clues to future land use and reclamation opportunities.

Delineation of the physical and chemical relationships of overburden materials and associated coals is depicted by construction of generalized cross sections similar to those in northern West Virginia and western Maryland as illustrated in EPA reports 670/2-74-070 (Smith et al., 1974) and 600/2-76-184 (Smith et al., 1976). Sampling of correlative rock units can usually be obtained at exposures, abandoned and active surface mines, or from drill cuttings and cores along or adjacent to the line of cross section in areas of contour stripping. Cores and highwalls of active strip mines are usually the only source of samples in environs of area stripping, which are often covered with unconsolidated deposits (e.g. loess, glacial till, and outwash).

Collection of more closely spaced detailed geological and chemical data continues during exploration of the proposed stripping site and also during the stripping operation. Sources of geological information and samples are cores, churn drill cuttings, blast hole cuttings, and exposures of excavations and highwalls. Sampling sites should be spaced to give a three-dimensional coverage of the area of stripping. The geologist-pedologist describes the soil and lithologic units exposed or penetrated by the drill in some detail. He samples the rock section either in arbitrary 30 cm intervals or other appropriate intervals (see section 2.2) for chemical and physical analysis. Three-dimensional illustrations such as ribbon diagrams (showing soil profiles and lithologic units plus acid-base or other relationships) or isopachous maps (contouring thickness of separate lithologic units and weighted averages of acid-base relationships) can provide interesting artistic views of problem areas to be encountered prior to stripping. A similar exercise is the construction of a series of intersecting cross sections illustrating the overburden information derived from all available sources. Such cross sections show a combined geologic and chemical accounting of the overburden materials throughout the area to be stripped. Intersecting cross sections provide the operator with a pictorial view of the physical and chemical characteristic of the overburden rock in advance of strip mining and guides the operator in the handling and segregating of materials to ensure favorable minesoils and economical reclamation for intended land use.

Following mining, the young minesoils are appropriate for classification into classes based on properties. The mapping of soil classes and phases is simplified by good advance information about overburdens and their placement during mining. Short-term treatment and long-range management follow established patterns once minesoil mapping units have been established and delineated.