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TO: Local Health Departments

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SUBJECT: The Evaluation of Mine Soil Sites and Their Use For On-Site Sewage Disposal Systems

INTRODUCTION

One of the purposes of surveying soils is to identify, on maps, soils that have similar use and management. Since the early 1950's these precepts guided soil surveys on undisturbed lands, but in recent years environmental and planning concerns have greatly expanded the research needed in soil survey and the uses of soil survey. One of the expanded uses of soil surveys in the past 15 years has been their application to surface mining and reclamation problems.

Prior to 1951 the soil survey used established vegetation on spoil as the major means of classifying the mine spoil materials. The term "soil" was not used to define this material. The mine spoil material was generally identified as "mine dumps or strip mine areas." The research at that time revealed that the nature of surface mine spoils was a result of the character of the overburden and the method of mining used.

During the 1970's the term "Orthents" was used. In some instances graded mine spoil was classified differently than ungraded spoil. Areas that have been surface mined for their natural coal resources have been referred to by many names, including spoil, mine spoil, coal mine spoil, surface mine spoils, graded mine spoil, ungraded mine spoil, mine dumps, strip mine areas, strip mines, overburden, Orthents, reconstructed soils, and mine soil.

<u>The term mine soil will be used in this document to include all of the above names. This document pertains only to the use of land which has been surface mined for coal. It does not pertain to sites which were disturbed or filled for any other reasons.</u>

The primary problem with the existing soil classification system for these mine soils is its failure to recognize compaction as the single most important factor limiting use and management.

Even with the establishment of mine soil series, pedologists have still been slow to define and map different soil series within surface mined areas. Pedologists believe that mine soils are inherently too variable and that mappable patterns of order are not apparent.

Mine soils are typically so young that the active factors of soil formation have had little or no effect. The lack of an appropriate conceptual model can cause the apparent complexity to be overwhelming, thus preventing the perception of order which is necessary to classify and map soils.

At the present time mine soil is being actively studied. The *Proceedings of the 1992 National Symposium on Prime Farmland Reclamation* is an example of this continuing research. Indorante and Jansen recognized that there is a need to develop and use new techniques and terminology to describe and characterize mine soils and drastically disturbed lands. The current soil classification scheme for mine soils is inadequate. Surface mining, reclamation methods, and compaction alleviation treatments vary among companies, locations, and even over time. It has been extremely difficult to develop sufficient soil series to reflect all of these differences.

In 1984, Indorante and Jansen proposed a conceptual soil landscape model useful for perceiving order on surface mined land. With this perception of order, mine soils can be mapped and classified. The concept postulated a relationship between soil character and:

1. mining methods
2. reclamation or soil construction procedures
3. premined soils
4. premined geologic columns

Inherited properties of mine soils include soil texture, coarse fragment content, pH, and topsoil color and thickness. Properties resulting from reclamation include density or compaction, slope, drainage, "top soil" thickness, and coarse fragment content.

Much of the land surface mined in Indiana prior to 1967 was not reclaimed. The utility of the land was sometimes completely destroyed by surface mining with improper or no reclamation. There are many ways to reclaim surface mined land. The most common methods include scraper, shovel-truck, drag-line, and bucket-wheel excavation systems. The extent of soil distribution depends upon the reclamation methods.

The Surface Mining Control and Reclamation Act (SMCRA, Public Law 95-87) was passed in 1977 to protect the public from potential adverse effects of surface mining for coal. The Congressional Office of Technology Assessment, in the 1985 staff memorandum *"Reclaiming Prime Farmlands and Other High-Quality Croplands after Surface Coal Mining"* observed a critical need for additional reclamation research. It had become quite apparent that saving and replacing each soil horizon from natural soils did not guarantee good reclamation. Substantial progress in technology development had been made, but many questions critical to success remained unanswered.

REASONS FOR ISDH TO EXAMINE MINE SOILS

Local health departments in southern Indiana will be requested to issue between 300 and 400 residential sewage disposal system permits each year on mine soils. Since areas with mine soils are receiving ever greater pressure for development, the Indiana State Department of Health investigated the evaluation and use of mine soil for residential on-site sewage disposal systems.

ISDH Rule 410 IAC 6-8.1, *Residential Sewage Disposal Systems*, contains scientific criteria for evaluating soil characteristics of natural soils, but not of disturbed or altered soils. Tables IV and V of that rule were developed by Purdue University as a result of the five year Purdue On-Site Wastewater study. The values in these tables (loading rates) indicate the amount of water or effluent that a soil can accept in gallons per day per square foot. These tables are based on soils with natural, undisturbed textures and structures. An accurate assessment of the ability of the septic tank effluent to be transmitted and treated by the soils at the site is critical to proper system selection, size and design. These criteria cannot be applied to disturbed soils due to the heterogeneous characteristics of the materials.

The staff of this agency decided that a comprehensive ban on development in these areas due to insufficient information was not an acceptable resolution to the situation. In an effort to develop a policy to address these mine soils, ISDH staff interviewed the Indiana Geological Survey, Consulting Soil Scientists, local health department sanitarians, home builders, homeowners, and other professionals involved with residential on-site sewage disposal systems.

Information obtained from the Proceedings of the 1992 National Symposium on *PRIME FARMLAND RECLAMATION*, "The Surface Mining Control and Reclamation Act: 15 Years of Progress" held August 10-14, 1992 in St. Louis, Missouri, was used in this evaluation. Information was also obtained from a number of other state governments, provinces in Canada, and soils experts throughout the country. The responses received from most of those sources were very negative concerning the evaluation and use of disturbed soils, including mine soils, for on-site sewage disposal systems. Many regulatory agencies indicated that they have banned the installation of on-site sewage disposal systems in such areas. The remainder have placed very strict requirements on the use of disturbed or filled sites.

ISDH staff also conducted numerous soil profile evaluations of mine soil in an attempt to establish criteria to evaluate the soils and to design septic systems for use in these mine soils. This agency received assistance with these investigations from Soil Scientists with the USDA-Soil Conservation Service, the IDNR Reclamation Office, Purdue University Cooperative Extension Service, and private enterprise. Over a period of 16 days, mine soils in Clay, Warrick and Vigo Counties were examined by digging pits with a backhoe. The performance of existing residential on-site sewage disposal systems installed in mine soils was also evaluated. These systems had been installed over a period of several years. As part of this investigation, several different types of strip mine operations were observed. A comparison of the various types of reclamation that has been used in southern Indiana and Illinois was also made.

PROBLEMS WITH MINE SOILS

The mine soil features that affect engineering use of the soil are the slope, stoniness, moderate frost action potential, moderately slow permeability, high shrink-swell potential, seepage, compaction, and subsidence.

There is a 20 percent swell factor in mining processes. Reclaimed areas increase in total volume (expand). They then settle for many years after being leveled. The settling is uneven and similar to the shrinking and swelling of montmorillonite clays. It never shrinks or swells in the same way twice. Therefore, this material has a poor potential for building foundations.

Soils constructed in surface mined and reclaimed areas differ from the original soils since soil materials are not put back on a tract in the same location and the soil horizons are often mixed. The characteristics of the spoil material, such as texture, color, structure, size and number of roots, percent of coarse fragments, degree of weathered bedrock, and kinds of bedrock are extremely variable.

One of the major problems resulting from surface mining operations is the drastic change of the soil profile. Disrupting the soil environment can cause an adverse effect in the hydrologic balance in adjacent areas. The mine soils reflect an unpredictable variation of soil textures and structures. Each soil texture provides a different ability to allow liquids and gases to pass through a bulk mass of soil or a layer of soil. The result is different rates of movement of water or septic tank effluent. Consequently, variability of soil texture can make liquid movement extremely difficult to predict in soils that have been disturbed.

Structure

Soil structure in non-mined soils is dependent upon many years of soil formation. Soil formation includes the type of parent material, physical and chemical weathering, topography, vegetation, animal activity, climate and time.

The soil structure has been altered in mined soils. This is caused by the breaking of soil and geologic material into individual pieces and by compaction. Mining disturbance disrupts the original structural units and creates a soil unlike the original soil. The result is that the natural channels within the soil are truncated and partially destroyed. The term "fritted" structure has been used to describe the artificial structure unique to constructed soils. "Fritted" structure describes structural bodies formed by mechanical disturbance and are considered to be structural units. The structure is highly variable and cannot be determined using current evaluation technology. Any structure observed in the mine soil will not be continuous along vertical and horizontal planes as it would be in an undisturbed soil. An article in the *Journal of Soil and Water Conservation*, Sept-Oct. 1985, page 440, indicates that the coal mine spoil material is more developed than the typical "BC" horizons in a natural soil. This was observed in the field investigation of coal mine spoil in Warrick and Vigo Counties. This is especially evident in shaly material where it becomes highly weathered when it is exposed to the surface and is subjected to root growth. Although development is slow, significant horizon development can be observed in the root zone of mine soil within the span of a generation.

Thickness of the layers that have been laid down during the filling process vary. Mine soils are so young that the active factors of soil formation have had little or no effect. Therefore, water movement through disturbed soils cannot be predicted to any degree of accuracy.

The uniformity of the heterogeneous spoil material of the mine soils in Warrick and Vigo Counties was highly integrated. The resulting mine soils were so heterogeneous that they were actually homogeneous in distribution. All of the rock fragments are surrounded by soil material and highly weathered shale fragments in Warrick and Vigo Counties. It was concluded that water would readily flow around the clumps of denser materials and that any rapid flow would be immediately stopped by the finer soil material.

Compaction

One of the major problem with reclaimed mined land is soil compaction. Research at the University of Illinois has identified compaction as the limiting factor in reclaimed mine soils in Illinois. Regulatory agencies have recognized the adverse effects of excessive soil bulk density upon crop productivity and have encouraged development of methods for controlling compaction during soil reconstruction.

Compaction of mine soil can destroy soil structure, cause an increase in soil density and a simultaneous reduction in fractional air volume, increase penetration resistance, and greatly reduce macroporosity. The reduction in macroporosity leads to unfavorable hydraulic properties and poor water infiltration. Consequently, plant growth is altered due to poor soil aeration, low nutrient and water availability, slow permeability, and mechanical impedance to root growth. Fehrenbacher et al. found significant differences in corn yields and root densities between different soil replacement techniques.

Compaction near the surface is readily treated by mechanical tillage, but the problem is complicated for mine spoils by the considerable depths to which treatment is needed. We are seriously concerned about compaction in the post 1977 mine soils.

Roots and the type of vegetation that has been growing on the mine spoil will affect the development of soil structure and amount of weathering of the rock fragments. The evaluation of freshly placed mine soil will have to be made. At this time, the techniques are not available to make these evaluations.

The soil scientists contacted believe that they can determine compaction by determining soil resistance if the mine spoil is compacted to the degree that it will restrict water movement through the soil. But to assign a numerical value to the degree of compaction is more than they can do now.

The University of Illinois has developed a method of measuring bulk density and the soils related water holding capacity. This is a new technique involving a continuously recording penetrometer that shows promise in detecting the presence of a root restricting layer. This requires the use of a Gettings probe truck which has a recording penetrometer mounted into the system. This equipment measures resistance as it probes through the spoil material. This experimental procedure is very sensitive to small changes in soil moisture content and is limited by weather conditions. It may be that the equipment and procedures being used by the University of Illinois could be used to delineate areas of mine soils with compaction problems.

<u>Seasonal High Water Table</u>

One of the difficulties with the review of disturbed or filled sites is the inability to accurately determine the depth of the seasonal high water table from the soil characteristics observed.

The determination of the depth to the seasonal high water table is critical to the operation of the on-site sewage disposal systems. If the seasonal high water table encroaches on the absorption field, the result will be the failure of the system.

The wetness characteristics normally associated with undisturbed soils cannot be relied upon to determine the depth to the seasonal high water table of filled or disturbed sites. The criteria to recognize drainage (seasonal high water table) in those soils needs to be developed.

The depth to the free water is the depth of saturated soil conditions at the time of an evaluation, whereas the depth to the seasonal high water table is the minimum depth to soil layers continually saturated for the period of time necessary to produce the changes in soil colors associated with wet soil. Consequently, the observed depth to free water cannot be confidently used as a measure to the depth to the seasonal high water table. The depth to free water is frequently greater than the depth to the seasonal high water table.

Many mine soils are reclaimed in such a way that they are well or moderately well drained. In some cases, mined areas may be reclaimed to produce wetter soils which are somewhat poorly or poorly drained. When low lying areas are surface mined, they frequently produce somewhat poorly or poorly drained mine soil. The addition of drainage tiles may help overcome the seasonal high water table problem.

There is general agreement among soil scientists that the normal techniques of using soil colors would not work in determining the depth to the seasonal high water table or the temporary perching of the water table above compacted or less permeable pockets within the mine soil. It was suggested that the use of monitoring wells over a period of years was the only way to accurately determine the depth and duration of the seasonal high water tables within the mine soil.

LANDFORMS WITHIN MINE SOIL

The information gathered during the strip mine land study indicated that it can be divided into 4 distinct landforms.

TYPE 1 -- Pre-1967 Reclamation
TYPE 2 -- 1967-1977 Reclamation
TYPE 3 -- Post 1977 Prime Farmland Reclamation
TYPE 4 -- Post 1977 Non-Prime Farmland Reclamation

TYPE 1 -- Pre-1967 Reclamation

This type of mine soil was mined prior to 1967. It is typically older areas of mine soil banks that have generally been forested. It is usually very steep, unleveled, topped strip mined land. It is commonly considered to be the old spoil ridges that were the end result of the coal mining process. Little or no land reclamation has been applied to these areas except for the planting of trees (usually pine species) and are now forested.

These areas usually have not had any "top soil" added to the spoil material. The slopes may range from 30 to 90 percent. These areas may consist of the side slope, the topped, flattened ridge top about 10 to 15 feet wide, and the valley, also 10 to 50 feet wide. The peaks are about 40 to 75 feet apart. The difference in elevation between the peaks and valleys is 20 to 50 feet. The material on the side slopes are commonly similar to that on the ridgetops except they may have 15 percent or more exposed stones and boulders that range from 1 to 6 feet in diameter.

This type of mine soil generally contains the highest amounts of extremely acid "hot spots" high in sulfur within the surface layers. It also includes the vertical high walls, adjacent pits of water, and the final cut spoil which generally has a slope of 70 percent. The final cut dominantly contains the larger stones and boulders nearer the surface.

If the original Type 1 mine soil is to be used for residential on-site sewage disposal, it should not be disturbed except for the construction of the system. If the landscape is flattened or graded as a method of site preparation, as was Types 2 through 4 during original reclamation processes, the valleys will be filled with unstable mine spoil materials. Any existing soil structure that had developed since the mining operations terminated will be destroyed and any organic material that had developed in the surface layer will most likely be buried. It will also be impossible to identify which parts of the freshly graded areas were originally the tops of the ridges or the valley floors.

In Type 1 mine soil, care was not taken to bury the "hot spots" and larger rock fragments or boulders deeper in the soil profile, as was done for Types 2 through 4. When surface grading is used as a method of site preparation, Type 1 mine soil may have these undesirable "hot spots" and larger rock fragments or boulders exposed within the upper layers of the newly constructed areas. This type of mine soil has only a very limited potential for residential on-site sewage disposal. The potential for these unwanted materials to occur in the upper horizons is greatly increased when the area is graded as a means of site preparation.

If this type of landform is to be considered for a residential on-site sewage disposal system, the procedures outlined in this report shall be utilized on the undisturbed mine soil.

TYPE 2 -- 1967-1977 Reclamation

This type of mine soil was mined between 1967 and 1977. This is gently sloping to moderately steep, slightly leveled to leveled strip mined land. It is generally areas that was graded or leveled to some degree. These areas usually have not had any "top soil" added to the spoil material. The slope usually ranges from 0 to 25 percent.

This type of mine soil has the greatest potential for residential on-site sewage disposal systems.

If this type of landform is to be considered for a residential on-site sewage disposal systems, the procedures outlined in this report shall be utilized on the undisturbed mine soil.

TYPE 3 -- Post 1977 Prime Farmland Reclamation

Prime farmland must have a minimum of 48 inches of "top soil" and is generally in pasture or cropland. This type of mine soil has the least potential for residential on-site sewage disposal systems.

At this time, we must adopt the position that the prime farmland mine soils (TYPE 3) cannot be considered for placement of on-site sewage disposal systems because of the thickness and compaction of the layered "topsoil". The compacted "topsoil" in these areas is at least 48 inches thick, which will not allow for the installation of absorption field trenches below the compacted "topsoil."

TYPE 4 --Post 1977 Non-Prime Farmland Reclamation

Non-prime farmland can be addressed similar to the TYPE 2 mine soil depending upon the depth of the compacted "topsoil." The compacted "topsoil" in these areas range in depth from 0 to 24 inches, allowing the possibility of construction of absorption field trenches below the compacted "topsoil."

This type of mine soil has some potential for residential on-site sewage disposal systems.

If this type of landform is to be considered for a residential on-site sewage disposal systems system, the procedures outlined in this report must be utilized on the undisturbed mine soil.

MINE SOIL EVALUATION CRITERIA

Special evaluation criteria are required for mine soils in addition to the soils evaluation criteria listed in ISDH Rule 410 IAC 6-8.1. The mine soil will be addressed as if it is a naturally occurring soil under Rule 410 IAC 6-8.1 except that a loading rate of 0.25 gpd/sq. ft. will always be assigned because of the structures and textures and their variabilities. In addition to the provisions of Section 48 of ISDH Rule 410 IAC 6-8.1 for soils evaluations, the following shall apply:

I. Mine soil site evaluations must be conducted by a soil scientist certified by the American Registry of Certified Professionals in Agronomy, Crops, and Soils (ARCPACS); Indiana Association of Professional Soil Classifiers, Inc. (IAPSC), or by an employee of state or federal government whose official duties include the field description of soil characteristics.

II. Requirements for the number and locations for the soil profile pits and borings.

   A. A minimum of two soil profile pits are required for each proposed absorption field site for the purpose of determining the physical characteristics of the spoil material.

   B. The soil pits will be located in the opposite corners of the proposed absorption field site.

   C. The number of additional soil borings, post-hole borings, or soil pits will be left to the discretion of the soil scientist when determining the variability of materials within the proposed absorption field site.

   D. In cases where a profile pit or a part of a profile pit has been excavated within the boundaries of a proposed disposal area, the pit shall be backfilled after use in a manner that will not result in a major discontinuity with respect to soil horizonation, density, or hydraulic conductivity in the soil below the effluent disposal trench or bed.

III. Requirements for the preparation of the soil profile pits:

   A. Profile pits shall be excavated to a minimum depth of 5 feet below the existing ground surface.

   B. The depth of the (profile pit) soil evaluation shall never be less than 4 feet below the proposed trench bottom or absorption field bed for above-ground systems.

C. The length of the exposed pit being described shall extend continuously for a minimum of 10 feet.

D. It shall be the responsibility of the persons performing or witnessing soil evaluations to comply with all applicable Federal, State, and local laws and regulations governing occupational safety.

IV. Soil Characteristics of each recognizable soil horizon or substratum shall be determined and described using criteria outlined in ISDH Rule 410 IAC 6-8.1. The following are additional characteristics that will be described and the terminology that shall be used to characterize them:

A. The estimated soil texture class using the usual USDA-SCS system of classification shall be modified. This modification shall be representative of the total volume of the spoil matrix and recorded as a percentage of each identifiable USDA soil textural class and percentage coarse fragments. An example of describing the spoil matrix would be as 10% silty clay loam, 20% loam; 40% clay loam; and 30% coarse fragments.

B. The volume percentage of coarse fragments shall be estimated in the field visually using volume percentage, rock type, and average length and thickness of identifiable rock fragments. The standard USDA-SCS guidelines for rock fragments will be used.

C. Degree of weathering of coarse fragments and presence of fritted rock structure within the mine spoil material will be reported.

D. The standard USDA-SCS guidelines for soil structural class will be used where possible. The soil scientist will estimate the amount of compaction by determining soil resistance. It is important to identify the depths where the mine spoil is compacted to the degree that it will restrict water movement through the soil. This soil resistance is to be related to the resistance normally observed in massive, firm, loam glacial till. The use of the new technique involving a continuously recording penetrometer that detects the presence of a root restricting layer may assist the soil scientist in making this determination.

E. Number and size of roots and pore spaces in each soil horizon.

F. Presence or absence of earthworms in each soil horizon.

V. More specific site information is needed to evaluate a mine soil site and shall include the following:

A. Slope, Slope aspect, and configuration of complex slopes.

B. Depth in inches of "top soil" added during reclamation.

C. Was ponding of water observed on surface areas or within the adjoining landscapes? If strip pits were observed, what was the difference between elevation of the surface of the water in the pit and the elevation of the proposed septic area?

D. Was free water observed in the soil pit or borings and at what depth (in inches)?

VI. Additional information that needs to be provided by the owner shall include the following:

A. The method used to mine the coal.

B. The method used in reclamation and Type of mine soil:

1. Type 1
2. Type 2
3. Type 3
4. Type 4

C. The age of mine soil:

1. When the site was mined.

2. When the site was reclaimed.

3. Has the site been altered since the original reclamation?

D. The cropping (vegetative) history for last 5 years.

ALLOWABLE TYPES OF SYSTEMS THAT CAN BE CONSIDERED

Our study of mine soil lessened our concerns about the use of these soils for the disposal and treatment of wastewater in private on-site disposal systems.

The use of experimental equipment and procedures may be considered for these mine soils because it is designed to test alternative systems. It is important to see how well the various types of septic systems work and if they will protect the ground water and prevent public health hazards from occurring. If the mine soil site meets all of the criteria for system selection contained ISDH Rule 410 IAC 6-8.1 and the recently established criteria for mine soil, we would not object at this time to the installation of a residential on-site sewage disposal system.

All of the criteria for system selection contained in ISDH Rule 410 IAC 6-8.1 must be met except for the use of Tables V and VI (Loading Rates for Subsurface and Surface Systems). Because of the amount of variation in textures and the amounts and sizes of rock material contained within mine soil, a Loading Rate of 0.25 gallons per day per square foot (gpd/sq. ft.) of absorption field area will be assigned to coal mine spoil.

The size of the absorption field shall be determined as outlined in Sections 52 through 56 of ISDH Rule 410 IAC 6-8.1. Because of the depth to which the original soil and geological materials have been disturbed, the size reduction formulas for the absorption field may be applied to the proposed systems. This formula, provided in Sections 52(a)(5), 53(a)(5), 54(a)(5) and 55(a)(5) of ISDH Rule 410 IAC 6-8.1 for the calculated New Absorption Area, shall be permitted only if the soils evaluation is described to the necessary depth.

Soil compaction and the special problems described above for Types 1, 3, and 4 mine soil must be taken into consideration when making interpretations for residential on-site sewage disposal systems. It is important that all sites do not have any compaction at any depth within 24 inches below the bottom of the absorption trench or the above-ground absorption bed if they are to be utilized as residential on-site sewage disposal sites.

The decisions made concerning the use of mine soil for on-site residential sewage disposal sites take into account all scientific data available. General health hazards associated with failing septic systems must be given serious consideration in any ISDH interpretations for using mine soil. Potential liability must also be a factor in all decisions, both at the state and local levels. Therefore, the criteria developed for mine soils must be reviewed in an on-going manner. As studies continue of on-site disposal systems in mine soils, ISDH will continue to review these standards.

We have detailed information on file from our investigations of this issue. If you have any questions, or any problems, concerning our position on this matter, please contact this office.