KENTUCKY

LANDFARM MANUAL

Prepared for:

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Division of Waste Management

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TRAINING MANUAL

For

LANDFARMING OPERATORS

Commonwealth of Kentucky
Cabinet for Natural Resources and
Environmental Protection
Department for Environmental Protection
Division of Waste Management
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INTRODUCTION

INTRODUCTION

This section will introduce the reader to a general outline of the **TRAINING MANUAL for LANDFARMING OPERATORS**. This manual is intended to provide some specific detail on wastes, soil properties, site selection, regulations, and landfarming operation and management. These details are supported in several areas by a more general outline and summary that should be helpful in using these details. Landfarming in general is governed by regulations because of the wastes, and of the public's concern for their environment. Therefore, it becomes important to integrate both agronomic and regulatory features that affect landfarming. Agronomic discussions are not intended to replace regulations in this manual but to supplement them. Regulations discussed in this manual were put into effect on May 8, 1990 with additions becoming effective on June 24, 1992. Consult the Division of Waste Management for regulations applying to a particular waste or landfarming practice. ***This Manual is written specifically for the state of Kentucky. On March 22, 1993, new federal rules went into effect which regulate use and disposal of sewage sludge. This rule (40 CFR 503) has certain requirements, which are not included or incorporated in Kentucky's sludge management program. If you generate, treat, dispose, incinerate, or beneficially reuse sewage sludge in Kentucky, you must comply with both state and federal rules. This manual discusses some requirements of the 503 rules, but is not intended as a complete guide.***

Purpose

This manual provides detailed and general information for landfarming Special and Solid Wastes in Kentucky. This information should be especially helpful in (1) assisting the training of landfarming operators, and (2) serving as a reference for treatment plant operators, permit writers, consultants, regulators, and others interested in landfarming. Throughout the manual both principles and practical application are stressed along with the Kentucky regulations. This manual provides relevant information, identifies available resources of information, and explains methods of evaluating information, identifies available resources of information, and explains methods of evaluating information for use in site studies and proposals. Whether someone is conducting a site evaluation, writing a permit application, reviewing a proposal or monitoring the landfarming system, a solid base of technical information is mixed with a healthy dose of common sense. The Kentucky regulations in many cases serve as the minimums for further evaluations.

This manual cannot provide however, a complete and detailed prescription for wastes, site evaluation and system management. Because each landfarming operation represents a unique combination of wastes, soil, cropping system and monitoring, a unique set of conditions or parameters must be prepared for each system. This unique combination must be evaluated within the current regulations while considering the environment, the landfarming system and monitoring schedules.

Beneficial Reuse

Anytime a waste material is applied to the land, this is viewed as part of a recycling effort or beneficial reuse of a waste. Land application of wastes benefits

agriculture, the environment and society. Agriculture benefits as wastes improve the physical condition of the soil and supplies nutrients for crop production. The environment benefits as this reduces the concentration of nutrients handled by waste treatment facilities. Society benefits from a reduced need for landfill space and in having wastes applied in a safe and effective manner. It is suggested that all landfarming permit applications or proposals should list these benefits in addition to the importance of maintaining environmental quality and protecting the public from hazards that may be associated with any waste.

Landfarming

Landfarming is the application of wastes on or just below the surface of the land. Concurrent with improving soil productivity, landfarming also functions as a waste treatment process. Sunlight and soil microorganisms help destroy any potentially harmful pathogens, and some toxic organic substances remaining after primary treatment. Heavy metals and, to some extent, nutrients in wastes are trapped by soil as a result of various physical and chemical properties. Nutrients are converted to useful biomass, which reduces concerns for surface and groundwater degradation.

However, the land has a limit to its capacity to treat wastes, and any landfarming system must be designed and operated to work within this capacity. If these principles are followed, it is generally expected that any additional limitations from regulations will not drastically affect the landfarming system.

Operator Certification

All landfarming facilities must operate under the supervision of a "Certified Landfarming Operator". People who desire certified landfarm operators must apply to

the Cabinet, attend required training, and successfully pass an examination. The training consists of waste treatment and biology, site selection, management of the soil-crop-waste system, regulatory requirements, equipment operation and safety, monitoring, and duties of the certified operator.

Regulatory Overview

Regulations for landfarming follow two important principles: (1) to provide overall environmental safety in reducing any potential harmful effects from wastes; and (2) to maintain a consistent recognition of limits for the land to adequately process wastes. Having minimum requirements, establishing site evaluation and system operating requirements, and maintaining monitoring requirements for both the environment and the landfarming system accomplish this.

The landfarming regulations in Kentucky are administered in the Division of Waste Management as Kentucky Administrative Regulations (KAR) that were developed in response to several sections of Chapter 224 of the Kentucky Revised Statutes (KRS) as enacted by the Kentucky Legislature.

SECTION 1

SPECIAL AND SOLID WASTES

FOR LANDFARMING

SECTION 1

SPECIAL AND SOLID WASTES FOR LANDFARMING

A. Definition

Special wastes are those materials of high volume and low hazard that remain after a supporting role, or intermediate or final processing by an individual, business, industry, or municipality. KRS 224.50-760 specifies special wastes, which include mining wastes, utility wastes (fly ash, bottom ash, scrubber sludge, fluidized bed combustion waste), sludge from water treatment facilities, sludge from wastewater treatment facilities, cement kiln dust, gas and oil drilling muds, and oil production brines. Other wastes may be added to this list by regulation (410 KAR 45:210) as new waste materials are generated.

B. Sludge – Water treatment

This material consists of the solids (plus liquid for handling) remaining after water treatments to enter private or municipal drinking water systems. Water taken from surface rivers, lakes or underground sources contains some suspended solids or dissolved solids that need to be removed in making potable water. Coagulants, most commonly aluminum, ferric chloride, or ferric sulfate are added for solids removal. Lime softening may also be part of the treatment process. Water treatment solids consist of metal oxides that precipitate during treatment, small particles of organic matter and soil mineral matter that are filtered out, and combinations of lime used during treatment and the metal oxides. If handled as a liquid, this material is usually low in solids.

However, when dry, water treatment solids are very fine and thus subject to blowing by winds.

Since the solids contain very low organic matter amounts, the need for treating to reduce pathogen levels is not considered necessary. Further, these solids contain very low levels of nutrients beneficial to crops except calcium (Ca) which either is precipitated out of the water or is a major ingredient of materials added during the treatment process. The calcium can be beneficial for raising soil pH when this material is land applied. The water treatment solids do contain low levels of heavy metals (cadmium, chromium, copper, nickel, lead and zinc) that will require an analysis before land application.

C. Sludge – Wastewater treatment (Biosolids)

Sludge (also known as wastewater solids or biosolids) is solids generated by the treating of wastewater to remove organic matter, reduce or eliminate pathogens, and to reduce chemical elements to an acceptable level before discharging the water.

Sludge usually contains from 93 – 99% liquid when it is first separated in the treatment process. The sludge's chemical and biological characteristics depend on the makeup and contents of the incoming wastewater, and the treatment processes used to treat the wastewater. Sludges may be classified into different types depending on type or degree of treatment.

a) **Primary sludge** is raw sludge obtained following the primary treatment processes. This unstabilized material should not be used for land application.

b) **Secondary sludge** is obtained after further biological treatment and stabilization within the treatment plant. This material usually has a solids content ranging from 0.5-2.0%.

c) **Activated sludge** is a secondary sludge consisting of bacterial cells, stabilized organic matter and inorganic compounds. This material is collected from the settling tanks in the plant.

d) **Stabilized sludge** is a secondary sludge that has been further processed by microorganisms or by adding some materials to reduce odors and to either eliminate or acceptably reduce pathogens.

e) **Aerobic sludge** is an activated sludge resulting from continuously injected air into the biological treatment process. Injected air stimulates microorganisms that require oxygen for digesting organic materials during this secondary treatment process.

f) **Anaerobic sludge** is an activated sludge resulting from the exclusion of air (oxygen) from the microbial process. Some heat may be added so that microbes convert some of the organic material to carbon dioxide, methane and water.

g) **Chemical stabilized** sludge results when materials like lime or ferric chloride are added during secondary sludge treatment to further decrease biological activity, reduce pathogens, reduce odors and increase percentage of solids.

h) **Dewatered sludge** is stabilized sludge that is mechanically processed to remove water and thus increase the solids percentage (usually>20% solids).

i) **Composted sludge** is a mixture of stabilized sludge and such materials as sawdust, woodchips, yard waste, other plant materials, or sorted municipal garbage and is aerobically composted in windrows, aerated static piles or forced air vessels.

Sludge is normally land applied in one of three forms:

1) Liquid sludge	1-10% solids
2) Semi-solid (wet) sludge	10-25% solids
3) Solid (dry) sludge	25-60% solids

More than 50% of the solids are organic matter consisting primarily of dead microbe cells and undecomposed organic materials. This material contains all of the nutrients necessary for plant growth but not usually in a desirable ratio for most plants. These sludges contain various levels of chemical elements classified as heavy metal or pollutants (arsenic, cadmium, chromium, cobalt, copper, iron, manganese, mercury, molybdenum, nickel, lead, selenium, and zinc). These inorganic elements are precipitated from the wastewater during treatment.

Some of the microorganisms entering the treatment plant are regarded as pathogens. The sludge may contain some of these pathogens except that the major reason for the two-tier treatment process is to eliminate or greatly reduce pathogens before any land application. Sludges may contain some synthetic organic chemicals that arise from both households and industry. Very minute levels should not pose any threat to human health or the environment, but their presence and levels to be confirmed by laboratory analysis.

D. Compost

Compost is generated by a biological decomposition of organic materials under controlled or managed conditions which stabilizes the organic fraction so that the material may be stored, handled, land applied or further used in an environmentally

acceptable manner. Simply creating "piles" to allow biological decomposition under uncontrolled or unmanaged conditions is not considered composting.

Land application of compost is often used as an alternative disposal method for large volume generators. This material contains low levels of the major plant nutrients, but will still contain the heavy metals that were present in the wastes that were composted. The composition of various composts will vary with both type of wastes composted and composition of the wastes. Compost may have an adverse effect on plant growth (depending on application method and rate) due to its salinity (highly soluble effect from such elements as sodium, chloride, nitrate, bicarbonates, etc.). Land application of special or solid waste compost does not require a landfarming permit, unless concentrations of heavy metals are high, or pathogenic organisms have not been sufficiently destroyed by the composting process. Facilities in Kentucky that produce compost for sale or distribution must have a permit (for special waste) or a registered permit-by-rule (solid waste) for the composting operation. Information about the types of waste which have been incorporated in the compost mixture, as well as analysis of the finished compost, may be obtained from the facility operator or the Division of Waste Management.

E. Fly ash

Fly ash is a fine material, which is emitted into the stack of coal-fired boilers. This material is a combination of bottom ash that settles at the base of smoke stacks or is accumulated by specially designed collectors to keep it from going into the atmosphere.

Properties of fly ash vary greatly with the source and type of coal burned, and the type of ash collection system. Some very fine material comes from electrostatic

precipitators. Fly ash is a low-grade source of phosphorus, potassium, calcium, magnesium, sulfur, boron, molybdenum, and other micronutrients. It has some value for neutralizing soils ranging from little to high depending on the coal source. Fly ash can improve moisture-holding capacity and other physical properties of sandy or gravelly soils or mine spoils.

Fresh fly ash is initially toxic as a media for plant growth resulting from its content of boron, molybdenum and high pH (alkalinity) from the alkali metal oxides. Contact of these metal oxides with moisture forms carbonates. Thus, fly ash should be exposed to the atmosphere until the material is stabilized and salinity is sufficiently reduced to prevent plant toxicity. Fly ash will contain low levels of all the heavy metals, which means that a complete analysis including total boron, molybdenum and alkalinity must be performed prior to land application.

F. Lime Scrubber Sludge

This sludge is generated in coal fired boiler stacks by scrubbing sulfur dioxide from the stack gases using liquid suspensions of finely ground limestone. This scrubber sludge is usually pumped to holding ponds where excess water is removed leaving a solids content of about 50%, and further dewatering occurs very slowly due to the fine particles that make up the material. Usually this sludge must be stabilized before land application by adding either more lime, fixing agents, sodium silicate or cement followed by dewatering mechanically or in ponds.

Scrubber sludge may contain some fly ash depending on the type of coal burned, whether fly ash collectors are located ahead of scrubbing, and whether additional fly ash is added to the sludge before ponding and stabilization. The unstabilized material

consists largely of calcium sulfite, unreacted ground lime and fly ash components. The calcium sulfite reacts during stabilization to become calcium sulfate.

Dried limestone scrubber sludge contains fine particles that can support vegetative growth if mixed with soil and fertilized with nitrogen, phosphorus and potassium. Fresh unstabilized sludge may be toxic to plant growth as a result of the content of boron and high pH (alkalinity) from unreacted lime. Scrubber sludge will have some liming value for soils that will vary with its content of unreacted lime, and fly ash. This material should have a complete chemical analysis prior to land application including total boron and liming value (unreacted calcium carbonate.)

G. Fluidized Bed Combustion Waste

Fluidized bed combustion waste (FBCW) is generated in newer technology boilers when fine coal is burned in a bed of inert ash and ground limestone. The bed is suspended (fluidized) by air injection at controlled rates to allow the ground limestone to react with the sulfur dioxide from combustion.

FBCW is a fine granular solid material containing calcium sulfite, unreacted lime, and metal oxides that result in extremely high pH levels. The metal oxides (calcium oxide is the major one) convert to hydroxides in the presence of moisture which generates heat. Further changes involve the hydroxides reacting with carbon dioxide in the atmosphere to form carbonates which stabilizes the material. This material should be stabilized before land application so that most of the unreacted calcium oxide has converted to calcium carbonate. Fresh FBCW, because of its extremely high pH, should be handled with care and should not be land applied.

Stabilized FBCW is a source of sulfur and calcium for plant growth. It is a good source of lime for adjusting soil pH depending on the percentage of unreacted lime. The ability to adjust soil pH is reduced by the increased content of calcium sulfate and fly ash. The immediate liming value is about 10% with longer term liming value of about 40% that of fine calcium carbonate. Transportation costs probably will limit the use of FBCW as a liming material. The material will need to have a complete chemical analysis including total boron, alkalinity and liming value before land application.

H. Cement Kiln Dust

Cement kiln dust is a fine granular solid material obtained by mixing waste from several sources during cement manufacture. Sources include the dust from stack scrubbers, dust collected from grinding rock and shale before heating, and impurities separated before the raw product passes into the rotary kiln. Contents of the stack scrubber component will depend on the sources of fuel used in the rotary kiln. Some plants may use unconventional fuels (such as wastes) which may result in hazardous components in the stack scrubber material. If any type of waste is being burned for fuel, the cement kiln dust should be checked for hazardous waste content.

Normally, cement kiln dust is quite high in calcium oxides, calcium hydroxides, other metal oxides and clay. It will contain all of the metallic elements found in the rock and shale used for making the powdered product. Because the material contains a large amount of calcium oxides and hydroxides, it will have a very alkaline (high pH) reaction when placed in contact with water.

It is most commonly used in Kentucky to mix with biosolids as a method to reduce pathogens. When mixed with biosolids, the pH of the mixture will soon increase

to 12, which is capable of significantly reducing pathogens. In addition, in the process of attaining this level of pH, some nitrogen is lost through ammonia volatilization. When this mixture reacts for long periods, the alkalinity is reduced thus; the cement kiln dust-biosolids mixture is suitable for land application. The mixture is dewatered as a result of adding the dry cement kiln dust and reacting. This mixture should be tested for the same parameters as biosolids plus alkalinity before landfarming.

I. Gas and Oil Drilling Muds

During the drilling of oil and gas wells, special fluids are pumped down into the bore hole to lubricate and cool the drilling bit, float out the loose material, seal porous strata, and prevent the bore hole from filling with water. Most drilling fluids, commonly called drilling muds, are prepared most often by mixing different proportions of barite (barium sulfate), bentonite (type of clay), chrome lignosultonate, lignite, and sodium hydroxide. Most drilling muds contain trace elements, petroleum residue, salt water components, and sources of alkalinity.

Most of the drilling mud (fluid) is pumped to catchment basins at the drilling site and allowed to dewater before handling. The material is then handled as a solid (>20% solids) which in recent years is transported to special sites away from the drilling activity. These special sites are designed and constructed land areas that will maintain material confinement, and allow inoculation with bacteria to convert the petroleum residues to simple organic compounds. Commonly, these “cells” of land are underlain with a drain field that will allow the leaching of soluble components out of the drilling mud. The insoluble components will remain in the “cell” with the drilling mud. Drilling mud is removed when monitoring indicates that the petroleum residue has been

sufficiently converted to render little or no hazard to the environment. The finished drilling mud is then removed and can be used for industrial fill material. This material should be analyzed for all required heavy metals plus total arsenic (As), barium (Ba) and mercury (Hg). In addition, analysis should be performed for total polyaromatic hydrocarbons (PAH's), and specialized organics such as alkanes, chlorinated alkanes, and chlorinated aromatics.

J. Oil Production Brines

This liquid or dewatered material is separated from oil following pumping of the oil wells, drilling, or during the normal extraction of oil. Most of this material is typically returned underground through injection wells following separation from the oil in a tank near the producing well. However, when an injection well is not available for handling the brines, then the material must be handled as a special waste.

Brines are very salty because they are composed largely of sodium-laden waters that are mixed with the oil underground. This presents some application rate limitations for landfarming due to the toxic nature that high sodium levels in the soil will have on plants. This material must be analyzed for sodium, chlorine, alkalinity and the required heavy metals before landfarming. Application rates will be limited by the sodium and chlorine content.

K. Food Waste

These wastes are the results of food production and processing, or food supplement processing. They may include: liquid and solid wastes from various food preparation plants; whey from cheese making; starch, peels and rejects from potato chips; rejected milk from milk processing; peels and rejects from cucumbers; trimmings

and rejects of vegetables and fruits from restaurants and grocery stores; pomace from fruit processing; tomato pulp from catsup; hulls and skins from peanut processing; dust and hulls from coffee grinding and oil seed extraction; and spent media from drug and food supplement manufacturing, to name a few.

Most food wastes are relatively unprocessed, thus there is a concern for the high BOD levels of these wastes. In some cases (whey, potato starch and milk), BOD (Biological Oxygen Demand) limits should determine the application rates unless nitrogen or other elements limit land application to lesser rates. On the other hand, some materials (potato peels, cucumber parts, vegetable trimmings, peanut hulls, and oil seed hulls) represent crop residues that could be easily land applied. In addition, some of these materials are sought by composting operations because they are relatively easily decomposed.

In addition to the standard waste analysis needed for landfarming, these materials should be analyzed for BOD levels. Some assurance is needed that these wastes are not a mixture of chemicals used for processing and the discarded portion of the raw food products. Acceptable landfarming of these wastes depends on frequent application to prevent decomposition due to storage that leads to odors.

SECTION 1

SPECIAL AND SOLID WASTES

Terms of Interest

Aerobic	Heavy Metals
Anaerobic	Lime Scrubber Sludge
Biological Oxygen Demand (BOD)	Oil Production Brines
Cement Kiln Dust	Pathogens
Compost	Primary Sludge
Fluidized Bed Combustion Waste	Secondary Sludge
Fly Ash	Solid Waste
Food Waste	Special Waste
Gas and Oil Drilling	Waste

Study Questions

1. Special wastes are those materials of _____ volume and low _____.
2. Sludge is normally applied to the land in the form of a _____ sludge, a _____ solid sludge, and as a solid dry sludge.
3. Wastes classified as special wastes include:
   1.) Mining wastes
   2.) _____ wastes (fly ash, bottom ash, scrubber sludge, fluidized bed combustion.
   3.) _____ and _____ drilling muds
   4.) Sludge from _____ and wastewater treatment facilities.

5.) _____ kiln _____.

6.) Oil production _____.

4. _____ _____ dust is commonly combined with wastewater sludge to meet pathogen reduction requirements by increasing pH.

5. Some of the microorganisms entering the treatment plant are regarded as _____.

6. A concern of relatively unprocessed food waste is the _____ _____ _____ level of these wastes.

SECTION 2

SOIL PROPERTIES

SECTION 2

SOIL PROPERTIES

Site evaluation, site selection and site management all begin with an assessment of soil properties. These properties determine the physical, chemical and biological processes in soils that affect plant nutrient availability, heavy metal immobilization, waste utilization, and crop management.

A. Soil Properties

This section will be a general discussion of soil properties that influence the beneficial use of wastes and will increase technical understanding. More information on soil properties will appear in sections to follow.

Soils in waste treatment

The four roles of soil are to provide a medium for:

1. Plant root growth;
2. Water and nutrient entry, and movement;
3. Immobilization of metals and other chemicals;
4. Biological activity to assimilate wastes.

An aerobic environment is necessary for plant growth and for the soil microbes that decompose organic residues and destroy pathogens. Aerobic environments provide a favorable balance between air-filled pores and water-filled pores. Soil management for beneficial utilization of wastes should strive to maintain aerobic conditions in the soil.

Ideal soils have about 50% solids and 50% pore space. In Kentucky we would expect mineral matter to comprise 48% and 2% would be native organic matter (total of 50% solids). Of the pore space we would expect one-half (25% of the total) to be filled with water and one-half (25% of the total) to remain as pore space.

Aerobic soil conditions are related to soil texture, soil structure, and soil water content. Loamy soils, as we have in most of Kentucky, have good soil structure that provides aerobic conditions. Some Kentucky soils may be more clayey and have poor structure that tends to be less well aerated. Soils that are saturated with water for long periods of time tend to be anaerobic and thus are not favorable for normal decomposition of added wastes. Fragipan soils in some parts of Kentucky have impermeable horizons that create perched water tables that can restrict land application.

Soil and water management for land application must control water movement over and through the soil in order to prevent contamination of surface and groundwater supplies. The potential for leaching is higher when the soil is more permeable and has high rainfall amounts. Soils that are less permeable or have a higher slope will experience greater surface runoff.

Runoff occurs when the soil cannot absorb the rainfall. Surface runoff increases the potential for contamination of surface water bodies. The runoff potential depends on the soil's slope and wetness, the surface infiltration, and whether the soil is frozen. Amount of vegetative cover, rainfall intensity and use of soil conservation measures affect the amount of runoff.

The soil can immobilize many metals and other chemical elements contained in wastes. Soil pH and the cation exchange capacity (CEC) are the primary controlling

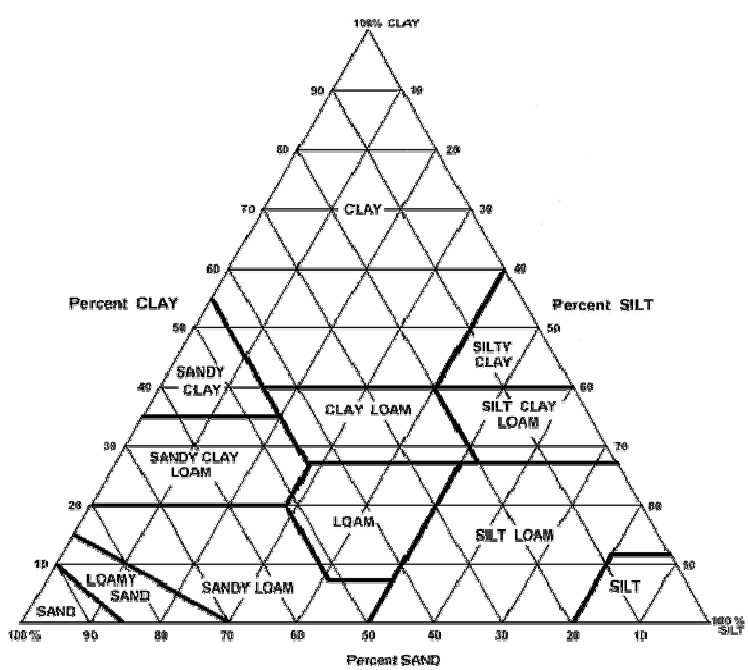
factors in immobilization. The CEC of a soil depends on amount of organic matter, percentage and type of clay.

B. The Collective Features of Soils

The collective features are the result of inherent soil forming practices that have determined several properties of soils at a potential landfarming site. These features include texture, structure, color, mottling, horizons, and soil depth.

1. Soil texture

Soil texture refers to the soil's particle size distribution. Soil particles are classified by size into three groups: sand, silt, and clay. Sand particles feel gritty and are so large that each grain is visible. Silt has a smooth feeling, like flour or cornstarch. Clay feels sticky when wet and can be molded into ribbons. Sand and silt do not contribute much to soil CEC as they have a lower surface area in a given volume of soil. Clay particles are flat with a large surface area per unit volume, and therefore, make a large contribution to CEC. Soil texture is classified into specific combinations with the



help of a textural triangle.

Texture affects the size and shape of soil pores, which affects water movement into and within the soil. Soil texture influences the balance between water-filled pores and air-filled pores, creating different environments for root growth and microbial activity. Texture influences the rate of organic matter accumulation.

Soils higher in clay tend to have smaller pores which affects rate of water movement into and through the soil. Air exchange and water movement restrictions increase the runoff potential and reduce microbial activity. Irrigation of wastewater or liquid wastes at high rates may cause soil saturation leading to reduce utilization of wastes.

Sandy soils have more large pores and fewer small pores which promotes well-aerated conditions. Since water enters and moves through these soils more rapidly, there is more risk for groundwater contamination from waste applications.

Medium textured (such as silt loams in Kentucky) soils are usually best for land application of wastes. The range of pore sizes allows water to move through the smaller pores but have enough larger pores to promote adequate air exchange. These soils provide a favorable environment for root growth, can store large amounts of plant available water, and have good nutrient-supplying ability.

In summary, soil texture affects:

a. Porosity
b. Water movement
c. Aeration
d. Water retention

e. Organic matter

f. Plant nutrition

g. Metal adsorption

2. Soil Structure

Soil structure refers to the aggregation of the individual particles of sand, silt, and clay into larger units called peds. Plant roots, soil organic matter, and clay particles provide the physical and chemical binding for the peds. Structure is characterized by the shape, size, and grade of peds. Granular peds are common in surface soils, which provide balanced air and water relations. Plates occur in some soils just below the surface which due to the horizontal occurrence tend to restrict air and water movement. Blocky and prismatic peds are both common in subsoils which tend to provide large pores between peds and smaller pores within peds for a more balanced air and water movement.

Soil structure modifies some of the undesirable effects of certain textures (usually higher clay content soils) by creating larger pores between peds that encourages air and water movement. Good structure means good aeration and a favorable balance between air and water containing pores that improves the environment for root growth and microbial activity.

Maintaining strong, stable peds is an important management objective in any good soil management strategy. Waste can be a valuable soil amendment because it adds organic matter that is vital to the formation and maintenance of good soil structure. In addition, waste application stimulates root growth that tends to bind particles together.

Heavily cropped soils may be prone to structural deterioration, and waste application is particularly valuable in providing organic matter for improving soil structure.

Clays tend to aggregate soils due to their chemical attraction, and their tendency to shrink and swell in response to wetting and drying, or freezing and thawing.

3. Soil Color

Soil colors provide important clues about the nature of the plant zone of soils. Dark colors (browns) in surface depths usually mean favorable amounts of organic matter. Usually the darker the color, the more organic matter in the soil and the more productive and fertile the soil. Since organic matter is a major factor in structural development, the darker the soil, the more the peds are stable and well formed.

Yellowish and reddish colors indicate favorable air and water relations. As plant roots and soil microbes remove oxygen from the soil pores, oxygen from the air above easily moves in to replace it. The iron oxide coatings on the soil particles cause these colors. Chemically, these coatings are the same as rust. Iron oxides are stable and as long as good aeration is maintained, these coatings remain and provide the dominant soil color. This makes for well-aerated soils that are ideal for plant growth, microbial activity, and therefore, beneficial for assimilating wastes applied to these soils.

Gray colors at any depth indicate soils that are poorly aerated due to long periods of wetness or water saturation. When soil pores are full of water, oxygen from the air cannot get into the soils. This creates an environment where the iron oxide coatings begin to change color from reddish or yellowish to gray and become more soluble. These soils tend to be more acid and less fertile which lowers plant root growth and thus plant

production. Soils that have gray colors near the surface are poorly suited for waste application.

4. Soil Mottles

Some soils have spots of one color in a matrix of a different color. These spots are called mottles, and the soil is said to be mottled. Some mottles appear as splotches of reddish-brown in a gray color. However, the more common in most Kentucky soils is to have gray mottles in a reddish or yellowish matrix. Mottling is caused by a fluctuating water table in the soil. When water is high, the soil pores are saturated and the iron oxide is changed to a gray color. As the water table lowers, air reenters the larger pores first, changing the gray color to reddish or yellowish. Soil around the smaller pores remains gray thus giving the mottled appearance. By understanding these processes, observation of soil colors and particularly soil mottles (if present) can help determine the height and duration of water tables in soils. This information is used to define classes of internal soil drainage which has direct application to assessing soil suitability for waste application.

5. Soil Horizons

A soil horizon is a layer of soil parallel to the earth's surface. Each horizon is defined and described in terms of its distinct soil forming properties: texture, structure, color and parent material. Together, all of the horizons (resemble layers in a layer cake) in a soil constitute a soil profile. A soil profile description is a complete set of horizon descriptions for all horizons that occur in a soil.

Soil horizons (master horizons) are named using the terms listed below. Transition horizons indicate zones of gradual change from one master horizon to another.

O Litter layer

A	Dark colored surface horizon
E	Strongly leached horizon
B	Distinct subsoil horizon
C	Weathered parent material
R	Bedrock or shale

Some horizons in Kentucky soils are considered restrictive due to specific properties of that horizon. Water and air cannot move into and through these layers as fast as it moves through the soil above these horizons. These layers also prevent normal downward root growth of many commonly grown crops. In most soils, these restrictive horizons create perched water tables during periods of high rainfall as indicated by either zones of all gray color or mottling of gray and either reddish or yellowish colors. These include:

Claypans	Horizons that have a very high Clay content, particularly in Comparison to those horizons both Above and below.
Fragipans	Horizons that are very silty and Very dense.

The presence of these layers will either severely limit or may even disqualify potential sites for waste application due to the occurrence of perched water tables during some seasons of the year. Soil profiles with restrictive layers used for waste application will have increased potential for water runoff due to the restricted downward movement of water. They often require conservation practices to manage runoff water.

6. Soil Depth

Soil depth refers to the total depth of the soil horizons above bedrock or shale. In Kentucky, several areas of the state have bedrock or shale at rather close depths to the surface. Depths are classified as follows:

Shallow	0 to 20 inches
Moderately deep	20 to 40 inches
Deep	More than 40 inches

These terms do not apply for depth to a restrictive horizon although from a practical point of view, depth to a restrictive layer more accurately describes the potential rooting zone for most crops, and for microbial activity to decompose applied wastes.

C. Soil Behavioral Properties

Several aspects of soil are difficult to measure directly in the field, but inferences can be made either from laboratory measurements or field observations on the bases of soil forming properties. Some of the important soil behavioral properties important for land application of wastes include permeability, infiltration, internal drainage class, available water holding capacity, leaching potential, shrink-swell potential, trafficability, pH, nutrient availability, and heavy metal immobilization.

1. Permeability

Soil permeability is the rate that water moves through the soil. Permeability depends on the amount, size, shape, and arrangement of soil pores, and on the homogeneity of the pore relationships between soil horizons. Water moves through soils in response to both gravity and an attraction between water molecules and soil particle

surfaces. Gravity moves water through large pores, and attractive forces retain water films on surfaces of soil particles.

Since permeability cannot be measured directly due to the complex pore structure, it is more convenient to determine hydraulic conductivity, which is a measure of water flow in a vertical direction in the soil. By relating the hydraulic conductivity measurement to soil texture, structure, and horizons, soil permeability can be classified. This classification appears in soil survey reports and can be used to determine site suitability for land application of wastes.

Hydraulic Conductivity (in./hr.)	Permeability Class
<0.06	Very slow
0.06 – 0.20	Slow
0.20 – 0.60	Moderately slow
0.60 – 2.0	Moderately
2.0 – 6.0	Moderately rapid
6.0 – 20.0	Rapid
>20.0	Very rapid

2. Infiltration

Infiltration is the rate that water enters the soil through the surface. This depends primarily on the pore number, distribution, texture, and structure. Clearly, coarse-textured soils have much faster infiltration rates than fine-textured soils.

Soil texture	Infiltration rate (in./hr.)
Sand	2.0 – 5.0

Loamy sand	1.0 – 1.5
Loam	0.5 – 0.75
Silt loam	0.2 – 0.3
Clay loam	0.15 – 0.3
Silty clay loam	0.1 – 0.2
Clay	0.05 – 0.15

Strong, stable peds at the soil surface create and maintain relatively large pores that encourage infiltration. High organic matter content of the surface helps maintain stable peds. Surface infiltration is also affected by the moisture content and permeability of the soil beneath the surface. Faster permeability allows drier soils beneath the surface which increases infiltration.

Infiltration is important for land application of wastes because of its affect on water quality. By itself, rapid infiltration is desirable, but if coupled with rapid permeability through the soil, then there is a greater risk of groundwater contamination. This is particularly important when liquid wastes are applied, or there are heavy rains following any waste application. However, slow infiltration is a more common problem. This increases the potential for surface runoff and when combined with slope, can increase the potential for surface water contamination on three important management factors:

a. Avoiding driving on wet soils to keep from compacting the surface and reducing infiltration.

b. Keep organic matter high by adding wastes or other organic residues to the soil.

c. Use sod-forming crops in a rotation as much as possible.

3. Internal drainage

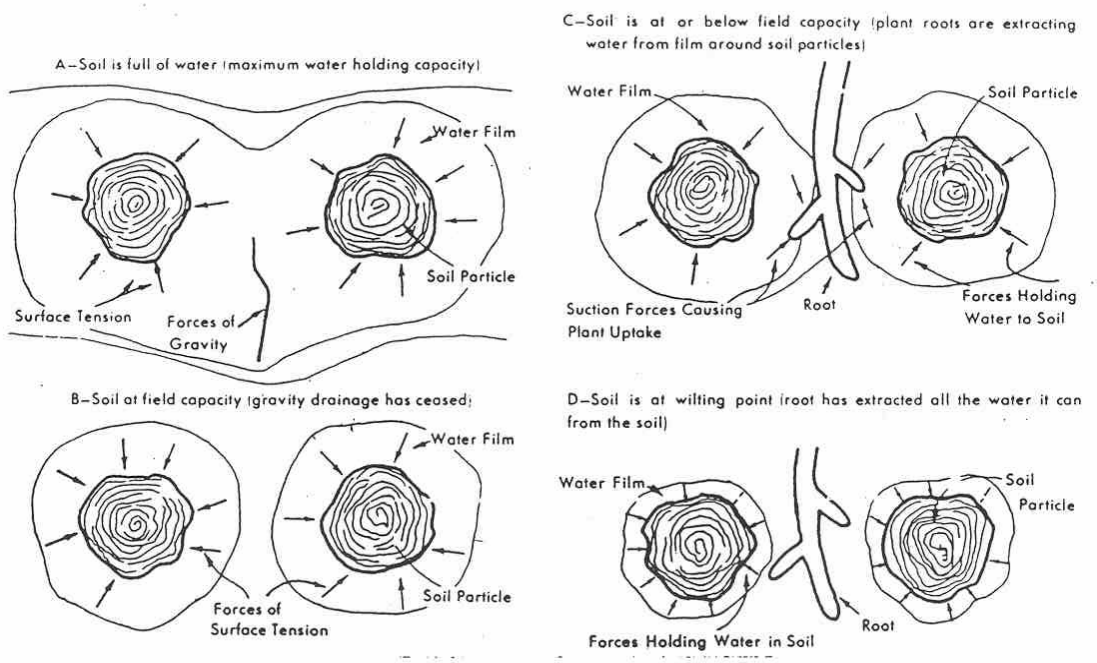
Internal drainage refers to the ability of free water to move through a soil. Internal drainage is not the same thing as permeability of a soil. Classes of internal drainage are based on the height that a water table raises in the soil and the length of time that the soil remains saturated.

Drainage affects soil temperature, as wet soils are cold soils. Biological processes that decompose wastes and release nitrogen for plant use do not operate as fast in cold soils. This can often delay the normal release of nitrogen from land-applied wastes, and can often encourage denitrification (gaseous loss of nitrogen), which reduces the efficiency of waste containing nitrogen for plant growth.

Internal drainage also indicates the depth of soil available for plant root development and uptake of soil nutrients. As these processes occur mainly in aerobic conditions, only the soil volume above the water table is available for waste utilization. Climate dictates the amount and frequency of rainfall, hence the frequency of high water tables. Water table fluctuations are seldom observed directly. Most of these conditions are studied during dry seasons using evidence of color and mottling to determine the height to which a water table occurs.

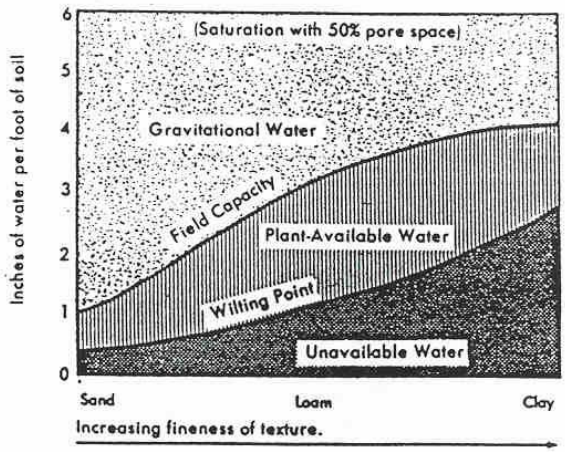
The following table lists depths to which there is no evidence of gray colors or gray mottles:

Internal Drainage	Depth in inches
Excessive & somewhat excessively drained	>40
Well-drained	30 – 40
Moderately well-drained	20 – 30
Poorly drained	10 – 20
Very poorly drained	<10



4. Available water holding capacity (AWHC)

Available water holding capacity refers to the amount of water that soils can store for plants to use. AWHC depends on the amount and size distribution of soil pores which is influenced by soil texture and structure.



Gravitational water passes through the large pores with very little available because it drains out as soon as the water table drops. A soil is at field capacity when gravity has removed excess water. Plants remove water easily when soils are at field capacity, but each increment of water removed makes it increasingly difficult for plants to remove the next increment. When a soil is so dry that plants can remove no more water, the soil is at the wilting point. Water that remains in the soil at wilting point is unavailable water. Plant available water is that amount between field capacity and wilting point.

AWHC is expressed as the number of inches of water that can be stored in the top 40 inches (or to the depth of root limiting layer) of the soil profile. A deep, medium-textured soil with no coarse fragments and no restrictive layers stores high amounts of available water. Soils that are shallow to bedrock or restrictive layers, and that have a

large amount of coarse fragments usually have low amounts of available water. Each soil texture class has a characteristic AWHC, expressed as inches of available water per inch of soil depth. Information on AWHC is listed in Soil Survey Reports for each soil series and soil type mapped within the scope of the Report. It is recommended that soils selected for landfarming should have a high AWHC (>5.2 in.) in the upper 40 inches of soil.

5. Leaching potential

Leaching refers to the downward movement of materials in solution by water passing through the soil. Leaching potential is a composite interpretation developed from interpretation on a soil's infiltration, permeability, water holding capacity, and hydraulic loading. It is one component which balances all water inputs against all water losses. Inputs include rainfall, irrigation, or liquid from wastes added to the soil. Losses include evaporation from the soil surface, transpiration by plants, and surface runoff. When inputs exceed losses, water passes through the soil (leaching). In Kentucky, leaching potential is high during periods of low rainfall with low potential evaporation, and leaching potential is low during periods of low rainfall and active plant growth. During periods of high leaching potential many land-applied wastes may be subject to leaching. It is important to provide sufficient time after application for immobilization of metal and organics before the next pulse of water is received to pass through the soil.

6. Trafficability

Trafficability refers to the soil's ability to support the weight of land application or farm equipment with a minimum of compaction or soil structural deterioration. Trafficability is important because:

a) Compaction and rutting of the soil reduces infiltration and permeability;
b) Loss of traction can delay and increase the cost of waste application; and
c) Crops do not grow as well in compacted and rutted soil, and the potential for surface runoff is greater.

Trafficability depends on soil texture, moisture content, and plant cover with moisture content the most important. All soils support weight when they are dry and lose stability when they are wet. The most important rule is: Avoid driving on any soil when there is free water in the top 18 inches. Silt loam soils, such as we have in Kentucky, have the lowest stability when wet and the most susceptible to compaction. Wait until silt loam soils are considerably less than field capacity before driving large equipment on them.

Soils with thick, actively growing sod crops provide greater vehicle support than bare soils. Plants also remove some of the water, thus speeding soil drying. If a silt loam is wetter than field capacity, even a thick sod crop may not be sufficient to support equipment.

7. Shrink-swell potential

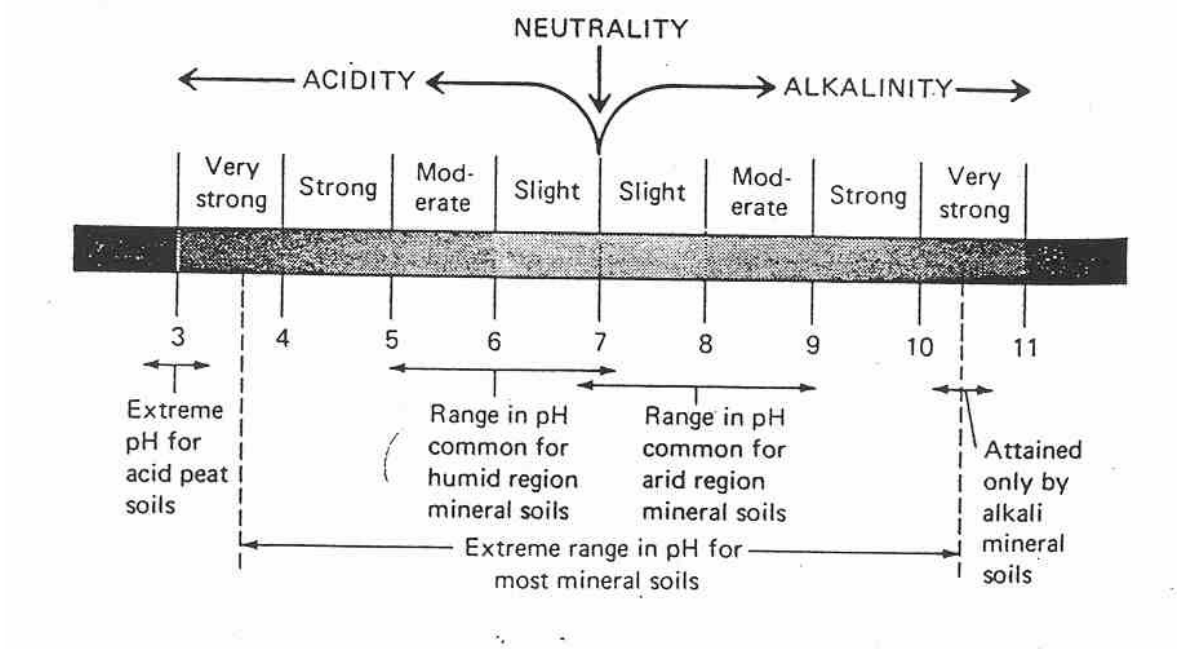
To a greater or lesser degree, clays tend to expand when wet and shrink when dry. Modest shrink-swell activity is beneficial in forming a well-developed soil, and is important in overcoming some slight compaction problems. Most Soil Survey Reports

contain information on the shrink-swell potential of soils mapped within the area. Any soil which is rated "high" requires careful management for waste utilization. When these soils become dry, they shrink to the point that deep, wide cracks form in the soil. Masses of soil between the cracks have such tiny pores that water penetrates only the large cracks. When these "high" rated soils become wet, the cracks close so tightly that the soil is one large, structureless mass. These conditions decrease soil water holding capacity when dry, restrict permeability when wet, and provide a hostile environment for biological activity when either wet or dry. This limitation can be overcome by continually adding and incorporating waste matter into the soil's surface.

8. Soil pH

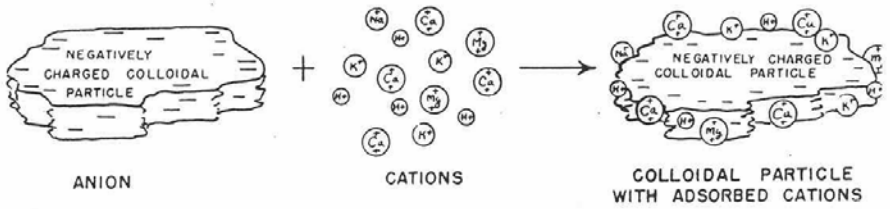
Soil pH is a measure of the degree of acidity or alkalinity of the soil. Technically, pH is a measure of the concentration of hydrogen ions in the soil solution. The pH scale runs from 0 to 14 with 7 being neutral. Numbers lower than 7 indicate acid soils and greater than 7 indicates alkaline soils. Soil pH can be measured accurately in the laboratory using a pH meter, and some general indication in the field can be obtained with color indicator papers.

Ultimately you will need to determine soil pH at the intended site for waste application. First, sample the soil following procedures listed in publication AGR-16 (Taking soil test samples). On-site sampling and laboratory analysis is the only way to determine this important chemical property.



9. Nutrient availability

The best way to determine availability of soil nutrients to growing crops is to take a soil sample following procedures listed in publication AGR-16 (Taking soil test samples) and has the sample analyzed in a laboratory using procedures adapted for Kentucky. Some nutrients such as potassium, calcium and magnesium carry a positive charge in the soil and are called cations. Others, such as phosphorus and nitrate, carry a negative charge and are called anions.



Clay particles and organic matter have a net charge in the soil and are therefore able to retain the positively charged ions (cations). The ability of a soil to hold these cations depends on the cation exchange capacity (CEC), which is a measure of the amount of negative sites available to attract the cations. The CEC value is expressed in terms of milliequivalents per 100 grams soil (me/100g.). CEC is not subject to large changes through soil organic matter for which additions of organic wastes can be beneficial.

The availability of nutrient anions depends mainly on their solubility in water and the rate of water movement in soil. Anion exchange capacity is not considered important in the retention of nitrate and phosphorus in the soil. Nitrate management with organic wastes depends on good management of the organic nitrogen reservoir. The objective is to encourage conversion of organic nitrogen to nitrate nitrogen that coincides with times when plants are actively growing and able to utilize the nitrate. Phosphorus in soils either occurs as inorganic compounds or is in the organic form. Availability of inorganic sources is tied closely to soil pH with a range of 6 to 7 being ideal. Phosphorus in the organic form is released slowly with decomposition of the organic matter.

10.Metal immobilization

Metals of concern in land-applied waste include cadmium, chromium, copper, nickel, lead, zinc, molybdenum, boron, selenium, and arsenic. Of these cadmium, chromium, copper, nickel, lead and zinc are present as cations in the soil, and molybdenum, boron, selenium and arsenic are anions. Many of these elements are toxic to plants, animals and humans if present is large quantities either in the soil or in plant materials when consumed.

The objective is to immobilize these elements during the land application process in order to avoid high levels becoming available for plant uptake. This is accomplished by restricting the annual application rates of some metals and the total application of metals for the life of the site, by recognizing the agronomic limits of some other elements that may cause toxicity symptoms in plants, and by maintaining soil pH at 6.5 or above. Some of the cations become immobilized by attaching to the cation exchange sites available in the soil. This requires that CEC be determined for each land application site in order to determine the ability of the soil to immobilize the metal cations. The metal anions should be analyzed in each waste to determine levels that will be land applied, and to determine if there may be conditions for potential plant toxicity.

Soil pH also affects metal availability to plants. Except for molybdenum, the lower the pH, the more soluble the metal in the soil. In order to avoid high metal availability to plants the soil pH should be maintained at 6.5 or above during and after waste application. This soil pH level will promote the formation of insoluble metal compounds that can immobilize most metals. Most soils are normally more acidic (lower than 6.5) and will require regular sampling to determine soil pH. If pH adjustment is required, agricultural grade limestone should be applied at rates slightly higher than normally recommended for crop production. Before waste application, lime should be applied and incorporated for maximum effectiveness, but after waste application begins, surface liming is usually followed to maintain soil pH. In some instances where soils are acid and incorporation is not possible, surface applied lime will require considerable time to change pH.

SECTION 2

SOIL PROPERTIES

Terms of Interest

Soil Properties	Leaching Potential
Soil Texture	Traffic ability
Soil Structure	Shrink Swell Potential
Mottle	Soil pH
Soil Horizon	Nutrient Availability
Permeability	Cation Exchange Capacity
Infiltration	Metal Immobilization

Study Questions

1. Site evaluation, _____ _____, and site management all begin with an assessment of _____ _____.
2. The potential for runoff depends on:
   1.) _____
   2.) _____ infiltration.
   3.) _____ of the soil.
   4.) Amount of _____ _____.

3. Soil particles are classified in 3 groups:

   1.) _____

   2.) _____

   3.) _____

4. Mottling is caused by a _____ of _____.

5. Fragipans are soil horizons that are very _____ and very _____.

6. Soil textures affect:

   1.) _____

   2.) Plant _____

   3.) _____ absorption

   4.) _____

   5.) _____ _____

   6.) _____ retention

   7.) _____ matter

SECTION 3

SITE SELECTION

SECTION 3

SITE SELECTION

Any land site on which a suitable vegetative cover or crop can be grown or produced using agricultural practices holds potential for beneficial use of waste materials. The focus of this section will be to distinguish suitable sites from less suitable sites. The more suitable sites can accept wastes in nearly any form and with few restrictions on application timing other than those imposed by the growing plants. Less suitable sites may restrict the type or form of waste, the method of application, and the timing of the application. These sites are likely to be more expensive to manage because additional waste processing may be needed, storage may be needed during some periods, or special practices may be needed to alter problems such as steep slopes, karst features (sinkholes), high water tables, and restrictive soil layers.

Site selection involves the recognition of soil, plant and regulatory factors that will be addressed in this section. Soil factors will be discussed to act as guides in selecting potential sites. Regulatory factors will be listed in order to relay the restrictions imposed during the selection process.

A. Soil Suitability

The ideal soil should be deep, well drained, and silt loam textured. It should have a black or dark brown colored surface, and reddish-brown or yellowish-brown subsoil. It should not be mottled with gray to a depth of 40 inches. The subsoil should have no restrictive layers within 40 inches. The structure should be stable, and the soils should have a low shrink-swell potential.

The ideal soil should allow water to enter and pass through easily, but not too fast. The infiltration rate should be moderate to rapid, and the permeability should be moderately slow to moderately rapid throughout. This soil should be nearly level to gently rolling with slopes between 0 and 3%. The site must not be on an active floodplain.

Very few soils qualify as ideal for waste application. Most depart in at least a small way, for at least one of the critical properties. Those soils that have only a few small departures are still suitable for land application of wastes; their limitation can be overcome easily with a minimum of special management practices. The greater the number of properties that depart from ideal and the greater the degree of departure, the more severely limited the soil. Often soil suitability for land application depends as much on interactions among several soil properties as it does on individual properties. The soil property information is contained in a soil survey report of an area. The reports are published cooperatively by the Natural Resources Conservation Service (formerly the Soil Conservation Service), the University of Kentucky, and the Kentucky Division of Conservation. By reviewing the soil profile description, each horizon will be described. Instructions for Table 1 listed below: (1) find the descriptions of the soil types that are present at the potential landfarming site; (2) by reading the soil type descriptions, find the soil texture of the horizon that has the most clay content; (3) then determine from the description whether any horizons contain gravel; and (4) determine the depth of the soil profile above bedrock. By using this information, Table 1 will rate general soil suitability for land application of wastes as excellent, good, fair, or poor. Those soils rated as

excellent or good are most suitable for land application. Those rated as fair or poor are generally unsuitable.

Table 1.

Depth/texture rating for land application.

Subsoil Texture	Coarse fragments	Depth to bedrock (in.) >40	20 – 40	<20
Loam	None	E	P	P
	Gravel	G	P	P
Silt loam	None	E	P	P
	Gravel	G	P	P
Clay loam	None	G	P	P
	Gravel	G	P	P
Silty clay loam	None	G	P	P
	Gravel	G	P	P
Silty clay	None	G	P	P
	Gravel	F	P	P

E = excellent; G = good; F = fair; P = poor

Use texture of subsoil horizon that has highest clay content.

A general rating of soil drainage and permeability can be obtained from Table 2. Soil type descriptions will list drainage and permeability categories within the first paragraph. Soil types are divided into two general classes: Those with uniform permeability and those with a restrictive layer (fragipan or claypan) present. Soil types

with ratings of E/E, G/E, or G/G are generally suitable for landfarming wastes. Other classifications are generally unsuitable or they will have some problems in adequately handling wastes throughout the year.

Table 2.

Drainage/permeability rating for land application.

	----Drainage class----			
	WD	MWD	SWPD	PD
Soils with uniform permeability				
Rapid & moderately rapid	G/E	G/E	F/G	F/P
Moderate & Moderately slow	E/E	E/E	G/E	F/G
Slow	G/E	G/E	F/G	F/G
Soils with slowly permeable restrictive layers				
>40 in. depth to layer	E/E	G/E	F/G	F/P

E = excellent; G = good; F = fair; P = poor

WD = well-drained; MWD = moderately well-drained;

SWPD = somewhat poorly drained; PD = poorly drained.

Infiltration ratings for land application are dependent on classification of soil structure terms for the surface horizon found in the soil survey reports into more broad categories. For using Table 3, the following categories are used:

Table term	Soil survey report term(s)
Weak	Weak, moderately weak, very weak
Moderate	Moderate, medium

Strong	Strong, moderately strong, very strong
Massive	Massive, structureless

In the infiltration rating, texture, structure, organic matter, and shrink-swell potential interact to control the rate of water or liquid entry into the soil. Soils rated as E or G/E are generally suitable for landfarming.

Table 3.

Infiltration rating for land application.

(Use only surface horizon data.)

		Loam Silt loam	Clay loam Silty clay loam	Silty clay Clay	
Structure Grade	Organic matter			Shr. – Sw. L-M	H
Weak	0-1%	F/G	F/G	P/F	P
	1-3%	G/E	F/G	P/F	P
	>3%	G/E	G/E	F/G	P
Moderate	0-1%	G/E	G/E	P/F	P
	1-3%	G/E	G/E	F/G	P
	>3%	E	E	F/G	P
Strong	0-1%	G/E	G/E	F/G	P
	1-3%	E	E	F/G	P
	>3%	E	E	G/E	P
Massive	0-1%	P/F	P/F	P/F	P
	1-3%	F/G	P/F	P/F	P

>3%	F/G	F/G	P/F	P

E = excellent; G = good; F = fair; P = poor

Shr.-Sw. = shrink-swell potential from soil survey report.

(L-M = low to medium; H = high)

Use of sloping sites for land application depends not only on the degree of slope but also on the infiltration rate and the type and density of plant cover. In addition, depth to any restrictive layer can limit infiltration into the soil. In Table 4, the infiltration rating from Table 3 is used to determine soil suitability.

Table 4.

Slope effect rating for land application.

(Depth to restrictive layer is greater than 40 inches.)

	Infiltration rating (Table 3)				
Slope (%)	E	G/E	F/G	P/F	P
0-3	E	G/E	G/E	G	G
3-8	E	G/E	G	F	F
8-15	G	F/G	F	P	P

B. Regulatory site restrictions

A few site and soil factors are specified for evaluating potential land application sites in Kentucky. These specified factors are contained in the Kentucky Administrative Regulations (KAR) dealing with siting requirements for landfarming special waste (401

KAR 45:100 Sec. 5) and solid waste (401 KAR 48:200 Sec. 7). These factors may reduce or limit the land area available at a potential site.

The following are regulatory siting requirements:

a. The site cannot be located within a 100-year flood plain unless the waste is to be injected or if surface applied, incorporation applies regardless of the density of vegetative cover.

b. The site must have soil that is at least 4 ft. deep over such restrictive layers as bedrock, and the seasonal high water table.

c. The soil is not suitable if the permeability rate is less than 0.2 in. per hr. or greater than 6 in. per hr. Suitable soils would include the following permeability classes: moderately slow, moderate, and moderately rapid.

d. The slope can be no greater than 15% for any soil area used for land application.

e. Land area is required to be maintained as a buffer zone between a land feature, object or structure and the land application area. These minimum buffer distances between the land application area and the listed feature are as follows depending on the method of land application:

Buffer zones for special wastes (401 KAR 45:100)

Application Method

Structure Or Object	Subsurface injection or incorporation	Surface application
Residences & Occupied building	200ft.	300ft.
Water well	200ft.	300ft.
Surface water body	200ft.	300ft.
Karst feature	200ft.	300ft.
Perennial stream	200ft.	300ft.
Intermittent stream	30ft.	50ft.
Ephemeral stream	30ft.	50ft.
Property line	30ft.	50ft.
Public road	30ft.	50ft.

At this time, landfarming solid wastes require slightly different distances for buffer zones as follows:

Buffer zones for solid wastes (401 KAR 48:200)

Application Method

Structure Or Object	Surface Injection	All other means of application
Residences & Occupied buildings	250 ft.	500 ft.

Drinking water well	250 ft.	500 ft.
Surface water body	250 ft.	500 ft.
Intermittent stream	250 ft.	500 ft.
Karst feature	250 ft.	500 ft.
Public road	30 ft.	50 ft.
Ephemeral stream	30 ft.	50 ft.
Property line	30 ft.	50 ft.

C. Procedures for site evaluation

When evaluating potential sites and soils at those sites, it should begin by locating the site on a soil survey report and USGS topographic map. Making a list of the soil type names located within the potential site and checking distances to features listed in the tables above should follow this. The names or symbols should be compared to the description of the soil types in the soil survey reports to determine if the regulatory criteria are met for all soils.

Once regulatory criteria are met, then proceed to establish a rating for each soil type at that site using Tables 1 through 4 listed above. The soil areas rated poor (P) for any grouping should be removed from consideration as suitable as these areas will either be severely limited in their use for land application or require costly alterations to make them suitable. When most soils are rated as fair (F) in the potential site, then an on site-visit should determine actual properties. In addition, when most soils are rated as good (G) or (E) for the soil properties you can proceed to make further assessments of the site. However, an on-site visit should be scheduled before finalizing the soil properties.

This on-site visit may require the help of personnel from the Natural Resources Conservation Service (NRCS) located in your county, or the services of a consultant who may be involved in permit preparation. The published soil survey reports are excellent tools for site evaluation. However, soil survey reports cannot resolve differences that are smaller than four or five acres. This is due to the scale of the soil map, not the general accuracy of the survey report.

During the on-site visit, the soil properties should be determined and recorded on a map of the area. In addition, there should be identification of structures, objects and land features that are to be located on the map. Then buffer zones should be measured and adequately marked on the map and in the field. This can lead to a final measurement and determination of suitable land area for waste application.

A geologic investigation related to groundwater must also be conducted. This step is the basis of developing a groundwater assurance plan that must be submitted in addition to the soil information. This investigation begins with obtaining a geologic map of the area (available from the Kentucky Geological Survey). The proposed site should be located on the map, which will help in identifying any karst features, springs or wells.

SECTION 3

SITE SELECTION

Terms of Interest

Site Selection

Buffer Zones

Soil Suitability

Ideal Soil

Kentucky Administrative Regulations

Kentucky Statutes

Groundwater Assurance Plan

Karst Terrain

Study Questions

1. Site selection involves the recognition of:

   1.) Soil

   2.) _____

   3.) _____ factors.

2. The recommended procedures for evaluating a potential site:

   1.) Locate site on a _____ topographic map

   2.) Identify and rate _____ types.

   3.) Check distances for _____ zones.

   4.) Conduct on-site visit to verify _____ properties.

   5.) Identify _____ and _____ that may not be on topo maps.

6.) Conduct _____ investigation relating to groundwater.

3. A slope can be no greater than _____% under Kentucky regulations for any area that is to be used.

4. Soil types are divided into two general classes:

1.) _____ permeability.

2.) _____ layer present.

SECTION 4

SOIL AND CROP MANAGEMENT

SECTION 4

SOIL AND CROP MANAGEMENT

Designing, implementing and evaluating a plan for land application of wastes requires working within the landowner's or site operator's existing management system and the limitations imposed by regulations affecting the land application process. Waste utilization may have some effect on crops to grow, the crop rotations to use, lime requirements of the area, and conservation practice needs of the area. Crop management will dictate when a field is accessible, the frequency of waste applications, the expected amount of some nutrients that can be applied, and the application methods. Some limitations will be imposed on landowners by the various programs of the ASCS/USDA that may affect timing of seeding, and practices needed to control erosion for some identified soil areas that are part of the Food Security Acts of 1985 and 1990.

Landowners or contractors need to determine whether a farm conservation plan is on file for the proposed landfarming area from the local NRCS office. The Food Security Acts require that all land be assessed for erodibility as defined in this legislation. The landowner may be required to file a farm conservation plan for all cropland. Without this assessment and conservation plan, both the landowner and any person leasing any part of the farm may lose USDA program benefits on all land that they either own or lease. The farm conservation plans must be fully implemented by January 1, 1995.

A. Crop Choice

Pasture and grasses for forage offer the greatest flexibility for land application as access is not as limited by the crop's growth stage. In many cases wastes can be applied

when ever climatic and soil moisture conditions are favorable. The sod created by these crops also promotes infiltration, reduces erosion and enhances site trafficability.

Some disadvantages that should be considered include: (1) wastes cannot be incorporated without damaging some percentage of the crop; (2) about 50% of the ammonium form of nitrogen is lost following surface application of wastes; (3) some physical benefits of wastes cannot be fully realized with surface applications; (4) subsurface injection of liquid wastes will reduce stand of an established sod; and (5) there is usually a waiting period between the last waste application and either animal grazing or hay harvesting.

Grain crops are well suited for waste application, although frequency may be limited to a single annual application about 1 month prior to planting. With the necessity of reducing tillage for crop production, many land areas will be limited to surface applications of wastes without incorporation. In Kentucky, the fall application of wastes should only be utilized when cover crops or fall seeded small grain crops can be successfully seeded. Rates should be limited to recommended nitrogen based on nitrogen that could move to the groundwater through leaching during the heavy rainfall months of the winter.

There are some restrictions (covered in the Regulations section) under certain conditions on the type of crops that can be grown on waste amended soils. These include direct food chain crops, those directly utilized by humans and those fed to animals, which in turn are consumed by humans. Legumes such as alfalfa, vetch, clovers (red or white flowered), lespedezas, and soybeans all have the ability to fix nitrogen from the air that is needed for plant growth. Therefore, they take up very little soil nitrate arising from

decomposition of the waste materials. Waste applications to legumes will result in excessively available nitrogen that has the potential of being leached to the groundwater.

B. Soil Testing

Soil testing is the basis for planning, designing and evaluating good management of nutrients for crop programs using waste materials as nutrient sources. This practice is essential in evaluating available nutrient supplies in soils at proposed sites and for formulating lime and nutrient recommendations prior to land application. Samples will need to be obtained as part of the site evaluation and planning process after determination of the final available land application areas (subplots). This will serve as the basis for determining nutrient recommendations that affects crop choice and rate of waste application. The continued monitoring of available nutrients will require that samples be taken annually from the land application areas.

Getting a good sample is essential for obtaining reliable soil test information and recommendations. Guidelines for taking and handling soil samples are listed in AGR-16 (Taking Soil Test Samples) published by the Cooperative Extension Service (See Appendix). Each sample should represent an area no larger than a subplot to which wastes will be applied (20 acre maximum).

Soil test levels for phosphorus and potassium are the basis for recommendations for crop needs. The soil pH denotes the current soil pH, and the buffer pH is used to make lime recommendations to achieve the minimum pH (6.5) necessary for waste application. Since nitrogen soil values fluctuate so widely in soils due to environmental and biological conditions, there is no soil test used to predict nitrogen recommendations. Instead the nitrogen recommendations result from long-term research studies under

controlled conditions with the various crops. These studies determine crop yield following rates of nitrogen addition, which is then formulated into recommendations.

C. Nutrients

Most wastes contain all of the nutrients needed for plant growth but the ratio of nutrients in the wastes is not commonly the same ratio as required by plants. Wastes should be viewed as fertilizer products for growing plants just like commercially obtained fertilizer materials. Research has indicated that nutrient availability over time is different for wastes as compared to commercial fertilizers, and not well defined because of the different materials that make up the waste. However, once a waste nutrient becomes available to the plant through the various decomposition processes, it will have the same effect on plant growth as the nutrient would if obtained from a commercial fertilizer source.

The amount of nutrients needed for producing various crops are suggested through nutrient recommendations listed in AGR-1 (Lime and Fertilizer Recommendations) as published by the Cooperative Extension Service (See Appendix). The lime and nutrient recommendations are based on long-term research to correlate soil test data and nutrient application data with crop nutrient needs on crops that are to be grown where wastes are to be land applied. Once nutrient recommendations are obtained, any residual levels from previous nutrient or waste applications must be subtracted to determine the current year's needs. This value will then be used to determine waste application rate based on nutrient availability from the waste.

Currently Kentucky is using nitrogen (or cadmium) as the determining factor for the annual rate of waste application. Some wastes will deliver more phosphorus and

potassium to the soil than is removed by the growing crop. These excesses add to the nutrient pool or levels of available nutrient in the soil. When wastes are continually applied over a long period of time, especially on the surface without incorporation, there is some concern for phosphorus and potassium build up at or near the soil surface. This can become important for the quality of runoff water thus placing more importance on controlling both runoff and erosion from a land application site.

Another factor influencing land application is liming to raise soil pH. Because soil pH affects metal immobilization and has a minimum level (6.5 or higher) that must be maintained at each site, it becomes important in crop and soil management. Farmers usually apply lime only when there is an economic benefit based on the crop and the lime recommendations. With land application of wastes, the need to reach and maintain the minimum regulatory level determines the frequency and the rate of lime application. In most cases, the subplot should receive more lime than is needed for economic crop growth thus the lime rate will be higher than that recommended for normal crop production.

D. Conservation Practices

Runoff, run-on, and erosion control are essential to land application of wastes. Overland flow from the site (runoff) increases the potential for contamination of surface waters. Water flowing to the site (run-on) may increase the runoff and the amount of water that needs to be safely handled at the site. Erosion increases sediment loads to surface waters and may carry waste solids to the surface waters.

Conservation practices are designed to slow down water velocity and increase infiltration. Sod crop plant covers (pasture and hay) are very successful in slowing water

runoff and increasing infiltration. Reduced or no-tillage methods are highly successful in reducing soil erosion and increasing infiltration for grain crops due to the residue cover that remains on the surface throughout the year.

As slope increases, the emphasis on conservation practices increases. More permanent sod crops are particularly valuable for controlling erosion. No-tillage methods are recommended for grain crops. In several cases it may be necessary to adopt practices such as planting row crops on the contour, and growing row crops in strips alternated with strips of sod crops. Some sites may require the construction of diversion terraces to interrupt the down slope water flow to avoid runoff reaching a high velocity. There should be an initial on-site determination of the need for these practices by personnel from the local Natural Resources Conservation Service office. In many cases, these practices may be needed as part of the farm conservation plan that must be in place for maintaining compliance with the Food Security Acts of 1985 and 1990. The farmer or landowner will need to review these needs with the local Agricultural Stabilization and Conservation Service (ASCS) office administering farm programs.

SECTION 4

SOIL AND CROP MANAGEMENT

Terms of Interest

Crop Management	Subsurface Injection
Food Security Acts	Infiltration
AGR-16	Trafficability
Soil Conservation Service	Legumes
USDA	Subplot
Grain Crop	Metal Immobilization

Study Questions

1. Crop management is important because it will dictate:
   1.) When a field is _____.
   2.) _____ of waste application.
   3.) Expected amount of some _____ that can be applied; and
   4.) Application _____.
2. _____ and _____, as a crop choice offer the greatest flexibility for land application.
3. Legumes such as alfalfa, vetch, and clovers have the ability to fix _____ from the air that is needed for plant growth.
4. The maximum acreage one composite soil sample can represent as a subplot is _____ acres.

5. Laboratory results must be reported to the division in _____ and _____.
6. The Division's approved method for analysis of soils and sludges is the E.P.A.'s _____ test method.
7. Metal immobilization is affected by soil _____.

SECTION 5

REGULATIONS

SECTION 5

REGULATIONS

The general principles for regulating land application of wastes involves two factors: (1) provide overall environmental safety in reducing any potential harmful effects from wastes; and (2) maintain a consistent recognition of limits for the land to adequately process wastes. Landfarming is the regulatory term used to define the application of wastes to land for the purpose of beneficial reuse and disposal that does not alter land topography nor disturb the soil below three feet from the surface.

In Kentucky, the legislature enacts legislation, which is codified in the Kentucky Revised Statutes (KRS). These statutes allow regulations to be developed, put in place and enforced. The Cabinet promulgates Kentucky Administrative Regulations (KAR) for Natural Resources and Environmental Protection, Department for Environmental Protection, Division of Waste Management at the direction of KRS Chapter 224. These regulations appear under several Chapters of 401 KAR, which are included in the Appendix.

In general, the regulations are divided into several specific sections but they will be discussed as definitions, environmental performance standards, required analysis, permits and the permitting process, operator certification, monitoring and fees. Operating requirements will be discussed as part of the section on operation and management.

A. Definitions

At the beginning of each chapter or the first section of any regulations there may be a section defining terms needed for that particular chapter or section. Most of the definitions needed for landfarming are listed in 401 KAR 30:010.

Landfarming applies to a category of special or solid wastes. These are defined in KRS 224.50-760 and KRS 224.01-010, respectively. Special wastes are those wastes of high volume and low hazard which include mining wastes, utility wastes (fly ash, bottom ash, scrubber sludge), sludge from water treatment facilities and wastewater treatment facilities, cement kiln dust, gas and oil drilling muds, and oil production brines; or other wastes as designated by the cabinet. Generators of special wastes shall register with the Cabinet and are subject to provisions of KRS 224.46-510, except generators of coal mining wastes, which are regulated under KRS 350.

Solid waste includes any type of garbage, refuse, sludge, and other discarded material, including the solid, semi-solid, liquid, or contained gaseous material resulting from industrial, commercial, agricultural, and mining operations (excluding coal mining wastes, coal mining by-products, refuse and overburden). This waste does not include sand, rock, gravel, or bridge debris extracted as part of a public road construction project, recovered material, special wastes (KRS 224.50-760), solid or dissolved material in domestic sewage, manure, crops, crop residue, or a combination of wastes which are returned to the soil as fertilizer or soil conditioners. Further, solid waste does not include solid or dissolved material in irrigation return waters, industrial discharges (point sources), or nuclear wastes classified as nuclear source, by-product or special nuclear.

For other wastes not specifically designated as special wastes by law there are criteria and procedures (401 KAR 45:210) followed by the Cabinet in making this designation. The criteria seek to more clearly define both volume and hazard of the waste. Any waste generated at greater than 1,000,000 metric tons at a Kentucky facility during the year shall be classified as a special waste. The waste must also be of low hazard meaning (1) there is a low probability that disposal or landfarming the waste would violate provisions of the environment performance standards (EPS) (401 KAR 30:031); (2) the waste is not classified as hazardous (401 KAR Chapter 31); (3) the primary waste is not mixed or co-disposed with another solid waste or hazardous waste; (4) the waste has a pH between 4.5 and 10; and (5) the level of waste constituents does not exceed the maximum levels of arsenic, barium, cadmium, chromium, lead, mercury, nitrate, selenium and silver specified in 401 KAR 30:031. When wastes are designated as special wastes then all regulations applying to special wastes must be followed.

B. Environmental Performance Standards (EPS)

The environmental performance standards (special waste, 401 KAR 30:031 and solid waste, 401 KAR 47:030) are standards imposed by regulation to determine whether the waste or landfarming site has any potential adverse effects on human health or the environment. These standards provide minimums for (1) floodplain location; (2) effects on endangered species; (3) surface water pollution; (4) groundwater contamination; (5) food chain crop culture; (6) disease vectors; (7) polychlorinated biphenyls (PCBs) in waste; (8) air emissions; (9) safety; (10) public nuisance; (11) wetland designation; and (12) karst terrain. For some factors (surface water, groundwater, food chain crops, and

PCBs), they list specific chemical values that cannot be exceeded during operation of a landfarming facility or as a result of regular monitoring.

C. Required Analysis

Any waste material that is to be landfarmed should be analyzed for several chemical and physical parameters to determine its suitability for land application. This information will also allow calculation of application rates for landfarming. As discussed previously, soils at the site should be analyzed before land application begins to determine the levels of available nutrients that affect the recommended amounts of nutrients that are needed for crops, and to determine if the soil pH should be modified with lime applications before landfarming begins.

1. Waste analysis

The following chemical analyses are to be conducted on a representative sample of the waste:

% Total solids	% Volatile solids
% Total phosphorus (P)	% Total potassium (K)
% Total (Kjeldahl) nitrogen (N)	% Ammonium nitrogen
% Nitrate nitrogen	pH
Total cadmium (Cd)	Total chromium (Cr)
Total copper (Cu)	Total nickel (Ni)
Total lead (Pb)	Total zinc (Zn)
Total polychlorinated biphenyls (PCBs)	

In some cases the waste will need additional analysis based on materials contributing to the waste in order to avoid potential toxic effects on several crops. These include boron (B), molybdenum (Mo), selenium (Se), and total alkalinity to mention a few. When considering the application of utility wastes, some of which may have value as a liming agent, the calcium carbonate equivalent should be determined. Oil drilling wastes and oil brines may need an analysis for polyaromatic hydrocarbons (PAHs). ***If the waste is domestic sewage sludge, waste analysis must also include total arsenic (As), total mercury (Hg), total molybdenum (Mo), and total selenium (Se), to meet federal requirements.***

Metal concentration values shall be determined and reported on a dry weight basis (401 KAR 45:100 Section 2(7)). Metal analysis of wastes shall be determined in the undried (or as-received basis) sample and converted to dry weight basis using percentage solids according to the following formula: milligrams/liter (mg/L) or milligrams/kilogram (mg/kg) wet weight divided by (% solids/100) = mg/kg dry weight.

2. Soil analysis

During the site evaluation, soil samples should be taken according to a plan approved by the Cabinet or as outlined in AGR-16. The sample should be split into two subsamples after mixing. One subsample should be submitted to a laboratory for analysis of cadmium, chromium, copper, nickel, lead, zinc and PCBs, and the other subsamples should be submitted to the local county Extension agent for agriculture to determine the following analysis, and to receive nutrient recommendations for crops and any lime recommendations.

Soil pH Buffer pH

Extractable phosphorus Extractable potassium

Total cation exchange capacity (CEC)

Extractable nutrients will be reported as pounds per acre and CEC will be reported as milliequivalents per 100 grams (me/100g) of soil. The recommendations for nitrogen, phosphate and potash will be recommended as lbs/acre of N, P_2O_5, and K_2O per acre, respectively.

D. Permits and Permitting Process

All facilities or sites involved in landfarming special or solid wastes must have a permit. The permit must be approved before any construction or operation can begin at the site. This section will discuss the types of permits and the process involved in obtaining a permit from the Cabinet to construct and operate a landfarming facility. The Cabinet issues two general types of permits for landfarming depending on the type, the chemical analysis, and the volume of waste. The permitting procedures and standards for special wastes are established in 401 KAR 45:030, 45:050, 45:060, 45:070, and 45:100, which appear in the Appendix. For land application of domestic sewage sludge, a federal permit may also be required. The Division of Waste Management can assist you in determining if your facility must also obtain a permit from the U.S. Environmental Protection Agency.

Special Waste

1. Types of permits

There are five types of permits (401 KAR 45:020 and 401 KAR 47:080) that may be issued by the Cabinet depending on the particular waste, intention and nature of the landfarming facility.

a. Permit-by-rule

Facilities or sites are granted this type of permit through specific wording in the regulations. Facilities declared to have this type of permit do not have to make application or register with the Cabinet. Examples as stated in the specific regulations (401 KAR 45:060) may include the following facilities related to landfarming special wastes:

1.) Oil production brine pits, and gas and oil drilling mud pits during the active life of the pit.

2.) Surface impoundments that are part of a domestic sewage treatment process and that do not contain industrial wastewater.

3.) An active site for coal mining also used to dispose of fly ash, bottom ash, and scrubber sludge (combustion wastes).

4.) Surface mining or other special waste impoundments having a KPDES permit.

5.) Temporary storage of special waste piles.

6.) Facilities reusing combustion wastes as an ingredient for manufacturing other products (Examples: concrete, cement,

paint, plastics, roofing granules, blasting grit, mine stabilization, etc.).

b. Registered permit-by-rule

This permit category is a registration process used by the Cabinet for certain special waste facilities. They will have a permit following a complete registration by the owner or operator that involved required form submission, review, and acknowledgment. The complete process involves specifying the special waste, sources, amount to be handled, storage, and methods of treatment, mixing and disposal. Some facilities that may require a registered permit-by-rule related to landfarming include (401 KAR 45:070):

1.) Facilities engaged in sludge giveaway.
2.) Facilities storing and treating special waste not specified in the section on permit-by-rule.
3.) Facilities that store or landfarm compost.

When the registered permit-by-rule has been acknowledged by the Cabinet it is expected that the facility will comply with the environmental performance standards (401 KAR 30:031). Anytime the permit holder wishes to include a new waste, change capacity or change the processes for storage, treatment, reuse, or final disposal of the special wastes at the facility, they must submit a revised registration form to the Cabinet.

c. Emergency permit

The Cabinet may issue an emergency permit that allows for the temporary storage or disposal of a special waste that poses an imminent threat to human health or the environment (401 KAR 45:135). This type of permit may only be issued when the immediate need to store, process or dispose of the special waste greatly outweighs the time required to process a required permit more directly related to the classification of the waste.

Certain conditions affect the issuance, duration and operation for an emergency permit. An emergency permit:

1.) Shall be given orally or in writing but if given orally, a written request must be forwarded to the Cabinet within five days.
2.) The duration shall not exceed 90 days.
3.) The request shall clearly specify the special wastes, the site location, method of treatment, storage, and disposal.
4.) The Cabinet may terminate when there is a potential threat to human health and the environment.
5.) All operation conducted for the duration of the permit shall be conducted within the limits of the environmental performance standards (401 KAR 30:031).
6.) Any wastes remaining at the site after 90 days are to be moved to a properly permitted site.

d. Research, development and demonstration permit

This category of permit may be issued by the Cabinet for a special waste or facility that seeks to demonstrate unproven technology related to either the waste or to handling, treatment or disposal. Requests for this type of permit are handled on a case-by-case basis which may take additional time and require that the request be accompanied by large amounts of additional information for the Cabinet to review before issuance. The request is made on form DEP 7094B entitled "Application For A Research and Demonstration Permit" and must demonstrate one of the following (401 KAR 45:135):

1.) That the process for storage, treatment, handling, or disposal is unique, innovative and experimental.
2.) That insufficient information exists on the characteristics of a special waste for the Cabinet to make a classification.
3.) That permit standards have not been established by the Cabinet for the waste, the process or disposal.

Research, development and demonstration permits may be issued for a period of up to 2 years and may be renewed one time for another 2 year period. All environmental performance standards (401 KAR 45:030) must be followed. Financial assurance requirements as specified in 401 KAR 45:080 must be met. The Cabinet may impose restrictions on wastes, processes or disposal, and provide standards for construction and monitoring.

e. Formal permit

Notice of Intent to Apply

To begin the formal permitting process, the Notice of Intent is submitted to the Cabinet. This Notice of Intent is submitted by those persons, businesses or municipalities to indicate their intent to apply for a required permit. The Cabinet should be contacted at the following address or by telephone to obtain the necessary form:

Division of Waste Management
14 Reilly Road
Frankfort, KY 40601
Telephone: (502) 564-6716

Upon review of the Notice of Intent, the applicant will be notified as to what type of permit application will be required.

The interested parties should request and must submit form DEP 7021A entitled "Notice of Intent to Apply for a Special Waste Landfarming or Composting Permit" (May 1992). The Cabinet classifies a waste landfarming facility as either a Type A or Type B depending on the following criteria of volume and chemical analysis of the special waste:

Type A

Greater than 250,000 gallons of liquid waste or 250 tons of dewatered waste per calendar year regardless of chemical analysis of waste.

Type B

Less than 250,000 gallons of liquid waste or 250 tons of dewatered waste per calendar year.

Waste Classification based on Analysis

Chemical Element	Concentration (ppm or mg/kg) Type A	Type B
Cadmium	>10	≤ 10
Copper	>450	≤ 450
Lead	>250	≤ 250
Nickel	>50	≤ 50
Zinc	>900	≤ 900

If any one element of the Type B category exceeds the listed values for 2 consecutive

samples taken one month apart, then the waste will be classified as Type A.

A waste landfarming facility shall be re-evaluated each year based upon the annual analysis section of the annual review forms and records submitted to the Cabinet. This re-evaluation will be based on the volume and chemical analysis listed above.

The formal permitting process (401 KAR 45:030) will involve discussion of a complete application, public information procedures (401 KAR 45:050), application review, financial assurance requirements (401 KAR 45:080), surface and groundwater monitoring plan (401 KAR 45:160) and permit issuance or denial. The entire process will be required for all facilities classified as needing a Type A landfarming permit.

The permitting process for Type B facility permits may be exempt from publishing a public notice, posting a financial assurance, and monitoring of groundwater. However, the Cabinet may require groundwater monitoring after a review of geological or related factors submitted with the application.

The request for a landfarming permit involves the submission of form DEP 7021B entitled "Application for a Special Waste Landfarming Facility Permit" which occurs at the direction of the Cabinet and after filing the "Notice of Intent to Apply for a Special Waste Landfarming or Composting Permit". Since the application is very extensive, some assistance may be necessary in providing technical data for the application. The application should forward to the Division of Waste Management, 14 Reilly Road, Frankfort, KY 40601.

The Cabinet will determine if the application is complete, and the applicant will be notified that the application is complete. If incomplete, the Cabinet will outline the

deficiencies and the applicant will be given time to add the requested materials or information.

The permit application must include form DEP 7094J "Past Performance Information" (March 1992) which can be obtained from the Cabinet.

When the Cabinet determines the application to be complete, the applicant shall publish a public notice (Type A permits) supplied by the Cabinet in the newspaper with local coverage of the proposed site. The general public will be given 30 days from the data of publication to submit comments and/or request a public meeting based on interest and the need for information on the proposed landfarming site.

After the public meeting, the Cabinet will proceed to review the application. The personnel in the Cabinet may use other published information that is readily available to assist in making a decision on the application.

Following a review of the application, supporting materials, and any other available materials, the Cabinet will make a preliminary determination to issue, modify or deny the permit. If the Cabinet makes a preliminary determination to issue the permit, a draft construction permit shall be prepared containing the proposed design and operational specifications. If the Cabinet makes a preliminary determination to deny the permit application, it shall issue a notice of intent to deny. If the Cabinet makes a preliminary determination to modify a permit, a modified draft construction permit shall be prepared containing the proposed changes in design and operational specifications.

When the applicant is notified that either a draft permit or a modified draft permit has been issued, the permit applicant shall publish a public notice, supplied by the Cabinet, in the local newspaper. The public will be given 30 days following the

publication date for a public comment period and to request a formal public hearing before an appointed hearing officer.

After the close of the public comment period and completion of the hearing process, the Cabinet shall issue a decision to either issue or deny the construction permit. This construction permit will be in effect until a Cabinet representative has inspected the site and verified, within 30 days, that the applicant has developed the site according to plans approved for the construction permit.

Before a formal construction/operation permit can be issued, the applicant is required to post financial assurance on form DEP 7094E entitled "Performance Bond" (March 1992). This requires a worst-case dollar estimate of the cost of closing the site or facility by a third party if that should become necessary, and the guarantee that money will be available for such closure.

With the satisfactory completion of all factors under the construction permit, the Cabinet may issue a formal permit for operation of the landfarming site for a term not to exceed ten (10) years. The Cabinet will review the conditions of the permit after five years and modify the permit if necessary.

Solid Waste

Permitting procedures and types of permits for landfarming solid wastes are similar to special wastes. These procedures are specifically covered in the following regulation: 401 KAR 47:100, 401 KAR 47:110, 401 KAR 47:120, 401 KAR 47:130, 401 KAR 47:140, 401 KAR 47:150, 401 KAR 47:160, 401 KAR 47:170, and 401 KAR 48:200. These procedures are outlined as a matter of information. Details are listed in

the Special Waste discussion above, and the regulations to confirm any specific criteria are cited above.

1. **Formal permit process**
    a. Notice of Intent to Apply (Form DEP 7065)
    b. Application for a Landfarming Facility Permit (Form DEP 7064) and Applicant Disclosure Statement (Form DEP 7087) are submitted to the Cabinet following determination of classification.
    c. Cabinet determines application completeness
    d. Cabinet makes determination to issue or deny permit.
    e. If recommendation is to issue, applicant publishes public notice in local paper.
    f. Waiting period for hearing request – 30 days.
    g. Administrative hearing held if requested.
    h. Cabinet issues or denies permit.

2. **Other permits (401 KAR 47:080)**
    a. Permit-by-rule
    b. Registered permit-by-rule
    c. Emergency permit
    d. Research, development and demonstration permit

E. Landfarming Operator Certification

This requirement is put into place to assure both the public and the regulatory agency that adequately trained personnel are on site to assure correct and safe operation of the facility. Each landfarming facility shall have a certified landfarming operator, and the facility shall not be operated in the absence of a certified operator.

People who desire to be certified as landfarming operators shall submit an application to the Division of Waste Management (Cabinet) at least 30 days prior to scheduled training on form DEP 6031 entitled "Application for Certification" (March 1992). The Cabinet will review the application and any supporting documents to determine eligibility for examination. Examination must be preceded by training determined and scheduled by the Cabinet.

The Cabinet determines eligibility for examination based on education and experience. The applicant should have either received a high school diploma or obtained an equivalency certificate. However, the Cabinet may consider the number of years of experience in a related field, such as water treatment or wastewater treatment, in determining eligibility for examination. The applicant must have at least 1 year experience at a landfarming facility.

The successful applicant will be asked to attend and complete a scheduled training session that will include the following landfarming topics (401 KAR 45:090 Section 6 and 401 KAR 47:070 Section 7):

a. Operation and management of a landfarming facility

b. Wastewater treatment processes

c. Waste characterization

d. Chemical and biological reactions of waste

e. Landfarming design and management

f. Permit application requirements

g. Preventing regulatory violations

h. Complying with environmental performance standards

i. Evaluating site suitability

j. Maintaining landfarming equipment

k. Site and facility safety

l. Duties and responsibilities associated with landfarming operation

Following completion of the training (or acceptance of alternate training), the applicant must successfully complete an examination that is given by the Cabinet. Upon meeting all of the above requirements, the Cabinet may issue a certificate to the landfarming operator for a period not to exceed five (5) years. Certificates must be carried on the person, or prominently displayed at the landfarming facility office. If the certified landfarming operator is scheduled to be away from the facility for more than 14 days during operation, the certified operator must notify the Cabinet of his/her absence at least 10 days ahead of the absence. This notice will specify the person to be an interim operator. The Cabinet will evaluate the proposed interim operator's qualifications and declare that the full-time certified landfarming operator at a facility will be responsible for actions of the approved interim operator.

F. Monitoring

This section of the regulations (401 KAR 45:160 and 401 KAR 48:200 (6)) sets the requirements and criteria for surface and groundwater monitoring of landfarming sites and facilities. These regulations apply to all Type A special waste landfarming facilities, class II and III solid waste landfarming, and any other class of special waste application to land where the Cabinet determines that such monitoring is needed due to any special location or geologic features.

1. Type A Facilities

Any facility landfarming Type A sludge shall sample surface water quarterly at designated sites as approved in the application and permit. These shall include a minimum of 1 upgradient and 1 downgradient sampling point from the facility. Parameters to be analyzed shall include:

Water pH	Ammonium nitrogen
Fecal coliform	Biological oxygen demand
Total organic carbon	Total dissolved solids
Total chromium	

All facilities classified as Type A (special waste) or Class III (solid waste) shall propose a groundwater monitoring plan and receive approval of the plan. The groundwater monitoring system shall reflect the regional and local groundwater flows at the facility. At least 1 monitoring well shall be sampled that reflects water located hydraulically upgradient from the landfarming site. This well should be representative of groundwater not affected by the landfarming site. In addition, at least 2 monitoring wells

shall be sampled that reflect water located hydraulically downgradient from the landfarming facility. The following parameters shall be analyzed from water samples taken on a semi-annual basis (401 KAR 45:160 Section 8) and (401 KAR 48:300):

Chemical oxygen demand	Total organic carbon
Total nitrogen	Nitrate nitrogen
Total lead	Total chromium
Total cadmium	Total coliform bacteria

In addition, groundwater elevations in the monitoring well must be recorded.

2. Other Facilities

Surface and groundwater monitoring may be required by the Cabinet for other wastes or other classes of facilities according to conditions and parameters listed above for the Type A facilities. Most of these determinations by the Cabinet will be handled case-by-case based on location of the facility in respect to surface water withdrawals for potable water, and on unique geological features that may allow access to groundwater as determined by reviewing USGS maps during the permit review process.

Due to the nature of the experimental processes, treatments or landfarming methods, there is high probability that the Research, Development and Demonstration permits will require plans for monitoring both surface and groundwaters using the conditions and parameters listed for Type A facilities.

G. Fees

Fees for landfarming special waste are specifically listed in 401 KAR 45:250 of the current regulations. The fee schedule application to landfarming is as follows:

Notice of Intent	$500
Formal Application	$5,000
Request for Variance from Regulations	$500
Construction/Operation Permit	$500
Renewal	$500
Certified Landfarming Operator	$125
Emergency Permit	$500

Research, Development & Demonstration	$2,500
Change of Ownership	$500
Transfer to Existing Permit	$500

Fees for landfarming solid wastes are specifically listed in 401 KAR 47:090 of the current regulations and are summarized as follows:

Combined – Notice of Intent	
& Formal Application	$5,500
Permit Renewal	$300
Existing Permit Modification	
a. Operating parameters	$1,000
b. Proposed closure	$1,000
c. Adding a waste	$50
d. Variance	$500

e. Change of ownership	$500
f. Transfer of permit	$500
Certified Landfarming Operator	$125
Emergency Permit	$500
Research, Development & Demonstration Permit	$500

Political subdivisions in the Commonwealth of Kentucky are exempt from these permit fees. The appropriate fee must accompany each application to the Cabinet, other than from political subdivisions.

SECTION 5

REGULATIONS

Terms of Interest

PCB	Research Development & Demonstration
Permit	Cation Exchange Capacity
Permit By Rule	Formal Permit
Registered Permit By Rule	Type A and B Landfarm Facility
Emergency Permit	Operator Certification

Study Questions

1. The _____ _____ _____ allow regulations to be developed, put into place and enforced.
2. The _____ _____ _____ are imposed by regulations to determine whether the waste or landfarming site has any potential adverse effects on human health or the environment.
3. Special waste permits are categorized as:
   1.) _____ _____ - greater than 250,000 gallons of liquid waste or 250 dewatered.
   2.) _____ _____ - less than 250,000 gallons of liquid waste or 250 dewatered tons per calendar year, low concentration of metals.
4. Type B facilities shall be exempt from:
   1.) Publishing a _____ _____.
   2.) Posting of _____ _____.

3.) Monitoring of _____.

4.) Post-closure care.

5. A landfarm operator certification is valid for _____ years.

6. A _____ _____ may be issued for the disposal or temporary storage of waste in response to a situation that poses an imminent and substantial threat to human health or to the environment.

SECTION 6

LANDFARMING MANAGEMENT

SECTION 6

LANDFARMING MANAGEMENT

Management of a landfarming facility includes the consideration of regulations, crop growth patterns, weather conditions, and the soil's ability to handle applied waste while promoting plant growth. Systems of landfarming should have some plants grown in which all or part of the plant can be removed from the land area in order to reduce the nutrient load imposed by the waste application. This requires attention to good soil and crop management principles that encourage a high level of crop productivity resulting in high nutrient removal from the land area. This section will review crop and soil management guidelines, and regulations that will impose further restrictions.

A. Crop Selection and Management

Grain producing crops are the main crops that can benefit from high nitrogen containing wastes as well as the phosphorus and potassium. Most grain crops (except soybeans) have a high nitrogen requirement, which benefit from the nitrogen. These crops have an additional advantage in that heavy metals do not tend to accumulate in grain as much as in the leaves of the plants.

Annual and perennial grasses used for pasture or hay also benefit from high nitrogen containing wastes as well as the other nutrients. Because forages are fed to livestock, there is an additional step of biological processing. Surface contamination of plant material by recently applied wastes may be a special hazard to grazing animals. It is recommended that pastures or hay fields be grazed or cut short just before waste application.

Legumes (alfalfa, vetch, clovers, and soybeans) have the ability to fix nitrogen from the air for their plant needs. Therefore, these crops do not receive additional benefits from nitrogen contained in the waste. In fact, applications of additional nitrogen will result in total nitrogen supplies for the legumes that may lead to leaching or other losses, will likely reduce the legume percentage in the hay or pasture field, and will certainly decrease the nitrogen utilization from the waste.

Plants and crops vary in their ability to take up and accumulate heavy metals either in the whole plant or in different parts of the plant. Based on current knowledge of crop tolerances of heavy metals, tobacco and vegetables (lettuce, cabbage, beets, kale, mustard, radishes, turnips, tomatoes, etc.) are very sensitive. Corn, soybeans and small grains are moderately tolerant. Most forage grasses (fescue, bluegrass, timothy, orchard grass, ryegrass, etc.) are more tolerant. With any plant, the concentration of heavy metals in the vegetative tissues (stems and leaves) is much higher than in the fruits and seeds.

Nutrient recommendations based on soil test results should be used for waste application rates. In order to keep some long-term balance of nutrients on the land area, the amount of nutrients (nitrogen, phosphorus, and potassium) removed in the harvestable portion of the crop should be close to the amounts added in the waste. If an excess of addition over removal continues over a long period, there is an increasing potential of some nutrients, particularly nitrogen, either leaching into groundwater or leaving the landfarming site in surface runoff. If the harvestable portion of the crop is not removed, this excess will become important very early in the life of the landfarming systems.

B. Operating Requirements

These requirements for landfarming management are imposed by regulation (401 KAR 45:100, Section 6; 401 KAR 48:200, Section 8). They are designed to assure some consistency from site to site in operating landfarming facilities.

1. All sludges must be processed to significantly reduce pathogens (PSRP) prior to land application.
2. A certified landfarming operator shall be available at the landfarming site during application.
3. Incorporation of wastes must occur within 48 hours if incorporation is included in the management plan. ***(Sewage sludge incorporated as a means of complying with 40 CFR 503.33 vector attraction reduction requirements must be incorporated within 6 hours).***
4. Surface application without incorporation can only be used where either vegetation or crop residue covers at least 75% of the land surface.
5. Hazardous wastes or waste mixtures containing hazardous wastes cannot be landfarmed.
6. Toxic wastes should not be stored, treated or landfarmed at a landfarming facility.
7. Leafy vegetables or root crops should not be grown and harvested for human consumption within 12 months of the last waste application.
8. Other crops should not be grown and harvested for direct human consumption within 2 months of the last waste application. ***(For sewage sludge, the additional food crop restrictions of 40 CFR 503.32 (b)(5) may apply.)***

9. Dairy animal grazing is prohibited within 6 months and other animal grazing is prohibited within 3 months of the last application.
10. The annual application rate of cadmium (Cd) cannot exceed 0.44 pounds per acre.
11. Food chain crops should not be utilized in the cropping season when annual cadmium (Cd) application exceeds 0.44 pounds per acre.
12. Tobacco should not be harvested within 5 years of the last waste application if the annual cadmium (Cd) application exceeds 0.44 pounds per acre at any time during the life of the landfarming site.
13. The general public shall be restricted from the waste application area during application and for at least 12 months after the last application unless the waste has undergone a Process to Further Reduce Pathogens (PFRP).
14. Waste shall not be applied when the soil is frozen, snow-covered, ice-covered, water saturated, or during any precipitation event.
15. Waste shall not be applied at rates in excess of those approved in the permit.
16. No raw or unstabilized waste shall be landfarmed.
17. Surface waste applications shall not be greater than one-half (1/2) inch in average thickness.
18. High pressure applications that produce aerosols are prohibited.
19. Subplots are to be staked or clearly marked in the landfarming area.
20. A sign shall be posted at the entrance to the landfarming facility indicating operator name, permit number, contact person, and emergency telephone number.

21. Surface water or liquid waste ponding within the application area shall not occur.

22. Both surface runoff and run-on shall be controlled.

23. Records of all waste application rates and dates, and all laboratory analyses for wastes and monitoring are to be maintained on Cabinet-approved forms during the landfarming operation.

24. Each permit holder shall submit a form entitled "Annual Landfarming Review" (March 1992) to the Cabinet 60 days prior to the anniversary date of the permit.

25. Soil in the application areas shall be sampled and tested annually.

26. Waste shall be analyzed for percent total solids, pH, ammonium nitrogen, nitrate nitrogen, total Kjeldahl nitrogen, total phosphorus, total potassium, total PCBs, total cadmium, total copper, total lead, total nickel and total zinc to be reported as mg/kg wet and dry basis. ***(Include total arsenic, total mercury, total molybdenum, and total selenium if domestic sewage sludge, per 40 CFR 503.13).***

For sludges, the following sampling schedule is to be observed:

Design Capacity (gallons/day)	Samples/Year
<1,000,000	2
1,000,001-10,000,000	4
>10,000,000	12

(Compare to 40 CFR 503.16, Table 1)

27. Soil pH in the sampling depth shall be maintained at 6.5 or greater during any crop production or animal grazing.

28. Wastes containing > 1 mg/kg PCB should not be landfarmed.

29. The amount of annual nitrogen application should not exceed the crop utilization amount.

30. The maximum amount of cadmium, copper, lead, nickel, and zinc to be applied for the life of the site is based on the initial cation exchange capacity (CEC) of the soil and should not exceed the amounts listed below:

	Cation Exchange Capacity (meq/100g)		
Parameter	0-5	5-15	15+
	(Pounds per acre)		
Cadmium	4.46	8.92	17.84
Copper	125	250	500
Lead*	500	1000	2000
Nickel	50	100	200
Zinc	250	500	1000

Maximum lead loading for sewage sludge, by federal rule, is 267 pounds per acre.

The following equation is to be used to calculate the maximum amount of waste (tons/acre) that can be landfarmed for each of the above metals:

Tons/acre = lbs metal allowed per acre/[(dry mg/kg of metal in waste) x (0.002)].

31. If the heavy metal applications exceed the amounts listed in the above table, the owner or operator shall immediately cease application, begin closure and submit a closure report to the Cabinet. This report shall include a copy of a notice that will be placed in the deed advising all future landowners that heavy metal concentrations exceeded those allowed by regulation. ***For domestic sewage sludge, there are additional record keeping and reporting requirements in 40 CFR 503.17 and 503.18.***

SECTION 6

LANDFARMING MANAGEMENT

Terms of Interest

Annual Grass

Perennial Grass

Annual Landfarming Review

Parameter

PSRP

Study Questions

1. Prior to land application, all sludges must be _____ to _____ _____ _____.
2. The annual application rate of cadmium (Cd) cannot exceed _____ pounds per acre.
3. Incorporation of wastes must occur within _____ hours after application of wastes.
4. Surface application may be done only when established vegetation or crop residue cover is at least _____ % of the land surface.
5. Dairy animals are restricted from grazing for _____ months, all other livestock for _____ months after the last waste application.
6. Special waste shall not occur on land where leafy vegetables or root crops for human consumption will be harvested within _____ months.

7. The general public shall be restricted from the application zone for a period of _____ months after each application.

8. The required posted sign at the entrance of a permitted facility shall contain:

   1.) Indicate the _____ and type of waste.

   2.) Type of operation.

   3.) Name of the _____.

   4.) _____ number.

   5.) Contact person.

   6.) _____ telephone number.

SECTION 7

CLOSURE

SECTION 7

CLOSURE

Landfarming facilities may be closed when waste is no longer available, upon expiration of the permit, or when violations of either environmental performance standards or other applicable regulations have occurred. The Cabinet has procedures that must be followed in beginning the closure process, some of which require action before an order is received from the Cabinet.

As part of the special waste permitting process, an applicant shall have a detailed, current cost estimate of the cost of hiring a third party to close the landfarming facility. This cost estimate serves as the basic value for determining the bonding and financial responsibility requirements for a permit to landfarm Type A wastes. The Cabinet requires that the applicant post financial assurance on form DEP 7094 entitled "Performance Bond" (March 1992) for permits of Type A special wastes. Solid waste Class II and Class III Landfarming facilities are required to post a performance bond.

A. Ceasing Operations

When permanently ceasing operation of a special waste landfarming facility, the permit holder shall submit to the Cabinet a closure report that includes the following:

a. Results of final soil samples taken according to the original permit conditions. These samples are to be taken within 18 months following the last application of wastes.

b. A historical record summarizing all landfarming activities including wastes applied, rates applied to each subplot, total regulated metal (Cd, Cu, Ni, Pb,

and Zn) applied (lbs/acre) to each subplot, total nitrogen applied (lbs/acre) to each subplot, and a summary of the annual landfarming reviews.

c. A certification that the landfarming facility is closed and complies with all environmental performance standards (401 KAR 30:031).

d. Any additional information required by the Cabinet related to the permit conditions, which could include groundwater and surface water monitoring.

The Cabinet will review the submitted information and determine if additional monitoring of the site is needed for some extended period.

For landfarming facilities accepting Type A special wastes, there is a post-closure monitoring and maintenance period of 2 years required for fully complying with the closure provisions. This 2-year period begins the day after certification that the facility is officially closed. After completion of the 2-year post-closure monitoring and maintenance, the permit holder shall submit a certification that this period is complete. The Cabinet will review this post-closure certificate and either accept it or require further time for post-closure. When the post-closure certificate is accepted, the financial assurance bond will be released. All costs of post-closure monitoring and maintenance, or additional corrective action will be borne by the permit holder.

SECTION 7

CLOSURE

Terms of Interest

Closure

Post-closure

Cost Estimate

Financial Responsibility

Performance Bond

Study Questions

1. A landfarming facility may be closed when:

   1.) Waste is no longer being applied.

   2.) _____ of the permit has occurred.

   3.) _____ of the Environmental Performance Standards have occurred.

   4.) Violations of applicable _____ _____ have occurred.

2. Type A facilities are required to :

   1.) Post financial assurance.

   2.) Perform groundwater monitoring.

   3.) Enter into a _____ year post-closure period on the first day after the facility permanently ceased to accept waste.

3. When a facility permanently ceases to accept waste, the owner or operator shall submit a _____ that post closure is compete.
4. At conclusion of the two-year post-closure monitoring and maintenance period, the owner or operator shall submit a _____ that post-closure is complete.
5. The closure report shall include:
   1.) The final _____ samples taken within 18 months following the last application of waste.
   2.) _____ summary of all landfarming, by subplot, showing the allowable and _____ rates of special waste application, heavy metals and nitrogen, incorporating the annual reviews.
   3.) A _____ from the owner or operator that the site is closed an in compliance with the Environmental Performance Standards.
   4.) Any _____ _____ required by the Cabinet.

SECTION 8

SAFETY

SECTION 8

SAFETY

Safe operation of landfarm activities is only possible with the complete cooperation of all personnel participating in the operation. This cooperation will only be achieved if there is a mutual trust and respect between members of management and labor. Concern for the welfare of all employees must be evident to maintain a safe workplace. A safe workplace does not mean a workplace free of all risks. It does mean a workplace where every attempt is made, by all involved, to recognize and minimize hazards and to train each employee in the proper procedures to manage those hazards.

Landfarm operations will involve certain risks because of the potential for encounters with: heavy equipment used in processing and application, transportation hazards during collection, foreign materials contained in raw materials, vectors, pathogens, noise, dust, fire, etc. Landfarm activities will involve risk, but those risks do not need to be unreasonable. Fairness to workers require that a thorough understanding of the risks and hazards present be conveyed to them; and, that workers receive training to deal with potential hazards.

The economic impacts of unsafe operations cannot be ignored. The direct cost of treatment for injuries or disabilities, employee death, equipment and facility damage, increased insurance cost, as well as the damage to worker morale and productivity will negatively impact the success of the operation. The effects of accidents and unprotected exposure to occupational hazards can and will overwhelm operational budgets.

In addition to fairness and economic concerns, safety on the worksite is mandated by U.S. Occupational Safety and Health Administration regulations. The regulations

contained in 29 CFR Part 1910 have been adopted by the Kentucky Occupational Safety and Health Standards Board as 803 KAR 2:300 through 2:320. OSHA regulations require employers to make employees aware of hazards they face in the workplace. Additionally, they must be trained to respond to those hazards in a safe manner. While it is not in the scope of this manual to address all regulatory requirements, we will consider some of the basics.

A. Landfarm Operation Safety Programs

The day-to-day operations at a landfarm facility can be developed by evaluating the hazards encountered in the normal workday, developing procedures to reduce those hazards and implementing those procedures through a comprehensive safety program. We can generally divide associated hazards into three broad categories: these are chemical, physical and biological. We will examine the chemical hazard first.

1. Chemical Safety

a. Employee Right to Know (29 CFR 1910.1200)

The first step in developing a safety program is to identify all chemical hazards and to ensure that all employees are informed. This means that employees have the right to know the identity of all hazardous chemicals they will encounter in the workplace, understand the health effects of exposure and know and understand how to work safely with those materials. This information must be provided in writing. Generally, there are not a great number of hazardous chemicals or materials on a composting site. However, a survey and inventory should be conducted to assure the proper Materials Safety Data Sheets are available.

The Employee Right to Know Program must include the following elements.

1. All hazardous materials in the workplace must be identified;
2. Material Safety Data Sheets (MSDS) on all identified hazardous chemicals must be prepared and placed in a notebook accessible to all employees at the site;
3. Employees must be trained on the requirements of Right–to-Know legislation, the content and purpose of MSDS; and how to access all information related to the workplace.
4. All containers at the worksite must be appropriately labeled to describe contents and have appropriate hazard warnings.
5. Employees must be trained in how to handle and manage the hazards to which they could be exposed.

b. Material Safety Data Sheet (29 CFR 1910.1200)

Materials Safety Data Sheets shall be in English, available for all hazardous materials on site and shall contain the following information:

1. The chemical manufacturer's name, address and emergency telephone number, the chemical name, trade name, and chemical formula.
2. The physical and chemical characteristics of the hazardous chemical (such as vapor pressure, flash point).
3. The physical hazards of the hazardous chemical, including the potential for fire, explosion, and reactivity.
4. The health hazards of the hazardous chemical, including signs and symptoms of exposure, and any medical conditions which are generally recognized as being aggravated by exposure to the chemical.
5. The primary route(s) of entry.

6. The OSHA permissible exposure limit, ACGIH Threshold Limit Value, and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the material safety data sheet, where available.
7. Whether the hazardous chemical is listed in the National Toxicology Program (NTP) Annual Report on Carcinogens (latest edition), or has been found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) Monographs (latest edition), or by OSHA.
8. Any generally applicable precautions for safe handling and use which are known to the chemical manufacturer, importer or employer preparing the MSDS, including appropriate hygienic practices, protective measures during repair and maintenance of contaminated equipment, and procedures for clean-up of spills and leaks.
9. Any generally applicable control measures that are known to the chemical manufacturer, importer, or employers preparing the MSDS, such as appropriate engineering controls, work practices, or personal protective equipment.
10. Emergency and first aid procedures
11. The date of preparation of the MSDS or the date of the last change made.

c. Protection From Chemical Hazards

Once information on the chemical hazard has been obtained, the employer and employee can select the proper personal protective equipment. Hazardous materials may enter the body by inhalation (most common), ingestion, absorption through the skin or eyes, or injection.

The primary ways workers are exposed include:

1. Failure to follow proper procedures or to use appropriate personal protective equipment;
2. Inadequate knowledge of the materials;
3. Failure to decontaminate yourself or your equipment; or
4. Carelessness: unprotected contact with hazardous materials; walking through puddles or into clouds of unknown vapors; consuming food, water or smoking cigarettes contaminated by contact with gloves, equipment or unwashed hands.

2. Physical Hazards

Physical hazards abound at landfarm operations from exposure to large equipment, as well as many relatively minor injuries such as cuts, strains, sprains, bruises and abrasions. These injuries occur because of slips and falls, improper lifting, incautious backing of equipment, and improper use of hand or power tools. While these injuries are generally minor, serious injuries or deaths may result. Prolonged exposure to loud noises may permanently damage hearing. Exposure to heat and cold may cause heat stroke or frost-bite; and, can lead to indirect effects such as fatigue, dizziness, and confusion which in turn can lead to accidents, injuries, and death.

General guidelines for protection from physical hazards include:

1. Use proper protective equipment such as hearing protection, hardhats, steel-toed boots, safety glasses and gloves;
2. Maintain equipment in safe working conditions: perform regular preventive maintenance on heavy equipment, replace frayed electrical cords on hand tools, replace broken handles on shovels, rakes, hammers, etc.

3. Keep guards properly adjusted and in place on rotating and moving equipment such as power takeoffs.
4. Practice good housekeeping by keeping the work area clean and free of debris and excess water.

3. Biological Hazards

Exposure to biological hazards is always a possibility. Appropriate precautions must be taken. While a landfarm facility may seem, at first glance, free from the possibility of exposure, this may not be the case. Closer examination reveals materials such as glass, metals, used needles and other sharp objects that may offer a significant risk of puncture to the skin, thus introducing pathogenic organisms into the body. These organisms may arise from human sources that have contaminated the materials.

Wastewater landfarm operations represent an additional risk as the materials are of direct human origin and very likely to contain pathogenic organisms which have not been totally removed in the treatment process.

Additionally, the process of landfarming may encourage the growth of a number of molds and fungus that act as allergens. There is also the possibility of exposure to blood borne pathogens from injured personnel if proper precautions are not followed.

It is important that all employees are aware of the possibility of exposure and that steps are taken to reduce risk factors. As with the risk from chemical and physical hazards, selection of the proper personal protective equipment and personal hygiene will greatly reduce the risk of biological exposure.

General guidelines for protection from biological hazards include:

1. Avoiding direct contact with suspect materials.

2. Wear latex or vinyl gloves, under work gloves, when in immediate contact with suspect materials.
3. Training for all personnel in blood borne pathogen protection.
4. Use of proper respiratory protection for personnel exposed to dust and debris in the processing of materials.
5. Employee availability to hand washing, shower and toilet facilities.

SECTION 8

SAFETY

Study Questions

1. A safe work place is one where every attempt is made to _____ and _____ hazards and to _____ each employee in the proper procedures to manage those hazards.
2. List three reasons for maintaining the safe operation of a landfarm facility.
   a. _____
   b. _____
   c. _____
3. List the three broad general hazard categories a worker at a landfarm facility may be exposed to:
   a. _____
   b. _____
   c. _____
4. An employee has the _____ ____ _____ what hazardous materials are on worksite and trained to work _____ safely with those materials.
5. A _____ _____ _____ _____ must be available to the employee for all hazardous materials used or stored on site.

6. List three ways an employee can increase protection from physical hazards.

   a. _____

   b. _____

   c. _____

7. List three possible sources of biological hazards at a composting facility.

   a. _____

   b. _____

   c. _____

8. List four ways to protect yourself from exposure to biological hazards.

   a. _____

   b. _____

   c. _____

   d. _____

APPENDIX A

GLOSSARY

GLOSSARY

Active life – the period from the initial receipt of waste at a facility until certification of closure is received by the cabinet.

Agricultural waste – any non-hazardous waste resulting from the production and processing of on-the-farm agricultural products, including manures, pruning and crop residues.

Application – the form approved by the Cabinet for applying for a permit, including any additions, revisions or modification.

Authorized representative – the person responsible for the overall operation of a facility or an operational unit.

Available water holding capacity (AWHC) – the capacity of soils to hold water available for use by most plants. Also the difference before the moisture level at field capacity and the moisture level at wilting point expressed as inches of water per inch of soil depth.

Base flood – a flood that is equaled or exceeded once in 100 years, or has a 1 percent or greater chance of occurring.

Bedrock – the solid rock that underlies the soil.

Biological oxygen demand (BOD) – the demand for oxygen created by the ability of a waste or wastewater to support biological activity. Measured over a set time (5 days) under a specifically maintained temperature (68 F).

Cation – a positively charged ion in the soil or a solution.

Cation exchange capacity (CEC) – the sum of the exchangeable cations a soil can adsorb expressed in milliequivalents per 100 grams of soil.

Certified landfarming operator – a person who holds a valid certificate upon the successful completion of an approved training course and examination that is the individual responsible for ensuring compliance with all permit conditions at a landfarming facility and who is reasonably available to the site.

Closure – the time at which a waste treatment, storage or disposal facility permanently ceases to accept wastes.

Compost – solid waste which has undergone biological decomposition of organic matter, been disinfected using composting or similar technologies, been stabilized to a degree which is potentially beneficial to plant growth and which is approved for use or sale as a soil amendment, artificial topsoil, growing media amendment, or similar uses.

Construction permit – a formal permit issued by the Cabinet to an owner or operator of a waste site or facility that authorizes commencement of site preparation for waste disposal.

Contamination – the degradation of naturally occurring air, water, or soil quality either directly or indirectly as a result of human activity.

Contour – growing crops in which rows and tillage operations are conducted perpendicular to the land slope direction.

Crop rotation – the sequence of crops grown on a field over a number of cropping seasons.

Denitrification – conversion of nitrate to nitrogen gas.

Disposal – the discharge, deposit, injection, dumping, spilling, leaking, or placing of any waste into or on any land or water so that waste may enter the environment or be emitted into the air or discharged into any waters.

Drainage class – classifies the frequency and duration of soil saturation or partial saturation with water.

Facility – all contiguous land, structure, and land improvements used for treating, storing, or disposing of waste.

Field capacity – the moisture content of a soil, expressed as a percentage of oven dry weight, after the gravitational, or free water has drained from the soil.

Food chain crops – includes tobacco, crops grown for human consumption, and crops grown for feed for animals whose products are consumed by humans.

Formal permit – a permit issued by the Cabinet for waste facility operations after review of the designated application form and completion of requirements by the applicant.

Fragipan – a restrictive soil layer that is extremely dense and compact but is not cemented nor high in clay content.

Generator – any person, by site, whose act or process produces waste.

Gravel – an angular or rounded rock fragment up to 3 inches in diameter.

Groundwater – water in the zone of perennial saturation below the land surface.

Hydraulic conductivity – a quantitative measure of the rate of water movement through soil.

Immobilization – conversion of a chemical element from the inorganic form to organic form by bacteria, plants or animals; or the retention on the exchange complex of charged ions.

Internal soil drainage – the downward movement of water through the soil profile.

Karst terrain – a type of topography where limestone is present and is characterized by naturally occurring closed depressions or sink holes, caves, or disrupted surface drainage, and has well developed underground solution channels formed by limestone dissolution by moving, underground water.

Landfarming – the application of waste on or just below the land surface; will not alter the land topography, and will not disturb the soil below three feet from the surface.

Legume – a crop that forms a specific association with bacteria that are capable of transforming nitrogen gas into organic compounds that can provide nitrogen requirements of the plant.

Mineralization – the biochemical conversion of nitrogen from the organic form to the inorganic form.

Minimum tillage – soil preparation for seeding a crop while leaving more than 30 percent of the land surface covered by crop residue.

Monitoring – the act of systematically inspecting and collecting data on operational parameters or on the quality of the air, soil, groundwater, or surface water.

Nitrification – the biochemical conversion of ammonium nitrogen to nitrate nitrogen.

Organic matter (soil) – the relatively resistant fraction of residues and other organic products that forms during biological decomposition in the soil.

Ped – an aggregate of individual grains of sand, silt and clay into a single unit of soil structure.

Permeability – the rate that water moves through the soil.

Permittee – any person holding a valid permit issued by the Cabinet to manage, treat, store, or dispose of waste.

pH – a number value between 0 and 14 that indicates the acidity (<7) or alkalinity (>7) of a liquid, soil or waste.

Pollutant – means and includes dredged spoil, solid, waste, incinerator residue, sewage, sewage sludge, garbage, chemical, biological or radioactive materials, heat, wrecked or discarded equipment, rock, sand, soil, industrial, municipal or agricultural waste, and any substance resulting from the development, processing, or recovery of any natural resource.

Pores – spaces, or voids, between mineral grains and aggregates in the soil.

Proposed permit – document prepared by the Cabinet indicating the Cabinet's tentative decision to issue or deny, modify, revoke or terminate a permit.

Publicly owned treatment works (POTW) – any device or system used in the treatment (including recycling and recovery) of municipal sewage or industrial liquid wastes which is owned by the Commonwealth or a political subdivision of the Commonwealth.

Recycling – any process by which materials that would otherwise become solid waste are collected, separated, or processed and reused to use in the form of raw materials or products including refuse – derived fuel.

Residual nitrogen – nitrogen that remains in the soil after crop harvest that is either immediately available or will become available to succeeding crops.

Restrictive layer – any soil horizon that is slowly or very slowly permeable and underlies more permeable soil horizons.

Run-off – any rainwater, leachate, or other liquid that drains overland from any part of a waste facility.

Run-on – any rainwater, leachate, or other liquid that drains overland onto any part of a waste facility.

Saturated zone – that part of the earth's crust containing groundwater in which all voids, large and small, are filled with liquid.

Shrink-swell potential – the tendency of a soil to change volume due to the grain or loss of moisture with the rating in proportion to the relative change based on a given volume of soil.

Sludge – any solid, semi-solid, or liquid waste generated from a municipal, commercial, or industrial wastewater treatment plant, water supply treatment plant, or air pollution control facility exclusive of the treated effluent from a wastewater treatment plant or any other waste having similar characteristics and effects.

Soil – a natural body that develops in profile form in response to forces of climate and organisms acting on a parent material in a specific landscape position over a long period of time.

Soil amendment – anything added to the soil to improve its physical or chemical condition for plant growth.

Soil conditioner – any material added to soil to improve aggregation and the stability of structural soil aggregates.

Soil horizon – a layer of soil that is approximately parallel to the earth's surface whose descriptive characteristics are rather distinct from layers above or below.

Soil slope – the inclination of the land surface determined as feet of rise from the level per 100 feet of distance.

Soil structure – arrangement of individual grains of sand, silt, and clay into larger units called aggregates or peds and characterized by size, shape, and strength.

Soil texture – the amounts of sand, silt, and clay that make up a soil.

Solid waste – any garbage, refuse, sludge, and other discarded material (solid, semisolid, liquid, or contained gas) resulting from industrial, commercial, mining (excluding coal mining wastes, coal mining by-products, refuse and over burden), agricultural operations, and from community activities.

Surface impoundment – a whole or partial facility which may be a natural topographic depression, manmade excavation, or diked area formed primarily of earthen materials and designed to hold liquid wastes or the free liquids from wastes which is not an injection well.

Tillage pan – a compact, dense layer of soil at the base of the surface layer of a cultivated soil.

Traffic pan – a compacted layer beneath the soil surface of a cultivated soil resulting from the cumulative effects over time of driving over the soil with heavy equipment or when soil moisture content is very high.

Treatment zone – a soil area of the unsaturated zone of a land treatment unit within which wastes are degraded, decomposed, transformed, or immobilized.

Unsaturated flow – water movement through soil when the large pores are filled with air.

Water table – the top of the zone of water saturated soil classes as either perched, apparent, or artesian.

Wilting point – moisture content of a soil at which plants can no longer extract water.

Zone of incorporation – the depth to which the soil on a landfarm is plowed, tilled, or otherwise designed to receive waste.