



Tennessee Division of Solid Waste Management:

Land Application of Solid Wastes

Guidance Document



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*The Technical Section
Division of Solid Waste Management
Solid Waste Management Program*

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Land Application of Solid Waste Guidance Document

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1. Overview:

Tennessee's Division of Solid Waste Management recognizes that properly designed and located land application facilities should be capable of receiving and processing select non-hazardous solid waste streams, if properly managed. The Division of Solid Waste Management also recognizes the potential for harm to human health and the environment in the event that a land application facility is poorly designed, improperly located or is operationally mismanaged. Therefore, Tennessee has developed a specific "Permit-By-Rule" process for these types of facilities, and has established relevant location, design and operating criteria.

Under ideal circumstances, land application of waste is performed in a manner that enhances the fertility of the soil, which in turn improves growth and productivity of the target crop(s). Land application of waste relies on a combination of:

- 1) microbial degradation of the complex waste constituents into components that can then be extracted from the soil matrix for plant use or to be incorporated into the organic and mineral fractions of the soil, and
- 2) direct utilization of waste constituents by vegetation.

Ideally, the vegetative crops are eventually harvested and removed from the site. The efficiency of this process is dependent upon a complex set of factors, involving soil chemistry, waste composition and the concentration of constituents, as well as the land application rate, and local climate. Each of these factors will be addressed in this document.

Successful land application of waste can be accomplished for many types of organic materials. "Successful" land application sites are those which are designed and managed in such a manner as to avoid negative impacts such as:

- Anaerobic conditions,
- Noxious odors (hydrogen sulfide, etc.)
- Long-term soil damage (accumulation of metals, etc),
- Releases to air, groundwater and surface waters



2. Land Application Site Approval Procedure

2a. General:

The Division of Solid Waste Management is promulgating regulations which detail the design, construction, operating and reporting requirements for land application facilities. The new regulations will be found in Tennessee Rule 1200-1-7-.13 *et sequiter*, and will apply to all sites which engage in land application of industrial food processing wastes. Farming wastes will be exempt from these permitting requirements. Municipal wastewater treatment plant biosolids which have not been mixed with other solid wastes, and which are land applied are subject to the rules and regulations of 40 CFR Part 503, and are not subject to these permit-by-rule requirements. Land application of any other industrial processing wastes will be subject to a “beneficial use” approval rather than these permit-by-rule requirements.

2b. Definitions:

“Aerobic” means living or active in the presence of oxygen. As used in this document, aerobic refers especially to microorganisms and/or decomposition of organic matter.

“Anaerobic” means living or active in the absence of oxygen. As used in this document, anaerobic refers especially to microorganisms and/or decomposition of organic matter.

“Aquifer” means a geologic formation, group of formations, or part of a formation capable of yielding significant quantities of groundwater to wells or springs.

“Biosolids” means the organic solids product of municipal wastewater treatment that can be beneficially utilized, and consists of wastewater treatment solids that have received “Process to Further Reduce Pathogens” (PSRP) or “Process to Significantly Reduce Pathogens” (PFRP) treatment, or their equivalents, according to the 40 CFR Part 503 to achieve a Class A or Class B pathogen status.

“Commercial solid wastes” means all types of solid waste generated by stores, offices, restaurants, warehouses, and other non-manufacturing activities, excluding domestic and industrial wastes.

“Department” means the Tennessee Department of Environment and Conservation.

“Disposal facility” means a facility or part of a facility at which solid waste disposal occurs.

“Division” means the Division of Solid Waste Management of the Department, unless otherwise specified.

“Division Director” means the Director of the Division of Solid Waste Management, unless otherwise specified.

“Facility” means all contiguous land including structures and other appurtenances and improvements on the land used for processing, disposal or land application of solid waste by an owner or operator.

“Heavy metals” includes any of the following: arsenic, barium, cadmium, chromium, lead, mercury and/or silver.

“Hydraulic loading rate” refers to the amount of liquids applied to a given treatment process and is expressed as volume per unit time per surface area.

“Infiltration” means the rate at which a liquid enters the soil surface, is expressed in inches per hour, and is influenced by both the permeability and moisture content of the soil.

“Land application” means a facility where solid wastes are applied onto or incorporated into the soil surface (excluding manure spreading operations) for agricultural purposes or for treatment.

“Land reclamation” means the restoration of productivity to lands made barren through processes such as erosion, mining or land clearing.

“Manure” means a solid waste composed of excreta of herbivorous domestic animals, and residual materials that have been used for bedding, sanitary or feeding purposes for such animals.

“Municipal wastewater” means household and commercial water discharged into municipal sewer pipes; contains mainly human excreta and used water. Distinguished from solely industrial wastewater.

“Nutrient management plan” consists of a series of good management practices aimed at reducing agricultural nonpoint source pollution by balancing nutrient inputs with crop nutrient requirements. A nutrient management plan includes soil testing, analysis of organic nutrient sources (e.g., the land application candidate waste or wastes), utilization of organic nutrient sources based on nutrient content, crop requirements and the absorption capacity of the soil.

“On-site” means the geographically contiguous property with the same owner/operator which may be divided by public or private right-of-way. Non-contiguous properties owned or operated by the same person and connected by a right-of-way which he controls and to which the public does not have access, is also considered on-site property.

“Operate” means to construct, alter, own, maintain, close or care for after closure, or control a facility. In the event of an unpermitted facility the term shall include to place solid waste at the disposal site.

“Operator” means the person or persons applying for or holding a permit, or who are otherwise responsible for the operation of a facility.

“Overland flow” means the free movement of a substance over the land surface.

“Permeability” means the rate of liquid movement through a unit cross-section of a saturated soil per unit of time, and is usually expressed in centimeters per second.

“Permit” means the written authorization granted to a person by the Commissioner, to operate a solid waste processing and/or disposal facility. The terms “permit” and “registration” are synonymous for purposes of this rule chapter.

“Permittee” means any person holding a valid permit under the Act to operate a processing and/or disposal facility.

“Person” means any and all persons, natural or artificial, including any individual, firm or association, and municipal or private corporation organized or existing under the laws of this state and any department, agency, or instrumentality of the executive, legislative, and judicial branches of the federal government.

“pH” is a measurement used to indicate the degree of acidity or alkalinity of a substance. The pH is expressed as the \log_{10} of the reciprocal of the actual hydrogen ion concentration. The pH ranges from 0 – 14, where 0 is the most acidic, 14 is the most alkaline, and 7 is neutral.

“Placing” includes, but is not limited to discharging, depositing, injecting, releasing, dumping, spilling, spreading and leaking.

“Public water supply system” means a system that supplies to the public piped water for human consumption, if such system has at least 15 service connections or regularly serves an average of at least 25 individual daily at least 60 days of the year.

“Registration” means a process by which a solid waste disposal or processing operation is granted a permit to operate. In Tennessee Rule Chapter 1200-1-7, the words “registration” and “permit” are synonymous and may be used interchangeably.

“Representative sample” means a sample of a universe or whole (e.g., leachate, sludge, surface impoundment, surface water, ground water) which can be expected to exhibit the average properties of the universe or whole.

“Residue” shall mean any solid that remains after completion of solid waste processing including incineration products such as bottom ash, fly ash and grate siftings.

“Run-off” means any rainwater, or other liquid that drains overland from any part of a facility.

“Run-on” means any rainwater, or other liquid that drains overland onto any part of a facility.

“Saturated zone” means that part of the earth’s crust in which all voids are filled with water.

“Sludge” in the broadest sense, means any solid, semi-solid, or liquid waste generated from a municipal, commercial, industrial wastewater treatment plant, water supply treatment plant, or air pollution control facility, exclusive of the treated effluent from a wastewater treatment plant. For purposes of this document, the term sludge is limited to any solid, semi-solid, or liquid waste derived from industrial food production processes.

“Solid Waste” means any garbage, refuse, including without limitation recyclable materials when they become discarded, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility, and any other discarded materials, included solid, liquid, semi-solid, or contained gaseous

material resulting from industrial, commercial, and agricultural operations, and from community activities, but does not include solid or dissolved materials in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges which are point sources subject to permits under Section 402 of the Federal Water Pollution Control Act (compiled at 33 U.S.C. 1342) as amended, or source, special nuclear, or by-product material as defined by the Atomic Energy Act of 1954, as amended (compiled at 42 U.S.C. 2011, *et sequiter*).

“Solid waste disposal” means the process of placing, confining, compacting or covering solid waste except when such solid waste is for reuse, removal, reclamation, or salvage.

“Stabilization” means processing in a manner which reduces the mobility of waste constituents, or which makes the waste material easier to handle.

“Stream” means a watercourse which is not a wet weather conveyance.

“Surface impoundment” means a facility or part of a facility such as a natural topographic depression, man-made excavation, or diked area formed primarily of earthen materials (although it may be lined with man-made materials), which is designed to hold an accumulation of liquid wastes, or wastes containing free liquids, and which is not an injection well. Examples of surface impoundments are holding, storage, settling and aeration pits, ponds, and lagoons.

“Uppermost aquifer” means the geologic formation nearest the natural ground surface that is an aquifer, as well as, lower aquifers that are hydraulically interconnected with the aquifer within the facility’s property boundary.

“Vector” means a carrier organism that is capable of transmitting a pathogen from one organism to another.

“Washout” means the carrying away of solid waste by waters of a flood.

“Water table” means the surface of unconfined water at which pressure is atmospheric and is defined by the levels at which water stands in wells that penetrate the water.

“Well” means a shaft or pit dug, bored, drilled, jetted or driven into the earth. Wells are generally of a cylindrical form, and often walled with bricks or tubing to prevent the earth from caving in.

“Wet weather conveyance” means natural watercourses, including natural watercourses that have been modified by channelization, that flow only in direct response to precipitation in their immediate locality and whose channels are

above the groundwater table and which do not support fish or aquatic life and are not suitable for drinking water supplies.

“Wetlands” means those areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.

2c. Site Approval Procedure for Land Application:

Land application facilities which were in existence prior to the effective date of Tennessee Rule 1200-1-7-.13, *et sequiter*, must either permanently cease operations or submit a written application for approval of land application activities no later than August 1, 2005. “New” facilities (e.g., facilities which were not in existence prior to the effective date of Tennessee Rule 1200-1-7-.13 *et sequiter*) must submit a written application for approval of land application activities, and must receive written approval from the Division of Solid Waste Management before land application operations can commence. The written submission for land application must address all items contained in Tennessee Rule 1200-1-7-.13 *et sequiter*, as detailed in this guidance. Copies must be submitted to both the Central Office at:

Technical Section
Division of Solid Waste Management
5th Floor L&C Tower
401 Church Street
Nashville, TN 37243-1535

and the appropriate environmental assistance center (refer to Attachment IV for details).

2d. Application Contents:

The applicant must make a written submission to the Division of Solid waste Management which clearly and adequately demonstrates how the facility will be designed, constructed and operated in compliance with Tennessee Rule 1200-1-

7-.13, *et sequiter*. This submission must include a detailed narrative description including:

The full name and permanent mailing address of the permittee.

The street address(es) for all locations at which the permittee seeks to land apply food processing wastes, as well as the total acreage for each location.

A complete physical and operational description of the facility, including all associated equipment. A demonstration must also be made that the facility will be constructed, operated, maintained, and closed in such a manner as to minimize the potential for releases of solid wastes or solid waste constituents to the environment except in a manner authorized by state and local pollution control, waste pollution control and/or waste management agencies, and that the facility will also be constructed, operated, maintained, and closed in such a manner as to minimize the propagation, harborage, or attraction of flies, rodents, or other disease vectors.

The permittee must make a demonstration, for each location at which land application is proposed, that the facility will be constructed, operated, maintained, and closed in such a manner as to ensure that the land application facility does not:

- I. Cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife; or
- II. Result in the destruction or adverse modification of the critical habitat of endangered or threatened species;

The permittee must make a demonstration, for each location at which land application is proposed, that the facility is constructed, operated, maintained, and closed in such a manner as to minimize the potential for harm to the public through unauthorized or uncontrolled access. (The facility must demonstrate that it has an artificial or natural barrier which completely surrounds the facility and a means to control entry, at all times, through the gate or other entrances to the facility).

On-site storage of solid wastes at the land application facility is strongly discouraged, although not expressly prohibited. However, any on-site storage of solid wastes at the land application facility must be approved in advance by the Division of Solid Waste Management, and will be restricted to containers, bins, lined pits or on paved surfaces, designated for such storage. Any lagoons/surface impoundments must be designed in accordance with the requirements of Section 3f of this document, and detailed engineering drawings and a design/operational narrative must be included as part of the application submittal. Additionally, The owner or operator of a land application facility having a waste storage capacity in excess of 100,000 gallons (for liquids/sludges), or 1000 cubic yards (for solids) shall file with the Commissioner a performance

bond or equivalent cash or securities, payable to the State of Tennessee. Such financial assurance is intended to ensure that adequate financial resources are available to the Commissioner to insure the proper operation, closure and post-closure care of the facility. The types of financial assurance instruments that are acceptable are those specified in 1200-1-7-.03(3)(d). Such financial assurance shall meet the criteria set forth in T.C.A. §68-211-116(a).

The permittee must make a demonstration, for each location at which land application is proposed, that the facility is not located in a floodplain (unless it is further demonstrated to the satisfaction of the Commissioner that the land application area is operated and maintained to prevent washout of any solid waste).

The permittee must make a demonstration, for each location at which land application is proposed, that the facility is not located in wetlands (unless the owner or operator also makes the applicable demonstrations to the Commissioner as referenced at rule 1200-1-7-.04(2)(p)).

The permittee must make a demonstration, for each location at which land application is proposed, that the facility is not located in highly developed karst terrain (i.e., sinkholes and caves).

The permittee must make a demonstration, for each location at which land application is proposed, that wind dispersal of solid wastes at or from the facility is adequately controlled.

The permittee must provide, for each location at which land application is proposed, a list of all sources of food processing wastes to be land applied. For each food processing waste stream proposed for land application by the permittee, identify the site(s) at which the food processing waste is proposed for land application, the total estimated quantity to be land applied per year at each site, and the number of acres of land to which each waste stream is proposed for land application at each site; Additionally, provide analytical data for each of the waste streams proposed for land application. The analytical data must be sufficient to determine that each of the waste materials proposed for land application is: 1) not hazardous as defined in rule 1200-1-11.02(1)(c) of the *Hazardous Waste Management Regulations*, 2) is suitable for the proposed activity (e.g., soil amendment or agronomic benefit), 3) to be land applied at a suitable rate (whether for soil amendment or for agronomic benefit), 4) to be land applied in a manner which will have neither surface nor groundwater impacts., and 5) to be land applied in a manner which will minimize odors to the greatest extent practicable.

If wastes are to be land applied for agronomic benefits, the facility must demonstrate via soil/waste analysis and plant nutrient uptake rates, that the rate at which waste is to be land applied will benefit crop production at sites where

crops are grown, without exceeding crop nutrient needs or hydraulically overloading the receiving soils.

If wastes are to be land applied for soil amendment benefits, the facility must clearly demonstrate the amendment value of land application via soil/waste analysis, and that application rates will not exceed the soil amendment needs of, or hydraulically overload the receiving soils.

Regardless of whether the wastes are proposed for land application for agronomic benefit or soil amendment, the permittee must clearly demonstrate that the rate at which waste is to be land applied will not result in an accumulation of harmful levels of waste constituents or waste degradation by-products in the receiving soils, produced crops, or in the environment.

The submission must include recordkeeping provisions for acquiring/maintaining records of the amounts of waste, by waste stream, that are to be land applied, the dates of application, and the acreages involved.

The facility must include in its application provisions for periodically monitoring for waste constituents in soil and surface waters in accordance with an approved sampling plan. Ground water monitoring may be required by the Commissioner.

The submission must include a topographical map for each of the proposed land application locations and surrounding vicinity. Each topographic map must include, at a minimum, the following information:

- 1) Property boundary for the proposed land application site
- 2) Boundary of land application surface area. The setback requirements of Section 3d of this document must be met, both on the topographical map and in the narrative portion of the application.
- 3) The location/layout of all streams, wet weather conveyances, wells, and dwellings located both inside of, and within a 500 foot radius of the land application boundary.
- 4) The location of all public water supplies located both inside of, and within a 1000 foot radius of the land application boundary.
- 5) That the proposed land application area complies with the setback requirements set forth in Section 3d of this guidance document.

On or before March 1 of any calendar year, facilities which are permitted to land apply food processing wastes must submit to the Division an annual report for land application activities having taken place during the preceding calendar year. This annual report must contain, at a minimum, the following information:

The full name and permanent mailing address of the permittee.

The street address(es) for all locations at which the permittee has land applied food processing wastes during the previous calendar year.

The total acreage for each location at which the permittee has land applied food processing wastes during the previous calendar year.

A list of all sources of food processing wastes land applied by the permittee during the previous calendar year.

For each food processing waste stream land applied by the permittee during the preceding calendar year, identify the site(s) at which the food processing waste was land applied, the total quantity land applied at each site, and the number of acres of land to which each waste stream was land applied at each site.

Copies of any analytical data generated during the preceding year for any food processing waste materials that the permittee has land applied.

Copies of any analytical data generated during the preceding year from surface waters, groundwater monitoring or soils samples at each site where food processing waste materials have been land applied.

3. General Recommendations for Land Application:

3a. General:

Before the Division will grant an approval for the land application of solid wastes, it must be clearly demonstrated that wastes provide either an agronomic benefit to farming operations, or be of legitimate value as a soil amendment. Proposed application sites must demonstrate compatibility between the waste materials and the existing soil matrix. Hydraulic loading rates and the potential for both short and long-term accumulation of damaging quantities of waste constituents must also be given all due consideration. Nutrient loading rates must not exceed the capacity of the crop/soil system to absorb them without detrimental off site movement, as specified by an approved nutrient management plan.

3b. Aesthetic Quality of Land Application:

Although the bulk of land application operations are not conducted in highly populated areas, it is important to conduct such operations in a manner that is not aesthetically objectionable (e.g., such that no vector problem, or nuisance odor issues are created). In order to further this, land application will only be considered for those sites which adequately can demonstrate that the soil conditions are favorable to aerobic waste decomposition.

3c. Application During Inclement Weather:

Because of the potential for hydraulic overloading of the receiving soils, and subsequent overland transport of waste constituents (or the “washing” down of dissolved waste constituents into the groundwater environment), the land application of food processing wastes shall not be permitted during a rainfall event, for a period of 24 hours after a rainfall event exceeding ¼” of rain has occurred, or when the probability of rainfall exceeds 50% within the next 24 hour period, unless waste materials are injected or incorporated directly into the soil as it is applied. Additionally, land application of food processing wastes shall not be permitted when the soil is either saturated or frozen.

3d. Setbacks/Buffer Zones:

The Land Application of suitable waste materials shall not take place:

- a. Within 500 feet of a dwelling or private well;
- b. Within 100 feet of surface water (this limit is 500 feet from outer boundary for spray irrigation);
- c. Within 20 feet of a road (this limit is 200 feet from outer boundary for spray irrigation);
- d. Within 1000 feet of a public water supply well;
- e. On a slope exceeding 8 percent (except for slopes where *incorporation* is practiced, in which case the maximum acceptable slope for land application is 12 percent);
- f. In an area having a minimum depth of less than 3 feet to the seasonal high water table.
- g. In areas with karst features such as caves and open sinkholes, land application shall not be permitted within 200 feet of the cave or sinkhole. Further, a minimum of a 100 foot vegetative buffer must also be maintained around karst features.

3e. Silviculture and Reclamation:

In addition to land application of suitable wastes to crop and pasture lands, the Division will consider land application petitions for forests, tree farms and reclaimed mining sites. The process for obtaining a land application Permit-By-Rule for at these types of sites is similar to the process for obtaining a land application Permit-By-Rule for farmlands.

3f. Storage:

Because of the potential for adverse human health and environmental impacts, on-site storage of waste quantities to be land applied are to be kept at a minimum, and must be approved in advance, and in writing by the Division. Whenever possible, the generator of the waste to be land applied is to provide storage capacity for the waste materials at the site of generation. However, periods of inclement weather (rainfall, snow, frozen soil) are inevitable in Tennessee, so there may be times when land application must be suspended, and on-site storage provisions must be made. Therefore, the Division will allow facilities to accumulate at the land application site, up to 5 calendar days inventory of waste materials to be land applied **[NOTE: this is limited to the amount of waste material that would normally be spread/injected at the site during the 5 day period – it does NOT represent the total number of truckloads of material that can be hauled into the site over a 5 day period]**. In order for on-site storage of materials at the land application site to be allowed, the facility must gain written approval for on-site storage from the Division, and must demonstrate that the materials are stored in either lagoons or tanks, which have been designed, constructed and operated in accordance with the requirements of this section. On-site storage of malodorous wastes, or wastes with a high potential for vector attraction shall not be considered unless the facility can demonstrate that adequate odor/vector controls are included to prevent a nuisance from occurring.

Storage lagoons must be adequately designed and operated as to ensure that migration of wastes and waste constituents via run-on/run-off transport as well as via percolation into surface waters, ground waters and surrounding/underlying soils will be prevented. To this end, storage lagoon design must include the following provisions:

- 1) The lagoon must be designed/constructed with an impermeable liner (such as an epoxy coated concrete basin, or a welded HDPE flexible membrane).
- 2) The design must be such that the side walls extend to a vertical elevation which is at least 1 foot above the surrounding grade, or 1 foot above the 10 year flood elevation for the site, whichever is greater.
- 3) The design volume must include the maximum quantity of waste to be stored in the lagoon site, plus the capacity to hold the 10 year 24 hour rainfall, plus an additional 1 foot of freeboard for wind and wave action.
- 4) Lagoons must include a ground water monitoring system designed, constructed and operated in accordance with Tennessee Rule 1200-1-7-.04(7) *et. sequiter*.

As with lagoons, storage tanks must be adequately designed, constructed and operated as to ensure that migration of wastes and waste constituents via run-on/run-off transport as well as via discharge into surface waters, ground waters and surrounding/underlying soils will be prevented. To this end, storage tanks design must include the following provisions:

- 1) Must be of water-tight construction (Steel, Epoxy-coated concrete, or Fiber Reinforced Plastic).
- 2) The design must be such that the side walls extend to a vertical elevation which is at least 1 foot above the surrounding grade, or 1 foot above the 10 year flood elevation for the site, whichever is greater.
- 3) For open-topped tanks, the design volume must include the maximum quantity of waste to be stored in the lagoon site, plus the capacity to hold the 10 year 24 hour rainfall, plus an additional 1 foot of freeboard for wind and wave action.
- 4) Storage tanks must include a ground water monitoring system consisting of one or more lysimeters underlying or adjacent to the storage tank, and through which semiannual samples shall be taken to verify that the tank is not leaking constituents into the soils/ground water.

[For further information, refer to pages 51 – 61 of EPA document EPA/832-B-00-007, "Guide to Field Storage of Biosolids", July 2000]

4. Waste Characterization:

An assessment must be made of the waste's characteristics in order to determine if the waste is even an acceptable candidate for land application. The parameters which must (at a minimum), be considered in making this initial determination include:

- 1) Designated Groundwater parameters (Appendix II Constituents)
- 2) Total Solids
- 3) Soluble Salts
- 4) pH
- 5) Pathogens
- 6) Nutrients
- 7) Metals
- 8) Carbon to Nitrogen ratio
- 9) Calcium Carbonate Equivalent (CCE)

A brief description of the significance of each of these waste parameters concerning their relevance to land application follows:

4a. Designated Groundwater Parameters:

If the waste to be land applied contains any of the groundwater constituents listed in Appendix II of Tennessee Rule 1200-1-7-.04 (included as part of this Guidance Document as Attachment V), then a real potential for surface and groundwater impacts exists, as well as a possibility for accumulation in the crop mass (this is especially true for heavy metals), and groundwater and air risks may also need to be evaluated (via modeling, etc.).

4b. Total Solids:

Total Solids Content is a ratio, usually expressed as a percentage, of all solids present in a waste (suspended *and* dissolved), to the total weight of the waste. Total solids content will commonly dictate the method of application (e.g., spray irrigation, incorporation, etc.), and significantly impact the acceptable application rates.

4c. Soluble Salts:

Major soluble salts include bicarbonate, calcium, chloride, magnesium, nitrate, potassium, sodium and sulfate, and are important in land application of waste for 3 primary reasons.

First, soil which has excessive salt concentrations (also known as “saline” soil) can experience inhibited plant growth and seed germination, and as the soil salinity increases, osmotic pressure makes it harder for plants to absorb water from the soil.

Secondly, soil with excessive concentrations of sodium (also known as “sodic” soil) can alter the soil structure and can reduce soil permeability. The Sodium Absorption Rate (SAR) of a waste is a measure of its sodicity, and can be calculated by the following formula:

$$SAR = \frac{Na^+}{(1/2 * (Ca^{2+} + Mg^{2+}))^{1/2}} \quad \begin{matrix} \text{[all concentrations given]} \\ \text{[in milliequivalents/liter]} \end{matrix}$$

Soils that have high salts (e.g., excessive total dissolved solids as indicated by high electrical conductivity) and excessive sodium ions are called saline-sodic, and can be expected to have the negative characteristics of saline and sodic soils.

Finally, soluble salts are important in land application because certain ions can cause plant toxicities or even groundwater contamination.

Total Dissolved Solids (TDS) is essentially the sum of all salt ions, and other materials in solution. The TDS of a soil (or waste) can be estimated by measuring the electrical conductivity of a *mixture* of the waste or soil and water (the electrical conductivity of liquid waste can be measured directly). The TDS value is estimated by multiplying the electrical conductivity reading in millimhos/cm by 700 to yield a TDS value in ppm or mg/l. (**NOTE:** a copy of EPA Method 9050A – Specific Conductance from SW-846 is included herein as

Attachment II. Although the method states that it is not for solid or organic samples, it may be amenable to a TCLP-type extraction.)

Sodicity/Salinity Characterization				
Parameter	Normal	Saline	Sodic	Saline-Sodic
Electrical Conductivity ¹	<4	>4	<4	>4
SAR ²	<13	<13	>13	>13
<p>Notes: ¹ – Units = mmhos/cm ² - dimensionless Source: Fipps, G. Managing Irrigation Waster Salinity in the Lower Rio Grande Valley</p>				

4d. pH:

Most grasses and legumes (i.e., beans and peas) as well as many shrubs and deciduous trees grow best in soils having a pH ranging between 5.5 and 7.5. Additionally, acidic wastes will increase the migration of many metals via leaching. Conversely, while elevated levels of alkalinity in soils tends to impede metals migration, alkalinity can retard the growth of soil micro-organisms, and if the pH exceeds 11.0 an increase in the mobility of zinc, lead and cadmium may occur. A pH higher than 7.5 may cause micronutrient deficiencies in plants.

4e. Pathogens:

Although this document does not concern itself with the land spreading of sanitary wastewater treatment plant sludge, there are other potential sources of sludge (such as animal processing plants), which may contain bacteria, protozoa, larva, eggs from parasitic organisms, and/or viruses. These pathogens represent a public health risk if there is a transfer into food or animal feed crops, or if these materials are transferred offsite by vectors or run-off. Pathogenic waste should be stabilized and/or disinfected prior to land application, and the effectiveness of the stabilization/disinfection process should be verified periodically through testing. Common techniques for stabilization of waste prior to land application include:

- 1) Composting, and
- 2) Lime Stabilization

4f. Nutrients:

Nutrient levels are a fundamental factor in determining acceptable land application rates, and is dependent upon the amount of nutrients in both the waste and the receiving soil. The primary nutrients (a.k.a. “macronutrients”) are nitrogen, phosphorus and potassium. Secondary nutrients include sulfur, magnesium and calcium. In addition, there are other nutrients (called

“micronutrients”), including boron, chlorine, copper, manganese, molybdenum and zinc that are used in small quantities in plant growth.

Although the single most important nutrient is commonly nitrogen, any land application program needs to consider all of the macronutrients, plus heavy

metals (refer to Section 4g below), and a monitoring plan should be implemented to ensure that excessive nutrient levels are not being attained (excessive nutrient levels can damage plant growth, as well as threaten ground and surface waters). Monitoring the nutrient levels can also provide feedback for adjusting land application rates for optimal performance.

(I) Nitrogen:

If wastes are applied without consideration being given to the agronomic rate, there is a potential for the organic fraction to mineralize to nitrates to an excessive degree, resulting in the downward migration of nitrates in soil profile and into the groundwater environment. The following equations will provide guidance for calculation of the agronomic loading rate for nitrogen:

1. Available nitrogen from wastes.

a. Total Kjeldahl Nitrogen (TKN):

$$\text{TKN (mg/kg)} * 0.002 = \text{\#/ton}$$

b. Ammonium Nitrogen (NH₄-N):

$$\text{NH}_4\text{-N(mg/kg)} * 0.002 * K_v = \text{\#/ton}$$

Volatilization Factors for Ammonium: K_v	
If the wastes are:	K_v
Liquid and Surface Applied	0.50
Liquid and Injected into Soil	1.0
Dewatered and Applied in any Manner	0.050

c. Nitrate plus Nitrite Nitrogen (NO₃-N + NO₂-N):

$$(\text{NO}_3\text{-N} + \text{NO}_2\text{-N})(\text{mg/kg}) * 0.002 = \text{\#/ton}$$

d. Total Inorganic Nitrogen:

$$\text{Add 1b and 1c} = \text{\#/ton}$$

e. Organic Nitrogen in waste:

$$\text{Subtract 1b from 1a} = \text{\#/ton}$$

f. Available Organic Nitrogen for the first year of application:

$$\text{Multiply 1e by } F_m = \text{\#/ton}$$

Mineralization Rates : F_m	
Time After Waste Application (Yr)	Fraction (F_m) of Organic Nitrogen Mineralized From Waste
0-1	0.20
1-2	0.10
2-3	0.05

- g. Total Nitrogen Available from waste:
Add 1d and 1f = #/ton
2. Available nitrogen in the soil.
- Soil test results of background nitrogen in soil.
 - Estimate of available nitrogen from previous waste application.
3. Available nitrogen supplied by other sources.
- Nitrogen from supplemental fertilizers (if appropriate) = #/ton
 - Nitrogen from irrigation water (if appropriate) = #/ton
 - Nitrogen from previous crop = #/ton
 - Other (if appropriate) - Specify
 - Total Nitrogen from other sources: Add 3a, 3b, 3c and 3d if available = #/ton
4. Total Nitrogen available from existing sources:
Add 2 and 3e = #/ton
5. Total nitrogen requirement of crop (For crops other than those listed below, see an agricultural extension agent or other agronomy professional) = #/acre

Crop	Expected Yield	Nitrogen Requirement
		(# N/acre/year)
Corn (grain)	100 – 125 bu	120
Corn	125 – 150 bu	150
Corn (silage)	20 tons	150
Soybeans	40 bu	30
Wheat	50 bu	75
Summer Annuals	6 tons (1 cutting)*	60
Hybrid Hay	8 tons (4 cuttings)*	400
Tall Fescue Hay	3 tons (2 cuttings)*	120
Orchard Grass Hay	4 tons (2 cuttings)*	120
Sorghum	60 bu	60
Cotton	1 bale/acre	50
Cotton	1.5 bales/acre	90

Note: When less than the indicated number of harvests is expected, The total nitrogen rate should be reduced proportionally.
Source: University of Tennessee Agricultural Extension Service and EPA Guidance for Land Application of Biosolids

6. Supplemental nitrogen needed from waste: Subtract 4 from 5 = #/ton
7. Agronomic Loading Rate: Divide 6 by 1g = tons/acre

(II) Phosphorus (annual application rate limits):

To determine the annual phosphorous loading rate limit (tons waste/acre), divide the Phosphorus requirement of the crop by 20 times the percentage amount of Phosphorus in the waste. Unless a consistent crop yield rate is known for the area of the proposed land application activity, contact your county agricultural extension agent to obtain a reasonable estimate of the expected yield.

The phosphorus equation translates as follows:

$$\text{Tons waste/acre} = (\text{Crop requirement \#/acre}) / (20 * \%P \text{ in Sludge})$$

Crop	Unit of Yield	Phosphorus Requirement
		(# P ₂ O ₅ /unit/yield)
Corn (grain)	bu	0.375
Corn (silage)	bu grain equivalent	0.55
Corn (silage)	ton, 65% H ₂ O	3.50
Soybeans	bu	0.80
Oat and Straw	bu	0.40
Oat Straw	ton	5.0
Wheat	bu	0.60
Wheat Straw	ton	4.0
Sunflower	100 lb	0.80
Alfalfa	ton	12.5
Red Clover	ton	10.0
Vetch	ton	12.0
Smooth brome grass	ton	9.0
Timothy	ton	9.0
Perennial ryegrass	ton	12.0
Sorghum-sudan	ton	12.0
Switch grass	ton	12.0
Tall Fescue Hay	ton	12.0
Orchard Grass Hay	ton	14.0

Source: "General Guide for Crop Nutrient Recommendations in Iowa", Page 4, Iowa State University, University Extension, PM 1688, Revised March 1999

Note: P₂O₅ is 43.6619% Phosphorus by weight. This should be taken into consideration when using the above table.

(III) Potassium (annual application rate):

To determine the annual Potassium loading rate limit (tons waste/acre), divide the Potassium requirement of the crop by 20 times the percentage amount of Potassium in the waste. Unless a consistent crop yield rate is known for the area of the proposed land application activity, contact your county agricultural extension agent to obtain a reasonable estimate of the expected yield.

The potassium equation translates as follows:

$$\text{Tons waste/acre} = (\text{Crop requirement \#/acre}) / (20 * \%K \text{ in Sludge})$$

Crop	Unit of Yield	Potassium Requirement (# K₂O/unit/yield)
Corn (grain)	bu	0.30
Corn (silage)	bu grain equivalent	1.25
Corn (silage)	ton, 65% H ₂ O	6.50
Soybeans	bu	1.50
Oat and Straw	bu	1.00
Oat Straw	ton	33.0
Wheat	bu	0.30
Wheat Straw	ton	25.0
Sunflower	100 lb	0.70
Alfalfa	ton	40.0
Red Clover	ton	33.0
Vetch	ton	47.0
Smooth brome grass	ton	47.0
Timothy	ton	32.0
Perennial ryegrass	ton	34.0
Sorghum-sudan	ton	38.0
Switch grass	ton	66.0
Tall Fescue Hay	ton	66.0
Orchard Grass Hay	ton	68.0

Source: "General Guide for Crop Nutrient Recommendations in Iowa", Page 4, Iowa State University, University Extension, PM 1688, Revised March 1999

Note: K₂O is 82.979% Potassium by weight. This should be taken into consideration when using the above table.

Once the minimum nutrient application rates have been determined based on the nitrogen, phosphorus and potassium, compare the minimum nutrient application to the minimum metals application rates (see Section 4g of this document). The limiting factor will be the *lowest* calculated application rate.

4g. Metals:

In addition to the metals which appear in the listing in Appendix II of Tennessee Rule 1200-1-7-.04 (included as part of this Guidance Document as Attachment IV), there are also a number of other metals, such as copper, manganese, nickel and zinc which, in elevated concentrations, also have potential for adverse impact on vegetative growth (in addition to the potential for surface and ground water impact). It becomes important, therefore, to evaluate metals in the soil, waste, and vegetative matrices from the standpoint of agricultural significance, in addition to the inherent environmental and human health risks.

Calculations must be included which determine the limiting application rates according to the procedures outlined below. The lowest value is chosen as the limiting factor (i.e., maximum tons of waste per acre which can be land applied).

Heavy Metal Calculations:

For long term applications, heavy metals are often the limiting factor. Metals uptake by plants cause toxic effects in plants and detrimental health effects in persons or animals consuming those plants. Soils have varying abilities to bind with the metal ions. This ability is measured by the Cation Exchange capacity of the soil. It is necessary to determine the soil CEC for the specific application site to be used in order to establish the appropriate application rate. The following table provides the maximum allowable metals accumulations (in pounds) for the life of the application site:

Metal	Soil Cation Exchange Capacity (meq/100g)		
	0-5	5-15	15+
Lead	445	891	1782
Zinc	223	446	891
Copper	111	223	446
Nickel	45	89	178
Cadmium	4.5	8.9	18

[Note: the above metals values are cumulative limits, and NOT annual limits]

In addition to this maximum accumulation, the annual application of cadmium shall not exceed 0.45 pounds per acre per year.

The following calculations shall be used to calculate the total allowable sludge application for each metal:

- a. Lead (maximum allowable accumulation):

$$\text{Tons of sludge/acre} = \frac{\# \text{ Lead / Acre}}{\text{PPM Lead} * 0.002}$$

- b. Zinc (maximum allowable accumulation):

$$\text{Tons of sludge/acre} = \frac{\# \text{ Zinc / Acre}}{\text{PPM Zinc} * 0.002}$$

- c. Copper (maximum allowable accumulation):
Tons of sludge/acre = $\frac{\# \text{ Copper / Acre}}{\text{PPM Copper} * 0.002}$
- d. Nickel (maximum allowable accumulation):
Tons of sludge/acre = $\frac{\# \text{ Nickel / Acre}}{\text{PPM Nickel} * 0.002}$
- e. Cadmium (maximum allowable accumulation):
Tons of sludge/acre = $\frac{\# \text{ Cadmium / Acre}}{\text{PPM Cadmium} * 0.002}$
- f. Cadmium (maximum annual application rate):
Tons of sludge/acre = $\frac{0.45\# \text{ Cadmium / Acre}}{\text{PPM Cadmium} * 0.002}$

4h. Carbon to Nitrogen Ratio:

The Carbon to Nitrogen Ratio can be computed as the dry weight content of organic carbon divided by the total nitrogen content of the waste.

Soil microbes use carbon to build new cells, and use nitrogen to synthesize proteins. Excess nitrogen is converted (or mineralized) from organic nitrogen to inorganic ammonium, which is then available for plant growth. For minimal plant growth, it is recommended that the Carbon to Nitrogen Ratio be below 20 to 1. If the Carbon to Nitrogen ratio exceeds 20 to 1, soil micro-organisms outcompete plant roots, resulting in reduced plant growth.

If the desire is to maximize plant growth, monitor the soil content and once the soil's Carbon to Nitrogen Ratio exceeds 20 to 1, either reduce the waste application rate OR supplement the naturally occurring mineralized nitrogen content with an inorganic fertilizer such as ammonium nitrate. One method for measuring a soil's carbon content is EPA Method 9060 from SW-846 (**NOTE:** a copy is included herein as Attachment I).

If for some reason, it becomes impractical to monitor the C:N ratio of the soil, consideration may be given to monitoring the C:N ratio of the waste and adjust supplemental nitrogen fertilization accordingly. If the C:N ratio of the waste exceeds 30:1 and more than 1 ton (dry weight) of waste is being added per acre per year, it may be possible to increase the supplemental nitrogen added (in chemical form) by 10 pounds per acre per ton of waste (dry weight) added, up to a maximum of 60 pounds of additional nitrogen per acre, or half of the total crop requirement, whichever is least.

4i. Calcium Carbonate Equivalent (CCE):

The Calcium Carbonate Equivalent is, simply put, a measure of a waste's ability to neutralize acidity in soil, as compared to the amount of pure calcium carbonate required to have the same buffering effect.

5. Soil Conditions Favorable to Aerobic Waste Decomposition:

The biological, chemical and physical properties of soil determine the ability of a given soil to attenuate waste, and as such must be taken into consideration when evaluating a site as a potential land application facility. Aerobic microorganisms require oxygen to metabolize waste, and produce complex stabilized polysaccharides (called humus), carbon dioxide and water as end products. Favorable soil conditions for aerobic decomposition include:

- pH range of 6 to 8
- Soil temperatures of 10°C to 30°C (50°F to 86°F)
- Water content of 25% - 85% of soil's holding capacity
- Pore space exceeding 10% of soil volume (assuming soil overloading is *not* taking place)

5a. Cation Exchange Capacity:

Soil consists of a blend of clays, sands, silts and organic matter. Particles of clay and organic matter are typically anionic (e.g., they have a net negative electrical charge, and consequently attract positively charged materials). Anions commonly found in soils include chlorides, nitrates, phosphates and sulfates. Additionally, soils contain particles that are cationic (e.g., those which bear a net positive charge), including ammonium, calcium, hydrogen, magnesium, potassium and sodium. The negatively charged clay and organic soil particles (or anions) attract and hold onto the positively charged particles (cations) much like a magnet sticks to a refrigerator. Further, the cations retained by the clay and organic particles in soil can be replaced by other cations (i.e., the cations are "exchangeable"). The relative ability of soil to hold cations is referred to as the cation exchange capacity (CEC), and is measured in milliequivalents per 100 grams of soil (meq/100g). **[NOTE: Attachment III to this document contains 2 different SW-846 methods for determining the Cation Exchange Capacity for soils. Because the Cation Exchange Capacity of soil is partially pH dependent, the ammonium acetate test method at pH 7.0 is most appropriate, unless the soils in the field are near a pH of 8.0, at which point the sodium acetate test method at a pH of 8.2 is the more appropriate of the test methods.]**

Optimally, the soil to be considered for land application of wastes should be "deep" (i.e., depth from surface to both groundwater and bedrock), have a large total surface area per unit volume, and contain a substantial amount of clay and organic matter for absorbing and filtering wastes. Soils with a high CEC value are preferable because of their greater ability to immobilize heavy metals. In general, it should be noted that the soil CEC values will increase in the following order:

- 1) Sand
- 2) Loamy Sand
- 3) Loam
- 4) Silty Loam
- 5) Silty clay loam
- 6) Clay Loam
- 7) Clay

5b. Soil pH:

Additionally, soil pH is an important soil characteristic, insofar as plants grown in low pH soils tend to absorb metals at a higher rate than is the case for higher pH soils. Therefore it is desirable to maintain soil pH at 6.5 or higher for metals-laden wastes, and an annual determination of soil pH is in order to ensure that this condition is met. To this end lime application rates, if necessary, can be determined by the Agricultural Extension Service for any given site.

5c. Physical Properties of Soil:

Texture, pore-size distribution and the structure of soil will impact that soil's infiltration rate (permeability) and the capability of the soil to filter out waste constituents. Soils with very high permeability (e.g., sandy soils) may permit passage of waste constituents without adequate attenuation. Low permeability, or "tight" soils (e.g., clay), are prone to hydraulic overloading, and may allow unacceptable run-off concentrations of waste constituents during rainfall events.

The actual acceptable hydraulic loading rate for a given soil is dependent upon numerous factors, including but not limited to soil porosity, capillary action, and the soil's initial moisture content prior to waste application. Coarser soils allow for a higher hydraulic loading rate than finer grained soils. There is however, a general upper limit for hydraulic loading for a given soil type, which cannot be exceeded. When land applying wastes, the application rates must never hydraulically overload the receiving soils to the extent that ponding or overland flow of waste materials occur.

Soil Type	Infiltration Rate (inches / hour)	Maximum Per Acre Volume (gallons / hour)
Sand	1.00	27000
Sandy Loam	0.80	21000
Loam	0.40	10000
Clay Loam	0.20	5000
Clay	0.04	1000

Note: These are the maximum loading rates under IDEAL circumstances. Actual application rate limits may be considerably less than those contained in this table.

6. Crop Selection:

Consider plant growing seasons in relation to periods of peak waste generation. Waste application may not be possible at times because plants are not present to assimilate nitrogen and minerals from the waste. At other times, plant growth may be such that the passage of waste application equipment may be damaging to the crop.

Additional Requirements for Application of food processing wastes to Food-Chain Crops:

6a. Crops to be Avoided:

A) For Metals-laden material(s):

Tobacco, leafy vegetables and root crops should be avoided since they are the highest accumulators of heavy metals.

B) For Waste Potentially Containing Pathogenic Bacteria, Parasites and Viruses that may have escaped sterilization:

Raw crops (except crops such as orchard crops *where there is no contact between the sludge and the crop*) are to be avoided for at least one year period following the sludge application.

6b. Application Conditions

Sludge spreading may be conducted on pasture land if the following guidelines are followed:

- Prior to spreading the sludge, the pasture land should be mowed or grazed to a height of 6 inches or less.
- Animals should not be allowed to graze until at least two weeks after the sludge particles are no longer present on the grass blades. *(This should minimize the potential for adverse effects on grazing animals. The time interval from application to grazing depends on weather conditions, but there should be absolutely no visible sludge residue on the grass blades.)*
- Lactating animals producing milk for human consumption must not be allowed to graze for 12 months following sludge spreading.

Recommendations for specific pasture types are as follows:

- *Tall Fescue.* Sludge may be injected or broadcast to tall fescue pastures where forage is isolated overwinter. Sludge should be applied following the final winter grazing when grass is short (2-4")

and forage should be isolated a minimum of two months before cattle are allowed to graze.

- *Orchard grass*. Sludge may be injected or broadcast to orchard grass following the final fall grazing.
- *Bermuda grass*. Sludge may be incorporated by discing into established pastures from mid-spring through late summer. No sludge applications should be made within six weeks of the date of the first killing frost. Prior to sludge application, pastures should be grazed or mowed to a four inch stubble height and excess plant material removed. Bermuda grass regrowth to 8-12 inches of height should be allowed prior to grazing.

7. Calculating Land Application Rates and Constituent Limits:

This section consists of sample calculations for assessing a site's potential for land application of food processing wastes, and is intended to demonstrate the application of the principles and equations contained in this document.

Description of proposed activity

A farmer has been approached by a commercial dairy operation to land apply their whey wastes (a liquid). The farmer has 800 acres in cropland available, and wants to grow soybeans on the land. The proposed method of land application is spray irrigation.

Soil Characteristics (from soil testing)

Clay Loam, with a CEC of 7 meq/100g

pH = 7.2

Average soil temperature in upper 1 foot of soil is 51°F (~10°C)

Average water content of soil (39% of maximum)

Pore space in soil = 14.1% of soil volume

Background soil Nitrogen level (i.e., available for plant uptake) = 11.8 lbs/acre

Waste Characteristics (from analysis – on an “as applied” basis):

Total solids = 1.4 to 2.5 percent

PH = 7.5

Carbon to Nitrogen Ratio = 18.5 to 1

Metals:

Zinc = 29 parts per million

Copper = 5.8 parts per million

Unit Weight of waste = 8.42 lbs/gallon

Nutrients:

Potassium = 3110 ppm

Phosphorus = 138 ppm

Nitrogen (as follows):

Total Kjeldahl Nitrogen = 570 ppm

Ammonium Nitrogen = 850 ppm

Nitrate + Nitrite Nitrogen = 450 ppm

Waste Characteristics (from observation):

Waste has a mild “sour milk” odor that develops after 12 to 14 hours, and dissipates after around 72 hours.

General comments:

- Soil and waste pH are in the neutral range, so no pre-application modification of either soil or waste pH is in order.
- Soil temperature, porosity and average water content are in the normal range.
- Waste odor may pose a potential problem for surface application, therefore if the application is approved, there will need to be a provision for an incorporation-type of application method in the event that odors do become a problem.

7a Heavy metals – Pollutant Limits:

Before performing all of the other land application calculations, it is wise to determine the limiting lifetime tonnages that may be applied at the site. This will let us know if it is even worthwhile looking into land applying these waste materials.

The CEC of the soil is 7 meq/100 grams. From the chart on page 21 of this document, the maximum allowable application for the life of the facility would be:

446 pounds of zinc per acre, and
223 pounds of copper per acre.

Using the average concentrations for zinc and copper from the waste analysis (above), and applying the appropriate equations found on pages 21 and 22 of this document, we can determine the TOTAL tonnage limits for wastes to be applied over the life of this facility:

The Zinc limitation would be:

$$Zn_{Total} = 446 / (29 * 0.002) = 7,689 \text{ tons of waste}$$

The copper limitation would be:

$$Cu_{Total} = 223 / (5.8 * 0.002) = 19,224 \text{ tons of waste}$$

The total amount of sludge that could be applied to this site would be Zinc limited, and would be 7,689 tons of sludge per acre over the entire lifetime of the site. This is a respectable amount of waste for land application, therefore we will proceed with the evaluation.

7b Agronomic loading rates:

The proposed crop is soybeans, and the expected yield (from the table on page 18 of this document) is 40 bushels per acre (if the documented actual historical yield value for the property under consideration is different, then use the actual yield value, and scale the nutrient requirements accordingly).

Nitrogen:

From the table on page 18, a nitrogen requirement of 30 pounds per acre is required to produce 40 bushels of soybeans per acre.

From the waste analysis on page 26 of this document:

Total Kjeldahl Nitrogen is 570 ppm,
Ammonium Nitrogen is 850 ppm, and
Nitrate + Nitrite Nitrogen is 450 ppm

From the soils analysis on page 25 of this document, the background (e.g., available) nitrogen from the soils is equal to 11.8 pounds per acre.

Using the above analytical data, and Nitrogen equations on pages 17 and 18 of this document, we determine the nitrogen-based waste application limits:

1) Available nitrogen from wastes.

a) Total Kjeldahl Nitrogen (TKN):

$$\begin{aligned} \text{TKN (mg/kg)} * 0.002 &= \text{\#/ton} \\ 570 * 0.002 &= 1.14 \text{ pounds per ton of waste} \end{aligned}$$

b) Ammonium Nitrogen (NH₄-N):

$$\text{NH}_4\text{-N(mg/kg)} * 0.002 * K_v = \text{\#/ton}$$

[NOTE: The Volatilization Factor (K_v) is determined using the appropriate table on page 17 of this document and is based on the method of land application. In this case (spray irrigation) the waste is liquid and being surface applied, therefore K_v is 0.50.]

$$850 * 0.002 * 0.50 = 0.85 \text{ pounds per ton of waste}$$

c) Nitrate plus Nitrite Nitrogen (NO₃-N + NO₂-N):

$$\begin{aligned} (\text{NO}_3\text{-N} + \text{NO}_2\text{-N})(\text{mg/kg}) * 0.002 &= \text{\#/ton} \\ 450 * 0.002 &= 0.9 \text{ pounds per ton of waste} \end{aligned}$$

d) Total Inorganic Nitrogen:

$$\begin{aligned} \text{Add 1b and 1c} &= \text{\#/ton} \\ 0.85 + 0.9 &= 1.75 \text{ pounds per ton of waste} \end{aligned}$$

e) Organic Nitrogen in waste:

$$\begin{aligned} \text{TKN}_{\text{avail}} - \text{Ammon}_{\text{avail}} \\ \text{Subtract 1b from 1a} &= \text{\#/ton} \\ 1.14 - 0.85 &= 0.29 \text{ pounds per ton} \end{aligned}$$

f) Available Organic Nitrogen for the first year of application:

$$\text{Multiply 1e by } F_m = \text{\#/ton}$$

[NOTE: The mineralization Factor (F_m) is determined using the appropriate table on page 17 of this document and is based on how long land application of waste has been taking place at the site. Since this is a new site, F_m is 0.20.]

$$0.29 * 0.20 = 0.058 \text{ pounds per ton of waste}$$

g) Total Nitrogen Available from waste:
Add 1d and 1f = #/ton
 $1.75 + 0.058 = 1.808$ pounds per ton of waste

2. Available nitrogen in the soil = 19.8 pounds per acre

3. Available nitrogen supplied by other sources = None

4. Total Nitrogen available from existing sources:
Add 2 and 3 = #/ton
 $19.8 + 0 = 19.8$ pounds per acre

5. Total nitrogen requirement of crop = 30 pounds per acre

6. Supplemental nitrogen needed from waste:
Subtract 4 from 5 = pounds per acre
 $30 - 19.8 = 10.2$ pounds per acre

7. Agronomic loading rate of waste for nitrogen
Divide 6 by 1g = tons waste per acre
 $10.2 / 1.808 = 5.6$ tons of waste per acre

Phosphorus:

From the table on page 19 of this document we determine that soybean production requires 0.80 pounds of P_2O_5 per bushel. But the footnote below the table on page 19 indicates that the phosphorus content of P_2O_5 is 43.6619 percent, therefore the amount of actual phosphorus required is equal to $0.80 * 0.436619$, or 0.3493 pounds per bushel of soybeans. At 40 bushels of soybeans per acre, this translates to $40 * 0.3493$, or 13.971 pounds of phosphorus per acre.

Using the above analytical data, and Phosphorus equations on page 19 of this document, we determine the phosphorus-based waste application limits:

To convert the phosphorus content of waste (138 ppm) to percent, divide the concentration in ppm by 10,000.

Therefore 138 ppm phosphorus = 0.0138 percent.

Applying the equation from page 19 of this document:

$$\begin{aligned} \text{Tons waste/acre} &= (\text{Crop requirement \#/acre}) / (20 * \%P \text{ in waste}) \\ &= 13.971 / (20 * 0.0138) = 50.61 \text{ tons waste/acre} \end{aligned}$$

Potassium:

From the table on page 20 of this document, we determine that soybean production requires 1.5 pounds of K_2O per bushel. But the footnote below the table indicates that the phosphorus content of K_2O is 82.979 percent, therefore the amount of actual potassium required is equal to $1.5 * 0.82979$, or 1.2447 pounds per bushel of

soybeans. At 40 bushels of soybeans per acre, this translates to 40 * 1.2447, or 49.7874 pounds of potassium per acre.

Using the above analytical data, and potassium equations on page 20 of this document, we determine the potassium-based waste application limits:

To convert the potassium content of waste (3110 ppm) to percent, divide the concentration in ppm by 10,000. Therefore 3110 ppm potassium = 0.311 percent.

Applying the equation from page 20 of this document:

$$\begin{aligned} \text{Tons waste/acre} &= (\text{Crop requirement \#/acre}) / (20 * \%K \text{ in waste}) \\ &= 49.7874 / (20 * 0.311) = 8.00 \text{ tons waste/acre} \end{aligned}$$

A comparison of the nutrient-based calculations reveals that the most restrictive nutrient calculation is for nitrogen, at 5.6 tons of waste per acre.

7c Summary of Calculations:

Based on the waste and soils analysis, and given the nutrient needs for the planned crop, the nutrient requirement for optimal agronomic benefit would permit a land application of the proposed waste at the target site on the order of 5.6 tons of waste per acre of land. Based on the waste analysis, and the CEC of the land application site soils, the total quantity of this waste which should be land applied at the site would be 7,689 tons of waste per acre before the zinc limitation would apply.

Finally, because the soil type is "Clay Loam", then according to the table appearing on page 24, the absolute maximum hydraulic loading rate would be 5000 gallons per acre per hour (actual loading rates may be considerably less than this).

As you can see, the application determination methodology, while tedious, is straightforward. One merely calculates the allowable loading rates for each constituent of concern, and then limits the application rate to the most restrictive.

Also evident is the need for routine soils and waste analysis in order to allow adjustments to the application rates to be made before adverse environmental impacts can occur.

8. Application Methods:

The rate of waste application must be carefully monitored to ensure that the waste remains within the approved land application area (e.g., does not violate the setback limits through careless application, runoff transport or infiltration to the groundwater table. Wastes are not to be land applied during a rainfall event, when rain is expected within the next 24 hours, or when the soil is either saturated or frozen. Several methods of land application have been used successfully:

8a. Incorporation:

This method may be used with either liquid or solid waste. The solid waste is surface applied and then mixed or incorporated into the upper soil layer by disking or plowing. In general, soil incorporation is a superior method in that it minimizes runoff, conserves nitrogen, eliminates odor and pest problems, and is better accepted by neighbors.

8b. Injection:

Liquid waste is discharged into a channel that is opened by a tillable tool mounted on a tank trailer at the time that the waste is being placed.

8c. Landspreading:

Solid or dry waste is applied evenly by a box spreader or grader. The waste may then be incorporated into the soil.

8d. Ridge and Furrow:

This method is used for liquid waste. The waste is discharged into the furrows of a prepared plot or a standing row crop.

8e. Spray Irrigation:

Liquid waste is sprayed through a large orifice nozzle. This method can be used with some types of crops.

8f. Tank Truck (bulk discharge):

Liquid waste is gravity fed from a truck-mounted tank. If this method is employed, care must be taken to avoid ponding of the sludge on the soil surface.

9. Monitoring and Reporting Requirements:

In order to verify the suitability of a waste material for land application, and to demonstrate that waste constituent accumulation is not occurring in the receiving soils, it will be necessary to implement a periodic sampling program at the land application site. The extent of the monitoring program will be dependent upon the nature of the land application operation. All sites will be required to perform routine soils sampling to determine the accumulation of waste constituents, minerals released, and by-products of microbial decomposition in the soil matrix over time. Additionally, groundwater and surface water sampling will be required at all sites applying wastes at rates exceeding the agronomically beneficial loading rate.

The type and degree of sampling shall be as follows:

9a. Soil Testing:

A representative soil sample should be collected annually for pH determination (refer to Section 3b of this document). Initially with the land application submission, and every 3 years thereafter, in addition to pH, soil samples must be

collected and analyzed for Total Nitrogen, Nitrate-Nitrite Nitrogen, Ammonium Nitrogen, Organic Nitrogen, Phosphorous, Potassium, Copper, Lead, Cadmium, Hexavalent Chromium, Zinc, Mercury, Arsenic, Selenium, Nickel and any other parameters as deemed necessary by the Division of Solid Waste Management.

9b. Groundwater and Surface Water Testing:

Sites which practice land application of wastes must perform routine surface and groundwater testing. The frequencies for these tests shall be based upon the potential for waste constituents to impact surface and ground water, and shall be established by the Division on a case-by-case basis.

9c. Data Availability /Other Requirements:

Analytical data and agronomic load rate calculations must be readily available upon request by Division personnel. Analytical data is to be included in the Annual report submitted to the Division by the facility performing the land application activity.

The Division reserves the right to modify any or all of the provisions contained in this guidance document in order to meet changes in relevant state or federal regulations, and in order to ensure adequate protection of human health and the environment. Further, the Division reserves the right to rescind site approval(s) for land application sites at which any improper use or disposal activities have occurred, or for any reason that the Division deems necessary in order to protect human health and/or the environment.



Attachment I

EPA Method 9060

Total Organic Carbon

Source: SW-846

METHOD 9060
TOTAL ORGANIC CARBON

1.0 SCOPE AND APPLICATION

1.1 Method 9060 is used to determine the concentration of organic carbon in ground water, surface and saline waters, and domestic and industrial wastes. Some restrictions are noted in Sections 2.0 and 3.0.

1.2 Method 9060 is most applicable to measurement of organic carbon above 1 mg/L.

2.0 SUMMARY OF METHOD

2.1 Organic carbon is measured using a carbonaceous analyzer. This instrument converts the organic carbon in a sample to carbon dioxide (CO₂) by either catalytic combustion or wet chemical oxidation. The CO₂ formed is then either measured directly by an infrared detector or converted to methane (CH₄) and measured by a flame ionization detector. The amount of CO₂ or CH₄ in a sample is directly proportional to the concentration of carbonaceous material in the sample.

2.2 Carbonaceous analyzers are capable of measuring all forms of carbon in a sample. However, because of various properties of carbon-containing compounds in liquid samples, the manner of preliminary sample treatment as well as the instrument settings will determine which forms of carbon are actually measured. The forms of carbon that can be measured by Method 9060 are:

1. Soluble, nonvolatile organic carbon: e.g., natural sugars.
2. Soluble, volatile organic carbon: e.g., mercaptans, alkanes, low molecular weight alcohols.
3. Insoluble, partially volatile carbon: e.g., low molecular weight oils.
4. Insoluble, particulate carbonaceous materials: e.g., cellulose fibers.
5. Soluble or insoluble carbonaceous materials adsorbed or entrapped on insoluble inorganic suspended matter: e.g., oily matter adsorbed on silt particles.

2.3 Carbonate and bicarbonate are inorganic forms of carbon and must be separated from the total organic carbon value. Depending on the instrument manufacturer's instructions, this separation can be accomplished by either a simple mathematical subtraction, or by removing the carbonate and bicarbonate by converting them to CO₂ with degassing prior to analysis.

3.0 INTERFERENCES

3.1 Carbonate and bicarbonate carbon represent an interference under the terms of this test and must be removed or accounted for in the final calculation.

3.2 This procedure is applicable only to homogeneous samples which can be injected into the apparatus reproducibly by means of a microliter-

type syringe or pipet. The openings of the syringe or pipet limit the maximum size of particle which may be included in the sample.

3.3 Removal of carbonate and bicarbonate by acidification and purging with nitrogen, or other inert gas, can result in the loss of volatile organic substances.

4.0 APPARATUS AND MATERIALS

4.1 Apparatus for blending or homogenizing samples: Generally, a Waring type blender is satisfactory.

4.2 Apparatus for total and dissolved organic carbon:

4.2.1 Several companies manufacture analyzers for measuring carbonaceous material in liquid samples. The most appropriate system should be selected based on consideration of the types of samples to be analyzed, the expected concentration range, and the forms of carbon to be measured.

4.2.2 No specific analyzer is recommended as superior. If the technique of chemical oxidation is used, the laboratory must be certain that the instrument is capable of achieving good carbon recoveries in samples containing particulates.

5.0 REAGENTS

5.1 ASTM Type II water (ASTM D1193): Water should be monitored for impurities, and should be boiled and cooled to remove CO.

5.2 Potassium hydrogen phthalate, stock solution, 1,000 mg/L carbon: Dissolve 0.2128 g of potassium hydrogen phthalate (primary standard grade) in Type II water and dilute to 100.0 mL.

[NOTE: Sodium oxalate and acetic acid are not recommended as stock solutions.]

5.3 Potassium hydrogen phthalate, standard solutions: Prepare standard solutions from the stock solution by dilution with Type II water.

5.4 Carbonate-bicarbonate, stock solution, 1,000 mg/L carbon: Weigh 0.3500 g of sodium bicarbonate and 0.4418 g of sodium carbonate and transfer both to the same 100-mL volumetric flask. Dissolve with Type II water.

5.5 Carbonate-bicarbonate, standard solution: Prepare a series of standards similar to Step 5.3.

[NOTE: This standard is not required by some instruments.]

5.6 Blank solution: Use the same Type II water as was used to prepare the standard solutions.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 All samples must be collected using a sampling plan that addresses the considerations discussed in Chapter Nine of this manual.

6.2 Sampling and storage of samples in glass bottles is preferable. Sampling and storage in plastic bottles such as conventional polyethylene and cubitainers is permissible if it is established that the containers do not contribute contaminating organics to the samples.

[NOTE: A brief study performed in the EPA Laboratory indicated that Type II water stored in new, 1-qt cubitainers did not show any increase in organic carbon after 2 weeks' exposure.]

6.3 Because of the possibility of oxidation or bacterial decomposition of some components of aqueous samples, the time between sample collection and the start of analysis should be minimized. Also, samples should be kept cool (4°C) and protected from sunlight and atmospheric oxygen.

6.4 In instances where analysis cannot be performed within 2 hr from time of sampling, the sample is acidified (pH < 2) with HCl or H₂SO₄.

7.0 PROCEDURE

7.1 Homogenize the sample in a blender.

[NOTE: To avoid erroneously high results, inorganic carbon must be accounted for. The preferred method is to measure total carbon and inorganic carbon and to obtain the organic carbon by subtraction. If this is not possible, follow Steps 7.2 and 7.3 prior to analysis; however, volatile organic carbon may be lost.]

7.2 Lower the pH of the sample to 2.

7.3 Purge the sample with nitrogen for 10 min.

7.4 Follow instrument manufacturer's instructions for calibration, procedure, and calculations.

7.5 For calibration of the instrument, a series of standards should be used that encompasses the expected concentration range of the samples.

7.6 Quadruplicate analysis is required. Report both the average and the range.

8.0 QUALITY CONTROL

8.1 All quality control data should be maintained and available for easy reference or inspection.

8.2 Employ a minimum of one blank per sample batch to determine if contamination or any memory effects are occurring.

8.3 Verify calibration with an independently prepared check standard every 15 samples.

8.4 Run one spike duplicate sample for every 10 samples. A duplicate sample is a sample brought through the whole sample preparation and analytical process.

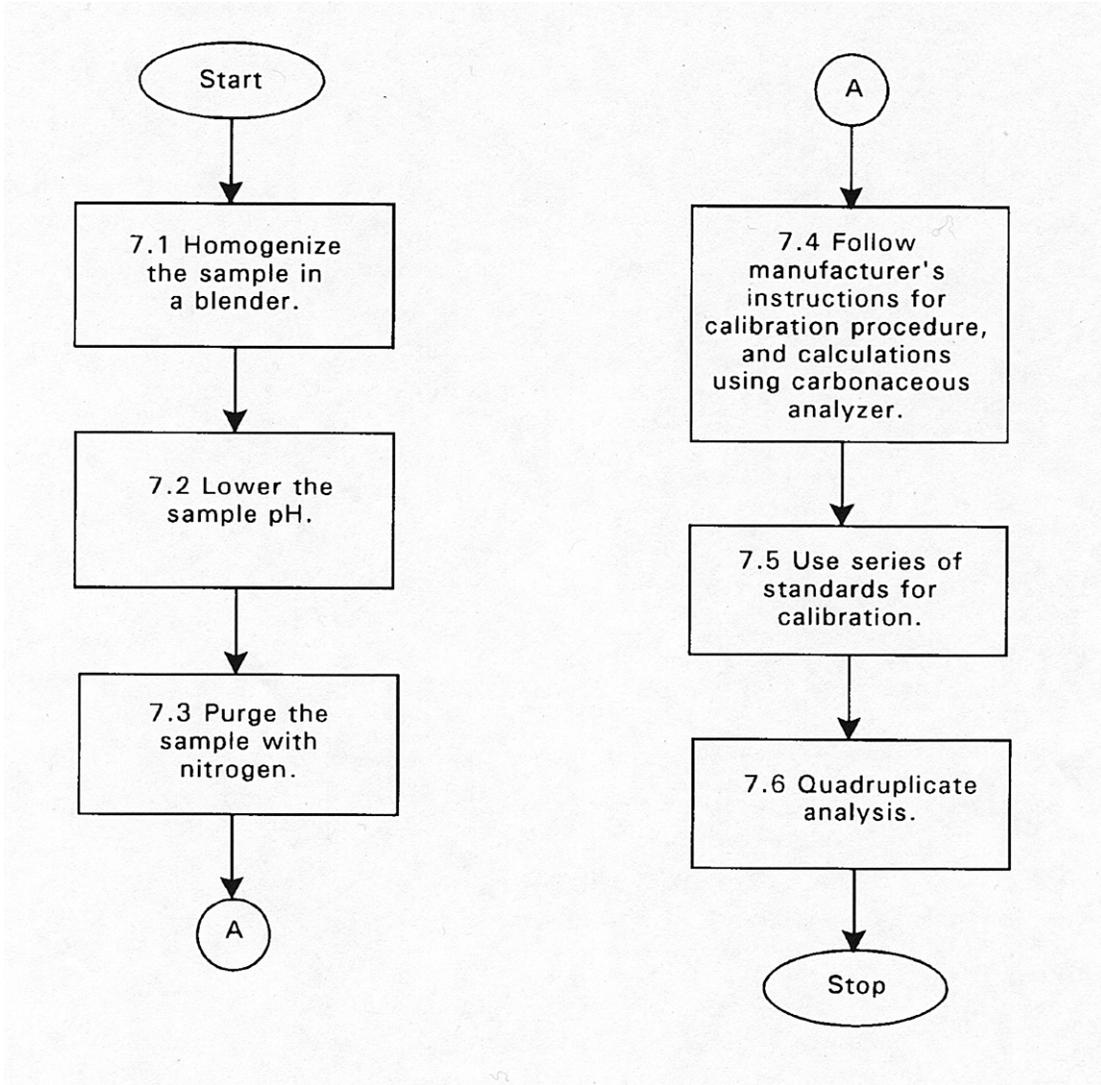
9.0 METHOD PERFORMANCE

9.1 Precision and accuracy data are available in Method 415.1 of Methods for Chemical Analysis of Water and Wastes.

10.0 REFERENCES

1. Annual Book of ASTM Standards, Part 31, "Water," Standard D 2574-79, p. 469 (1976).
2. Standard Methods for the Examination of Water and Wastewater, 14th ed., p. 532, Method 505 (1975).

Method 9060
TOTAL ORGANIC CARBON



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Attachment II

EPA Method 9050A

Specific Conductance

Source: SW-846

METHOD 9050A **SPECIFIC CONDUCTANCE**

1.0 SCOPE AND APPLICATION

1.1 Method 9050 is used to measure the specific conductance of drinking, ground, surface, and saline waters and domestic and industrial aqueous wastes. Method 9050 is not applicable to solid samples or to organic samples.

2.0 SUMMARY OF METHOD

2.1 The specific conductance of a sample is measured using a self-contained conductivity meter (Wheatstone bridge-type or equivalent).

2.2 Whenever possible, samples are analyzed at 25°C. Unless a temperature correction routine is used by the instrument, samples of different temperatures must be equilibrated to and results reported at 25°C.

3.0 INTERFERENCES

3.1 Platinum electrodes can degrade and cause erratic results. When this happens, as evidenced by erratic results or flaking off of the platinum black, the electrode should be replatinized.

3.2 The specific conductance cell can become coated with oil and other materials. It is essential that the cell be thoroughly rinsed and, if necessary, cleaned between samples.

4.0 APPARATUS AND MATERIALS

4.1 Self-contained conductivity instruments: an instrument consisting of a source of alternating current, a Wheatstone bridge, null indicator, and a conductivity cell or other instrument measuring the ratio of alternating current through the cell to voltage across it. The latter has the advantage of a linear reading of conductivity. Choose an instrument capable of measuring conductivity with an error not exceeding 1% or 1 $\mu\text{S}/\text{cm}$, whichever is greater.

4.2 Platinum-electrode or non-platinum-electrode specific conductance cell.

4.3 Water bath.

4.4 Thermometer: capable of being read to the nearest 0.1°C and covering the range 23°C to 27°C. An electrical thermometer having a small thermistor sensing element is convenient because of its rapid response.

5.0 REAGENTS

5.1 Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

5.2 Conductivity water: Pass distilled water through a mixed-bed deionizer and discard first 1,000 mL. Conductivity should be less than 1 uS/cm.

5.3 Standard potassium chloride (0.0100 M): Dissolve 0.7456 g anhydrous KCl in conductivity water and make up to 1,000 mL at 25°C. This solution will have a specific conductance of 1,413 uS/cm at 25°C.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 All samples must be collected using a sampling plan that addresses the considerations discussed in Chapter Nine of this manual.

6.2 All sample containers must be prewashed and thoroughly rinsed. Both plastic and glass containers are suitable.

6.3 Aqueous samples should be stored at 4°C and analyzed within 28 days.

7.0 PROCEDURE

7.1 Determination of cell constant: Rinse conductivity cell with at least three portions of 0.01 N KCl solution. Adjust temperature of a fourth portion to 25.0 + 0.1°C. Measure resistance of this portion and note temperature. Compute cell constant, C:

$$C = (0.001413)(R_{KCL})^{-1} + 0.0191 (t - 25)$$

where:

R_{KCL} = measured resistance, ohms; and
t = observed temperature, °C.

7.2 Conductivity measurement: Rinse cell with one or more portions of sample. Adjust temperature of a final portion to 25.0 + 0.1°C. Measure sample resistance or conductivity and note temperature.

7.3 Calculation: The temperature coefficient of most waters is only approximately the same as that of standard KCl solution; the more the temperature of measurement deviates from 25.0°C, the greater the uncertainty in applying the temperature correction. Report all conductivities at 25.0°C.

7.3.1 When sample resistance is measured, conductivity at 25°C is:

$$K = ((1,000,000)(C))/[R_m [1 + 0.0191 (t - 25)]]$$

where:

K = conductivity, uS/cm;
C = cell constant, cm-L;
 R_m = measured resistance of sample, ohms; and
t = temperature of measurement.

7.3.2 When sample conductivity is measured, conductivity at 25°C is:

$$K = ((K_m)(1,000,000)(C))/(1 + 0.0191 (t - 25))$$

where:

K_m = measured conductivity, uS at t°C, and other units are defined as above.

[NOTE: If conductivity readout is in uS/cm, delete the factor 1,000,000 in the numerator.]

[NOTE: In the International System of Units (SI) the reciprocal of the ohm is the siemens (S) and conductivity is reported as millisiemens per meter (mS/m); 1 mS/m = 10 µmhos/cm and 1 µS/cm = 1 µmho/cm. To report results in SI units of mS/m divide µmhos/cm by 10.]

8.0 QUALITY CONTROL

8.1 Refer to Chapter One for specific quality control procedures.

8.2 Analyze an independently prepared check standard to verify calibration.

8.3 Analyze one duplicate sample for every 10 samples.

9.0 METHOD PERFORMANCE

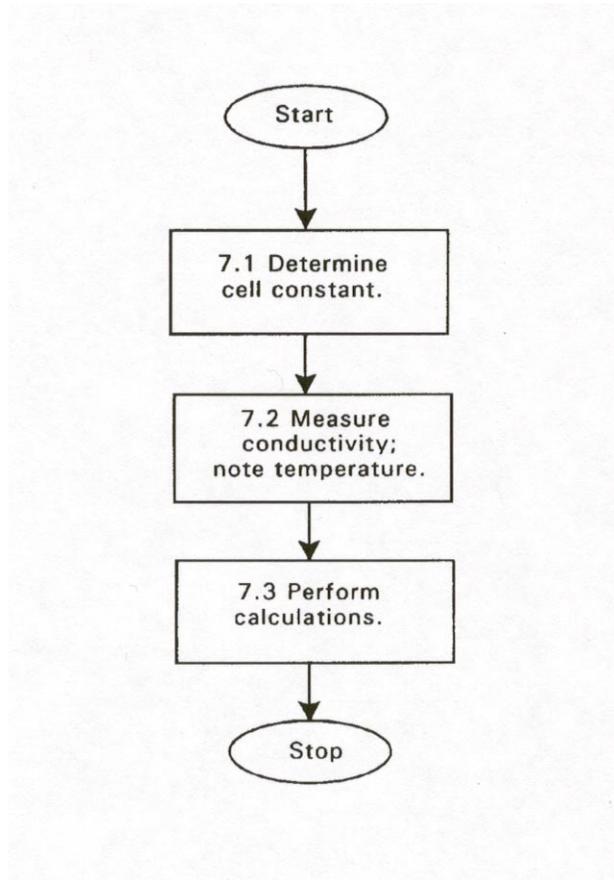
9.1 Three synthetic samples were tested with the following results:

Relative Conductivity uS/cm	No. of Results	Relative Standard Deviation (%)	Relative Error (%)
147.0	117	8.6	9.4
303.0	120	7.8	1.9
228.0	120	8.4	3.0

10.0 REFERENCES

1. Standard Methods for the Examination of Water and Wastewater, 16th ed. (1985), Method 205.

**METHOD 9050A
SPECIFIC CONDUCTANCE**



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Attachment III

EPA Method 9080

**Cation Exchange Capacity of Soils
(Ammonium Acetate)**

And

EPA Method 9081

**Cation Exchange Capacity of Soils
(Sodium Acetate)**

Source: SW-846

METHOD 9080
CATION-EXCHANGE CAPACITY OF SOILS (AMMONIUM ACETATE)

1.0 SCOPE AND APPLICATION

1.1 Method 9080 is used to determine the cation-exchange capacity of soils. The method is not applicable to soils containing appreciable amounts of vermiculite clays, kaolin, halloysite, or other 1:1-type clay minerals. They should be analyzed by the sodium acetate method (Method 9081). That method (9081) is also generally the preferred method for very calcareous soils. For distinctly acid soils, the cation-exchange capacity by summation method (Chapman, p. 900; see Paragraph 10.1) should be employed.

2.0 SUMMARY

2.1 The soil is mixed with an excess of 1 N ammonium acetate solution. This results in an exchange of the ammonium cations for exchangeable cations present in the soil. The excess ammonium is removed, and the amount of exchangeable ammonium is determined.

3.0 INTERFERENCES

3.1 Soils containing appreciable vermiculite clays, kaolin, halloysite, or other 1:1-type clay minerals will often give lower values for exchange capacity. See Paragraph 1.1 above.

3.2 With calcareous soils, the release of calcium carbonate from the soil into the ammonium acetate solution limits the saturation of exchange sites by the ammonium ion. This results in artificially low cation-exchange capacities.

4.0 APPARATUS AND MATERIALS

4.1 Erlenmeyer flask: 500-mL.

4.2 Buchner funnel or equivalent: 55-mm.

4.3 Sieve: 2-mm.

4.4 Aeration apparatus (assembled as in Figure 1):

4.4.1 Kjeldahl flask: 800-mL.

4.4.2 Erlenmeyer flask: 800-mL.

4.4.3 Glass wool filter.

4.4.4 Glass tubing.

4.4.5 Flow meter.

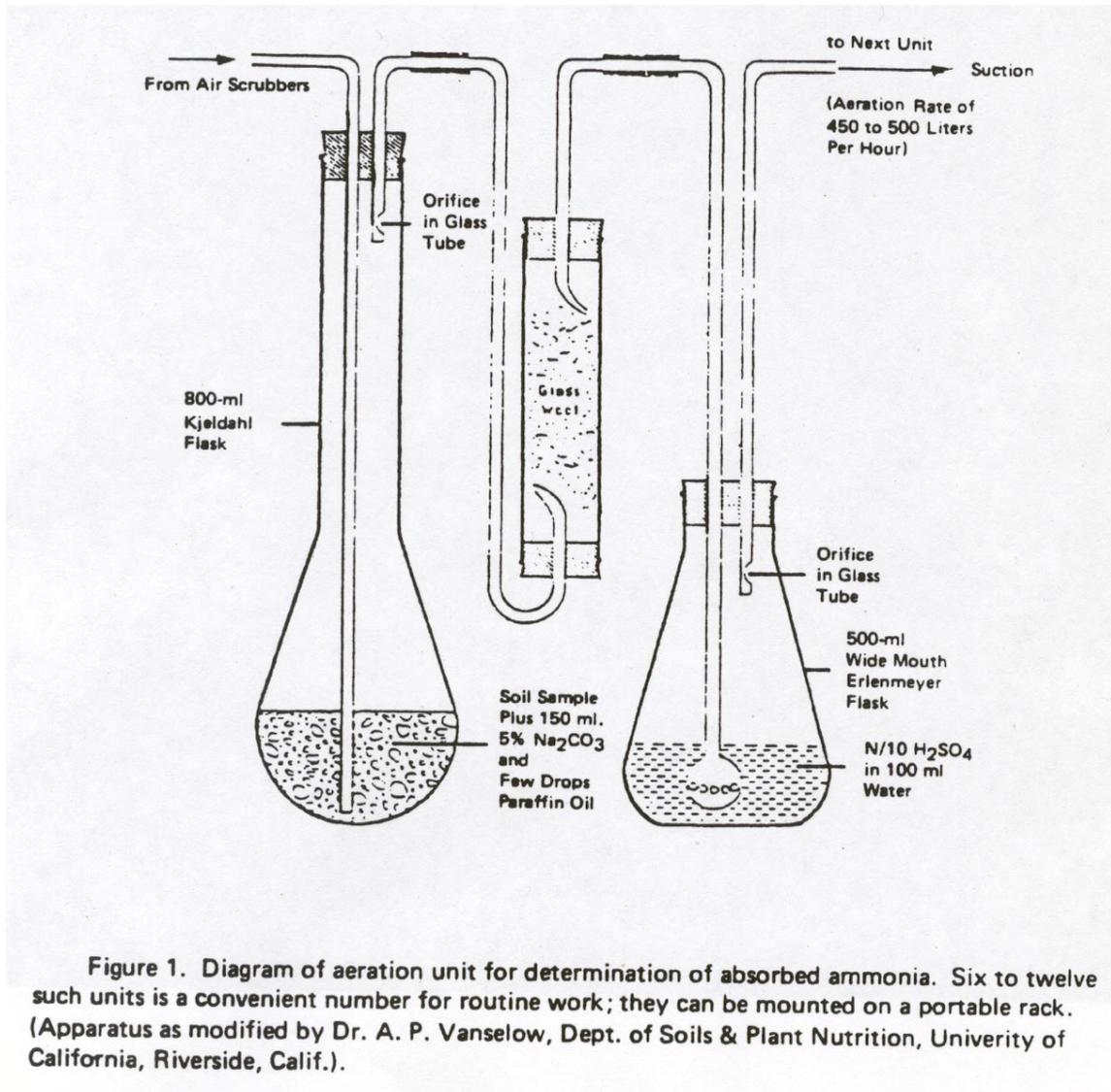
5.0 REAGENTS

5.1 Ammonium acetate (NH_4OAc), 1 N: Dilute 114 mL of glacial acetic acid (99.5%) with water to a volume of approximately 1 liter. Then add 138 mL of concentrated ammonium hydroxide (NH_4OH) and add water to obtain a volume of about 1,980 mL. Check the pH of the resulting solution, add more NH_4OH , as needed, to obtain a pH of 7, and dilute the solution to a volume of 2 liters with water.

5.2 Isopropyl alcohol: 99%.

5.3 Ammonium chloride (NH_4Cl), 1 N: Dissolve 53.49 g of NH_4Cl in Type II water, adjust the pH to 7.0 with NH_4OH , and dilute to 1 L.

5.4 Ammonium chloride (NH_4Cl), 0.25 N: Dissolve 13.37 g of NH_4Cl in Type II water, adjust the pH to 7.0 with NH_4OH , and dilute to 1 L.



5.5 Ammonium oxalate ($(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$), 10%: Add 90 mL of Type II water to 10 g of ammonium oxalate ($(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$) and mix well.

5.6 Dilute ammonium hydroxide (NH_4OH): Add 1 volume of concentrated NH_4OH to an equal volume of water.

5.7 Silver nitrate (AgNO_3), 0.10 N: Dissolve 15.39 g of AgNO_3 in Type II water, mix well, and dilute to 1 L.

5.8 Reagents for aeration option:

5.8.1 Sodium carbonate solution (Na_2CO_3), 5%: Add 95 mL of Type

II water to 5 g of Na_2CO_3 and mix well.

5.8.2 **Paraffin oil.**

5.8.3 **Sulfuric acid** (H_2SO_4), 0.1 N standard: Add 2.8 mL concentrated H_2SO_4 to Type II water and dilute to 1 L. Standardize against a base of known concentration.

5.8.4 **Sodium hydroxide** (NaOH), 0.1 N standard: Dissolve 4.0 g NaOH in Type II water and dilute to 1 L. Standardize against an acid of known concentration.

5.8.5 **Methyl red indicator**, 0.1%: Dissolve 0.1 g in 99.9 mL of 95% ethanol and mix well.

5.9 Reagents for distillation option:

5.9.1 **Sodium chloride**, NaCl (acidified), 10%: Dissolve 100 g of NaCl (ammonium-free) in 900 mL of Type II water; mix well. Add approximately 0.42 mL of concentrated HCl to make the solution approximately 0.005 N.

5.9.2 **Sodium hydroxide** (NaOH), 1 N: Dissolve 40 g of NaOH in Type II water and dilute to 1 L.

5.9.3 **Boric acid** (H_3BO_3), 2% solution: Dissolve 20 g H_3BO_3 in 980 mL Type II water and mix well.

5.9.4 **Standard sulfuric acid** (H_2SO_4), 0.1 N: See Step 5.8.3.

5.9.5 **Bromocresol green-methyl red mixed indicator**: Triturate 0.1 g of bromocresol green with 2 mL 0.1 N NaOH in an agate mortar and add 95% ethyl alcohol to obtain a total volume of 100 mL. Triturate 0.1 g of methyl red with a few mL of 95% ethyl alcohol in an agate mortar. Add 3 mL of 0.1 N NaOH and dilute the solution to a volume of 100 mL with 95% ethyl alcohol. Mix 75 mL of the bromocresol green solution with 25 mL of the methyl red solution and dilute the mixture to 200 mL with 95% ethyl alcohol.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 All samples must be collected using a sampling plan that addresses the considerations discussed in Chapter Nine of this manual.

7.0 PROCEDURE

7.1 Sieve a sample aliquot of the soil through a 2-mm screen and allow the sieved soil to air dry (at a temperature of $\#60^\circ\text{C}$). Place 10 g of the air-dried soil in a 500-mL Erlenmeyer flask and add 250 mL of neutral, 1 N NH_4OAc . (Use 25 g of soil if the exchange capacity is very low, e.g., 3-5 meq per 100 g.) Shake the flask thoroughly and allow it to stand overnight.

7.2 Filter the soil with light suction using a 55-mm Buchner funnel or equivalent. Do not allow the soil to become dry and cracked.

7.3 Leach the soil with the neutral NH_4OAc reagent until no test for calcium can be obtained in the effluent solution. (For the calcium test, add a few drops each of 1 N NH_4Cl and 10% ammonium oxalate, dilute NH_4OH to 10 mL of the leachate in a test tube, and heat the solution to near the boiling point. The presence of calcium is indicated by a white precipitate or turbidity.)

7.4 Then leach the soil four times with neutral 1 N NH_4Cl and once with 0.25 N NH_4Cl .

7.5 Wash out the electrolyte with 150 to 200 mL of 99% isopropyl alcohol. When the test for chloride in the leachate (use 0.10 AgNO_3) becomes negligible, allow the soil to drain thoroughly.

7.6 Determine the adsorbed NH_4 either by the aeration method (Paragraph 7.7) or by the acid- NaCl method (Paragraph 7.8).

7.7 Aeration method:

7.7.1 Place an excess of 0.1 N standard H_2SO_4 in the 500-mL Erlenmeyer flask on the aeration apparatus (50 mL is an ample quantity for most soils) and add 10 drops of methyl red indicator and enough distilled water to make the total volume about 100 mL.

7.7.2 Attach the flask to the apparatus. Then transfer the ammonium-saturated sample of soil (from Paragraph 7.5) quantitatively to the 800-mL Kjeldahl flask located in the flow line just before the Erlenmeyer flask with the standard acid. Use a rubber policeman and a stream of distilled water from a wash bottle, as needed, to complete the transfer.

7.7.3 Add 150 mL Na_2CO_3 solution and a few drops of paraffin oil and attach the flask to the apparatus.

7.7.4 Apply suction to the outflow end of the apparatus and adjust the rate of flow to 450 to 500 liters of air per hr. Continue the aeration for 17 hr.

7.7.5 Shut off the suction and remove the flask. Titrate the residual acid in the absorption solutions with standard 0.1 N NaOH from the original red color through orange to yellow at the end point. From the titration values obtained with the soil and blank solutions, calculate the content of adsorbed ammonium in milligram equivalents per 100 g soil.

7.8 Acid- NaCl method:

7.8.1 Leach the ammonium-saturated soil from Paragraph 7.5 with 10% acidified NaCl until 225 mL have passed through the sample. Add small portions at a time, allowing each portion to pass through the sample before adding the next portion.

7.8.2 Transfer the leachate quantitatively to an 800-mL Kjeldahl flask, add 25 mL of 1 N NaOH, and distill 60 mL of the solution into 50 mL of 2% H₃BO₃ .

7.8.3 Add 10 drops of bromocresol green-methyl red mixed indicator and titrate the boric acid solution with standard 0.1 N H₂SO₄. The color change is from bluish green through bluish purple to pink at the end point. Run blanks on the reagents. Correct the titration figure for the blanks and calculate the milliequivalents of ammonium in 100 g of soil.

7.8.4 Results should be reported as "determined with ammonium acetate" at pH 7.

8.0 QUALITY CONTROL

8.1 All quality control data should be maintained and available for easy reference or inspection.

8.2 Employ a minimum of one blank per sample batch to determine if contamination or any memory effects are occurring.

8.3 Material of known cation-exchange capacity must be routinely analyzed.

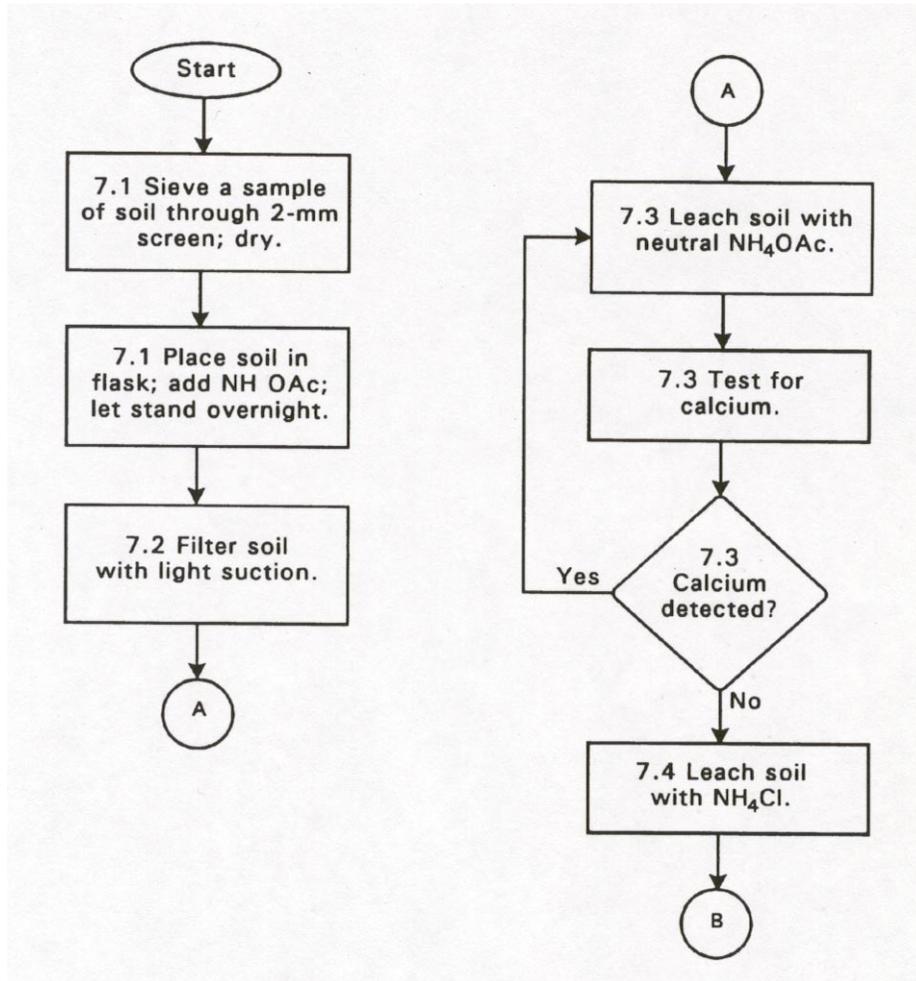
9.0 METHOD PERFORMANCE

9.1 No data provided.

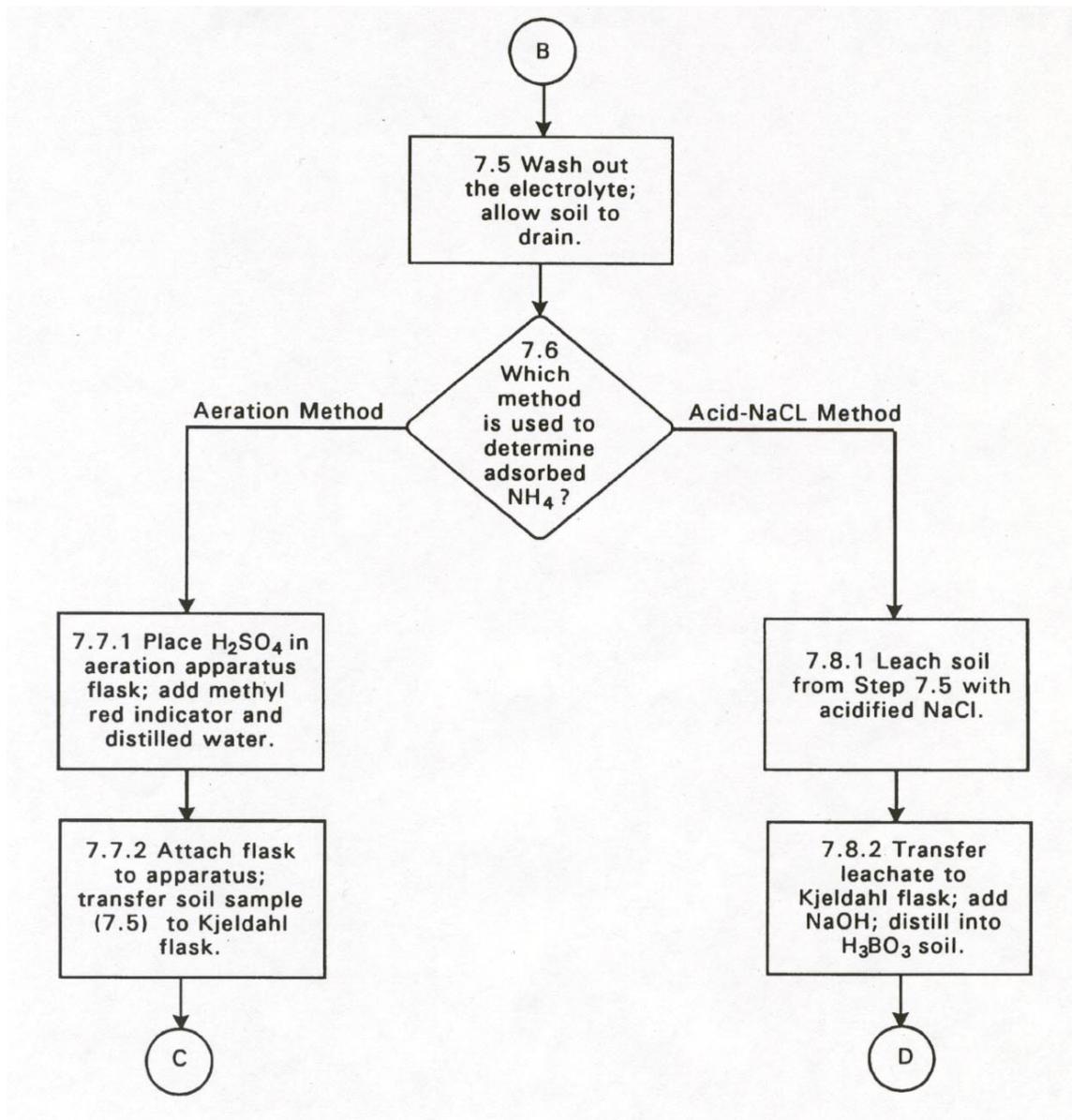
10.0 REFERENCES

1. This method is based on Chapman, H.D., "Cation-exchange Capacity," pp. 891-900, in C.A. Black (ed.), Method of Soil Analysis, Part 2: Chemical and Microbiological Properties, Am. Soc. Agron., Madison, Wisconsin (1965).

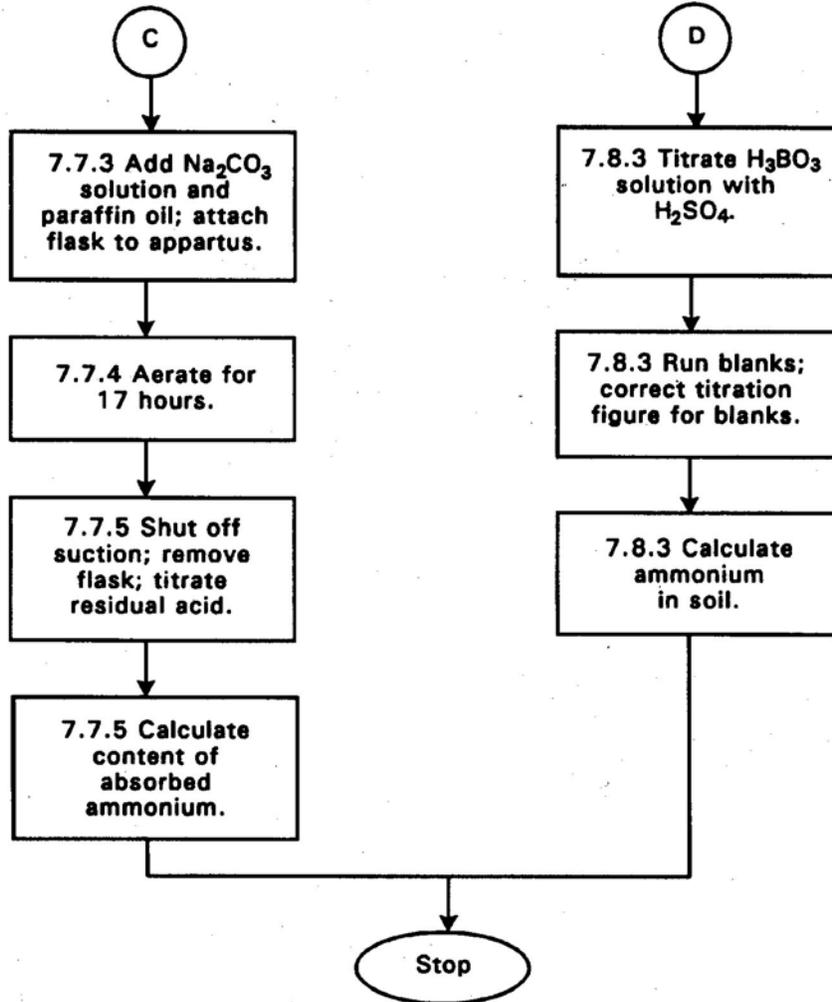
METHOD 9080
CATION-EXCHANGE CAPACITY (AMMONIUM ACETATE)



METHOD 9080
CATION-EXCHANGE CAPACITY (AMMONIUM ACETATE)
(Continued)



METHOD 9080
CATION-EXCHANGE CAPACITY (AMMONIUM ACETATE)
(Continued)



METHOD 9081
CATION-EXCHANGE CAPACITY OF SOILS (SODIUM ACETATE)

1.0 SCOPE AND APPLICATION

1.1 Method 9081 is applicable to most soils, including calcareous and noncalcareous soils. The method of cation-exchange capacity by summation (Chapman, 1965, p. 900; see Paragraph 10.1) should be employed for distinctly acid soils.

2.0 SUMMARY OF METHOD

2.1 The soil sample is mixed with an excess of sodium acetate solution, resulting in an exchange of the added sodium cations for the matrix cations. Subsequently, the sample is washed with isopropyl alcohol. An ammonium acetate solution is then added, which replaces the adsorbed sodium with ammonium. The concentration of displaced sodium is then determined by atomic absorption, emission spectroscopy, or an equivalent means.

3.0 INTERFERENCES

3.1 Interferences can occur during analysis of the extract for sodium content. Thoroughly investigate the chosen analytical method for potential interferences.

4.0 APPARATUS AND MATERIALS

4.1 Centrifuge tube and stopper: 50-mL, round-bottom, narrow neck.

4.2 Mechanical shaker.

4.3 Volumetric flask: 100-mL.

5.0 REAGENTS

5.1 Sodium acetate (NaOAc), 1.0 N: Dissolve 136 g of $\text{NaC}_2\text{H}_3\text{O}_2 \cdot 3\text{H}_2\text{O}$ in water and dilute it to 1,000 mL. The pH of this solution should be 8.2. If needed, add a few drops of acetic acid or NaOH solution to bring the reaction of the solution to pH 8.2.

5.2 Ammonium acetate (NH_4OAc), 1 N: Dilute 114 mL of glacial acetic acid (99.5%) with water to a volume of approximately 1 liter. Then add 138 mL of concentrated ammonium hydroxide (NH_4OH) and add water to obtain a volume of about 1,980 mL. Check the pH of the resulting solution, add more NH_4OH , as needed, to obtain a pH of 7, and dilute the solution to a volume of 2 liters with water.

5.3 Isopropyl alcohol: 99%.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 All samples must be collected using a sampling plan that addresses the considerations discussed in Chapter Nine of this manual.

7.0 PROCEDURE

7.1 Weigh 4 g of medium- or fine-textured soil or 6 g of coarse-textured soil and transfer the sample to a 50-mL, round-bottom, narrow-neck centrifuge tube. (A fine soil has >50% of the particles <0.074 mm,

medium soil has >50% 0.425 mm, while a coarse soil has more than 50% of its particles >2 mm.

7.2 Add 33 mL of 1.0 N NaOAc solution, stopper the tube, shake it in a mechanical shaker for 5 min, and centrifuge it until the supernatant liquid is clear.

7.3 Decant the liquid, and repeat Paragraph 7.2 three more times.

7.4 Add 33 mL of 99% isopropyl alcohol, stopper the tube, shake it in a mechanical shaker for 5 min, and centrifuge it until the supernatant liquid is clear.

7.5 Repeat the procedure described in Paragraph 7.4 two more times.

7.6 Add 33 mL of NH₄OAc solution, stopper the tube, shake it in a mechanical shaker for 5 min, and centrifuge it until the supernatant liquid is clear. Decant the washing into a 100-mL volumetric flask.

7.7 Repeat the procedure described in Paragraph 7.6 two more times.

7.8 Dilute the combined washing to the 100-mL mark with ammonium acetate solution and determine the sodium concentration by atomic absorption, emission spectroscopy, or an equivalent method.

8.0 QUALITY CONTROL

8.1 All quality control data should be maintained and available for easy reference or inspection.

8.2 Employ a minimum of one blank per sample batch to determine if contamination or any memory effects are occurring.

8.3 Materials of known cation-exchange capacity must be routinely analyzed.

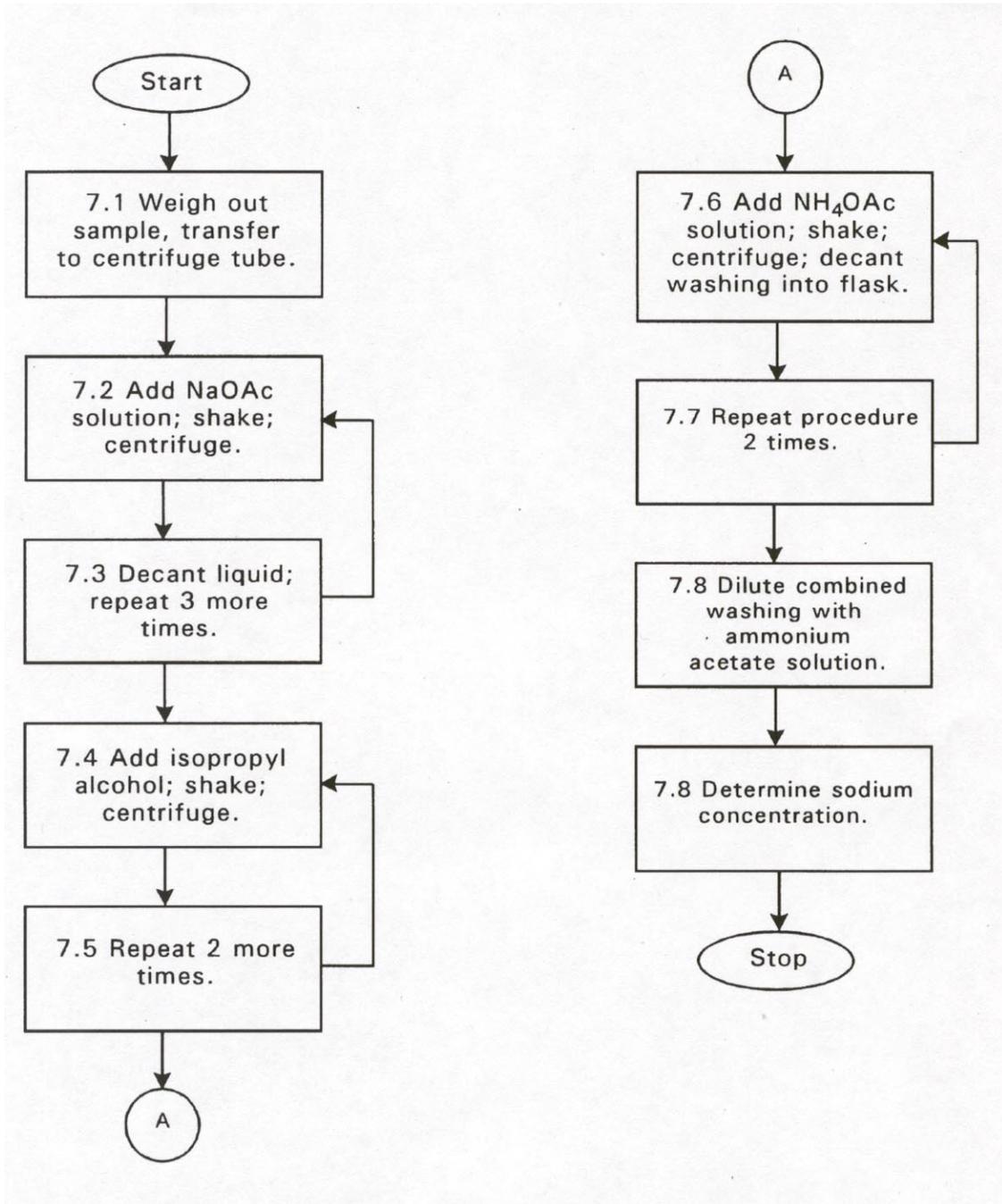
9.0 METHOD PERFORMANCE

9.1 No data provided.

10.0 REFERENCES

10.1 This method is based on Chapman, H.D., "Cation-exchange Capacity," pp. 891-900, in C.A. Black (ed.), Method of Soil Analysis, Part 2: Chemical and Microbiological Properties, Am. Soc. Agron., Madison, Wisconsin (1965).

METHOD 9081
CATION-EXCHANGE CAPACITY OF SOILS (SODIUM ACETATE)



Attachment IV

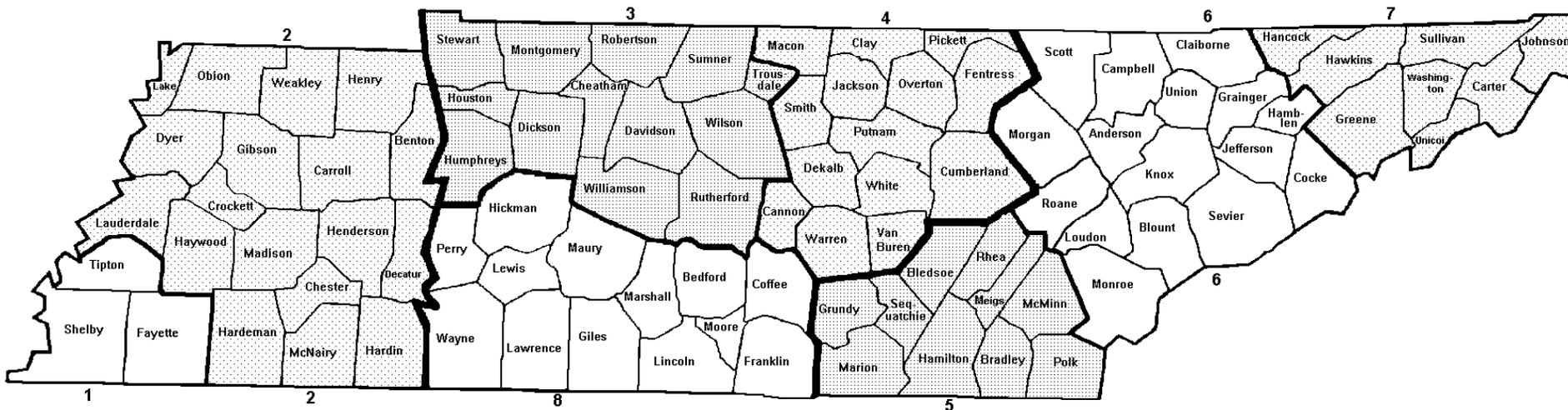
Tennessee Division of Solid Waste Management

**Environmental Assistance Center
Regional Map**

And

Contact Information

**Tennessee Department of Environment and Conservation
Solid Waste Management Contacts**



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**Division of Solid Waste Management
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updated February, 2002

Attachment V
Tennessee Rule Chapter 1200-1-7
Appendix II

Groundwater Constituent List

APPENDIX II
GROUND-WATER MONITORING LIST

<u>Common Name</u>	<u>Chemical Abstracts Service Index Name</u>
Acenaphthene	Acenaphthylene, 1,2-dihydro-
Acenaphthylene	Acenaphthylene
Acetone	2-Propanone
Acetonitrile; Methyl cyanide	Acetonitrile
Acetophenone	Ethanone, 1-phenyl
2-Acetylaminofluorene; 2-AAF	Acetamide, N-9H-fluoren-2-yl-
Acrolein	2-Propenal
Acrylonitrile	2-Propenenitrile
Aldrin	1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-(1a,4a,4aB,5a,8a,8aB)-
Allyl chloride	1-Propene, 3-chloro-
4-Aminobiphenyl	[1,1'-Biphenyl]-4-amine
Anthracene	Anthracene
Antimony	Antimony
Arsenic	Arsenic
Barium	Barium
Benzene	Benzene
Benzo[a]anthracene; Benzantracene	Benzo[a]anthracene
Benzo[b]fluoranthene	Benzo[e]acephenanthrylene
Benzo[k]fluoranthene	Benzo[k]fluoranthene
Benzo[ghi]perylene	Benzo[ghi]perylene
Benzo[a]pyrene	Benzo[a]pyrene
Benzyl alcohol	Benzenemethanol
Beryllium	Beryllium
alpha-BHC	Cyclohexane, 1,2,3,4,5,6-hexachloro-(1a,2a,3B,4a,5B,6B)-
beta-BHC	Cyclohexane, 1,2,3,4,5,6-hexachloro-(1a,2B,3a,4B,5a,6B)-
delta-BHC	Cyclohexane, 1,2,3,4,5,6-hexachloro-(1a,2a,3a,4B,5a,6B)-
gamma-BHC; Lindane	Cyclohexane, 1,2,3,4,5,6-hexachloro-(1a,2a,3B,4a,5a,6B)-
Bis(2-chloroethoxy)methane	Ethane, 1,1'-[methylenebis(oxy)]bis[2-chloro-
Bis(2-chloroethyl)ether	Ethane, 1,1'-oxybis[2-chloro-
Dichloroethyl ether	
Bis(2-chloro-1-methylethyl)ether;	Propane, 2,2'-oxybis[1-chloro-
2,2-Dichlorodiisopropyl ether;	
Bis(2-ethylhexyl) phthalate	1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl)ester
Bromochloromethane;	Methane, bromochloro-
Chlorobromomethane	
Bromodichloromethane	Methane, bromodichloro-
Dibromochloromethane	
Bromoform; Tribromomethane	Methane, tribromo-
4-Bromophenyl phenyl ether	Benzene, 1-bromo-4-phenoxy-
Butyl benzyl phthalate; Benzyl butyl phthalate	1,2-Benzenedicarboxylic acid, butyl phenylmethyl ester
Cadmium	Cadmium

APPENDIX II

GROUND-WATER MONITORING LIST

(Continued)

<u>Common Name</u>	<u>Chemical Abstracts Service Index Name</u>
Carbon disulfide	Carbon disulfide
Carbon tetrachloride	Methane, tetrachloro-
Chlordane	4,7-Methano-1H-indene, 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro
p-Chloroaniline	Benzenamine, 4-chloro-
Chlorobenzene	Benzene, chloro-
Chlorobenzilate	Benzeneacetic acid, 4-chloro-a-(4-chlorophenyl)a-hydroxy,ethyl ester
p-Chloro-m-cresol	Phenol, 4-chloro-3-methyl-
4-Chloro-3-methylphenol	
Chloroethane; Ethyl chloride	Ethane, chloro-
Chloroform; Trichloromethane	Methane, trichloro-
2-Chloronaphthalene	Napthalene, 2-chloro-
2-Chlorophenol	Phenol, 2-chloro-
4-Chlorophenyl phenyl ether	Benzene, 1-chloro-4-phenoxy
Chloroprene	1,2-Butadiene, 2-chloro-
Chromium	Chromium
Chrysene	Chrysene
Cobalt	Cobalt
Copper	Copper
m-Cresol; 3-methylphenol	Phenol, 3-methyl-
o-Cresol; 2-methylphenol	Phenol, 2-methyl-
p-Cresol; 4-methylphenol	Phenol, 4-methyl-
Cyanide	Cyanide
2,4-D; 2,4-Dichlorophenoxyacetic acid	Acetic acid, (2,4-dichlorophenoxy)-
4,4'-DDD	Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-
4,4'-DDE	Benzene, 1,1'-(dichloroethylidene)bis[4-chloro-
4,4'-DDT	Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro-
Diallate	Carbamothioic acid, bis(1-methylethyl)-, S-(2,3-dichloro-2-propenyl) ester
Dibenz[a,h]anthracene	Dibenz[a,h]anthracene
Dibenzofuran	Dibenzofuran
Dibromochloromethane; Chlorodibromomethane	Methane, dibromochloro-
1,2-Dibromo-3-chloropropane; DBCP	Propane, 1,2-dibromo-3-chloro-
1,2-Dibromoethane; Ethylene dibromide	Ethane, 1,2-dibromo-
Di-n-butyl phthalate	1,2-Benzenedicarboxylic acid, dibutyl ester
o-Dichlorobenzene	Benzene, 1,2-dichloro-
1,2-Dichlorobenzene	
m-Dichlorobenzene	Benzene, 1,3-dichloro-
1,3-Dichlorobenzene	
p-Dichlorobenzene	Benzene, 1,4-dichloro-
1,4-Dichlorobenzene	
3,3'-Dichlorobenzidine	[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dichloro-
trans-1,4-Dichloro-2-butene	2-Butene, 1,4-dichloro-, (E)-
Dichlorodifluoromethane	Methane, dichlorodifluoro-

APPENDIX II

GROUND-WATER MONITORING LIST

(Continued)

<u>Common Name</u>	<u>Chemical Abstracts Service Index Name</u>
1,1-Dichloroethane	Ethane, 1,1-dichloro-
Ethylidene chloride	
1,2-Dichloroethane; Ethylene dichloride	Ethane, 1,2-dichloro-
1,1-Dichloroethylene; Vinylidene chloride	Ethene, 1,1-dichloro-
1,1-Dichloroethene	
cis-1,2-Dichloroethylene;	Ethene, 1,2-dichloro-,(Z)-
cis-1,2-Dichloroethene	
trans-1,2-Dichloroethylene	Ethene, 1,2-dichloro-, (E)-
trans-1,2-Dichloroethene	
2,4-Dichlorophenol	Phenol, 2,4-dichloro-
2,6-Dichlorophenol	Phenol, 2,6-dichloro-
1,2-Dichloropropane	Propane, 1,2-dichloro-
Propylene dichloride	
1,3-Dichloropropane;	Propane, 1,3-dichloro-
Trimethylene dichloride	
2,2-Dichloropropane;	Propane, 2,2-dichloro-
Isopropylidene chloride	
1,1-Dichloropropene	1-Propene, 1,1-dichloro-
cis-1,3-Dichloropropene	1-Propene, 1,3-dichloro-, (Z)-
trans-1,3-Dichloropropene	1-Propene, 1,3-dichloro-,(E)-
Diieldrin	2,7,3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a, 7,7a-octahydro-,(1aa,2B,2aa,3B,5B, 6aa,7B,7aa)-
Diethyl phthalate	1,2-Benzenedicarboxylic acid, diethyl ester
O,O-Diethyl O-2-pyrazinyl phosphorothioate; Thionazin	Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester
Dimethoate	Phosphorodithioic acid, O,O-dimethyl S-[2-(methylamino)-2-oxoethyl] ester
p-(Dimethylamino)azobenzene	Benzenamine, N,N-dimethyl-4-(phenylazo)-
7,12-Dimethylbenz[a]anthracene	Benz[a]anthracene, 7,12-dimethyl-
3,3'-Dimethylbenzidine	[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dimethyl-
2,4-Dimethylphenol; m-xylenol	Phenol, 2,4-dimethyl-
Dimethyl phthalate	1,2-Benzenedicarboxylic acid, dimethyl ester
m-Dinitrobenzene	Benzene, 1,3-dinitro-
4,6-Dinitro-o-cresol; 4,6-Dinitro-2-methylphenol	Phenol, 2-methyl-4,6-dinitro-
2,4-Dinitrophenol	Phenol, 2,4-dinitro-
2,4-Dinitrotoluene	Benzene, 1-methyl-2,4-dinitro-
2,6-Dinitrotoluene	Benzene, 2-methyl-1,3-dinitro-
Dinoseb; DNBP; 2-sec-Butyl-4,6-dinitrophenol	Phenol, 2-(1-methylpropyl)-4,6-dinitro-
Di-n-octyl phthalate	1,2-Benzenedicarboxylic acid, dioctyl ester
Diphenylamine	Benzenamine, N-phenyl-
Disulfoton	Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio)ethyl] ester
Endosulfan I	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro-1,5,5a,6,9, 9a-hexahydro-,3-oxide,

APPENDIX II

GROUND-WATER MONITORING LIST

(Continued)

<u>Common Name</u>	<u>Chemical Abstracts Service Index Name</u>
Endosulfan II	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro-1,5,5a,6,9, 9a-hexahydro-,3-oxide, (3a,5aa,6B, 9B,9aa)-
Endosulfan sulfate	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro-1,5,5a,6,9, 9a-hexahydro-,3,3-dioxide
Endrin	2,7;3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6, 6a,7,7a-octahydro-,(1aa,2B,2aB,3a, 6a, 6aB,7B,7aa)-
Endrin aldehyde	1,2,4-Methenocyclopental[cd]pentalene- 5-carboxal-dehyde,2,2a,3,3,4,7- hexachlorodecahydro-,(1a,2B,2aB, 4B,4aB,5B,6aB,6bB,7R*)-
Ethylbenzene	Benzene, ethyl-
Ethyl methacrylate	2-Propenoic acid, 2-methyl-, ethyl ester
Ethyl methanesulfonate	Methanesulfonic acid, ethyl ester
Famphur	Phosphorothioic acid, O-[4] (dimethylamino)sulfonyl[phenyl]- O,O-dimethyl ester
Fluoranthene	Fluoranthene
Fluorene	9H-Fluorene
Heptachlor	4,7-Methano-1H-indene, 1,4,5,6,7,8,8- heptachloro-3a,4,7,7a-tetrahydro-
Heptachlor epoxide	2,5-Methano-2H-indeno[1,2b]oxirene, 2,3,4,5,6,7,7-heptachloro-1a,1b, 5,5a,6,6a-hexahydro-,(1aa,1bB, 2a,5a,5aB,6B,6aa)
Hexachlorobenzene	Benzene,hexachloro-
Hexachlorobutadiene	1,3-Butadiene, 1,1,2,3,4,4-hexachloro-
Hexachlorocyclopentadiene	1,3-Cyclopentadiene, 1,2,3,4,5,5- hexachloro-
Hexachloroethane	Ethane, hexachloro-
Hexachloropropene	1-Propene, 1,1,2,3,3,3-hexachloro-
2-Hexanone	2-Hexanone
Methyl butyl ketone	
Indeno[1,2,3-cd]pyrene	Indeno[1,2,3-cd]pyrene
Isobutyl alcohol	1-Propane, 2-methyl-
Isodrin	1,4,5,8-Dimethanonaphthalene, 1,2,3, 4,10,10-hexachloro-,1,4,4a,5,8,8a- hexahydro-(1a,4a,4aB,5B,8B,8aB)-
Isophorone	2-Cyclohexen-1-one, 3,5,5-trimethyl
Isosafrole	1,3-Benzodioxole, 5-(1-propenyl)-
Kepone	1,3,4-Metheno-2H-cyclobuta[cd]pentalen- 2-one,1,1a,3,3a,4,5,5a,5b,6- decachlorooctahydro-
Lead	Lead
Mercury	Mercury
Methacrylonitrile	2-Propanenitrile, 2-methyl-
Methapyrilene	1,2-Ethanediamine, N,N-dimethyl-N'- 2-pyridinyl-N'-(2-thienylmethyl)-

APPENDIX II

GROUND-WATER MONITORING LIST

(Continued)

<u>Common Name</u>	<u>Chemical Abstracts Service Index Name</u>
Methoxychlor	Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-methoxy-
Methyl bromide; Bromomethane	Methane, bromo-
Methyl chloride; Chloromethane	Methane, chloro-
3-Methylcholanthrene	Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-
Methyl ethyl ketone; MEK:	2-Butanone
2-Butanone	
Methyl iodide;	Methane, iodo-
iodomethane	
Methyl methacrylate	2-Propenoic acid, 2-methyl-, methyl ester
Methyl methanesulfonate	Methanesulfonic acid, methyl ester
2-Methylnaphthalene	Naphthalene, 2-methyl-
Methyl parthion; Parathion methyl	Phosphorothioic acid, O,O-dimethyl O-(4-nitrophenyl) ester
4-Methyl-2-pentanone; Methyl isobutyl ketone	2-Pentanone, 4-methyl-
Methylene bromide; Dibromomethane	Methane, dibromo-
Methylene chloride;	Methane, dichloro-
Dichloromethane	
Naphthalene	Naphthalene
1,4-Naphthoquinone	1,4-Naphthalenedione
1-Naphthylamine	1-Naphthalenamine
2-Naphthylamine	2-Naphthalenamine
Nickel	Nickel
o-Nitroaniline; 2-Nitroaniline	Benzenamine, 2-nitro-
m-Nitroaniline; 3-Nitroaniline	Benzenamine, 3-nitro-
p-Nitroaniline; 4-Nitroaniline	Benzenamine, 4-nitro-
Nitrobenzene	Benzene, nitro-
o-Nitrophenol; 2-Nitrophenol	Phenol, 2-nitro
p-Nitrophenol; 4-Nitrophenol	Phenol, 4-nitro-
N-Nitrosodi-n-butylamine	1-Butanamine, N-butyl-N-nitroso-
N-Nitrosodiethylamine	Ethanamine, N-ethyl-N-nitroso-
N-Nitrosodimethylamine	Methamine, N-methyl-N-nitroso-
N-Nitrosodiphenylamine	Benzenamine, N-nitroso-N-phenyl-
N-Nitrosodipropylamine; Di-n-propyl-nitrosamine; N-Nitroso-N-dipropylamine	1-Propanamine, N-nitroso-N-propyl
N-Nitrosomethylethylamine	Ethanamine, N-methyl-N-nitroso-
N-Nitrosomorpholine	Morpholine, N-nitroso-
N-Nitrosopiperidine	Piperidine, 1-nitroso-
N-Nitrosopyrrolidine	Pyrrolidine, 1-nitroso-
5-Nitro-o-toluidine	Benzenamine, 2-methyl-5-nitro-
Parathion	Phosphorothioic acid, O,O-diethyl-O-,(4-nitrophenyl) ester
Pentachlorobenzene	Benzene, pentachloro-
Pentachloronitrobenzene	Benzene, pentachloronitro-
Pentachlorophenol	Phenol, pentachloro-
Phenacetin	Acetamide, N-(4-ethoxyphenyl)-
Phenanthrene	Phenanthrene
Phenol	Phenol
p-Phenylenediamine	1,4-Benzenediamine

APPENDIX II

GROUND-WATER MONITORING LIST

(Continued)

<u>Common Name</u>	<u>Chemical Abstracts Service Index Name</u>
Phorate	Phosphorodithioic acid, O,O-diethyl S-[(ethylthio)methyl] ester
Polychlorinated biphenyls; PCBs Aroclors	1,1'-Biphenyl, chloro derivatives
Pronamide	Benzamide, 3,5-Dichloro-N-(1,1- dimethyl-2-propynyl)-
Propionitole; Ethyl cyanide	Propanenitole
Pyrene	Pyrene
Safrole	1,3-Benzodioxole, 5-(2-propenyl)-
Selenium	Selenium
Silver	Silver
Silvex; 2,4,5-TP	Propanoic acid, 2-(2,4,5- trichlorophenoxy)-
Styrene	Benzene, ethenyl-
Sulfide	Sulfide
2,4,5-T; 2,4,5-Trichlorophenoxy- acetic acid	Acetic acid, (2,4,5- trichlorophenoxy)-
1,2,4,5-Tetrachlorobenzene	Benzene, 1,2,4,5-tetrachloro-
1,1,1,2-Tetrachloroethane	Ethane, 1,1,1,2-tetrachloro-
1,1,2,2-Tetrachloroethane	Ethane, 1,1,2,2-tetrachloro-
Tetrachloroethylene; Tetrachloroethene	Ethene, tetrachloro-
Perchloroethylene;	
2,3,4,6-Tetrachlorophenol	Phenol, 2,3,4,6-tetrachloro-
Thallium	Thallium
Tin	Tin
Toluene	Benzene, methyl-
o-Toluidine	Benzenamine, 2-methyl-
Toxaphene	Toxaphene
1,2,4-Trichlorobenzene	Benzene, 1,2,4-trichloro-
1,1,1-Trichloroethane; Methylchloroform	Ethane, 1,1,1-trichloro-
1,1,2-Trichloroethane	Ethane, 1,1,2-trichloro-
Trichloroethylene; Trichloroethene	Ethene, trichloro
Trichlorofluoromethane	Methane, trichlorofluoro-
2,4,5-Trichlorophenol	Phenol, 2,4,5-trichloro-
2,4,6-Trichlorophenol	Phenol, 2,4,6-trichloro-
1,2,3-Trichloropropane	Propane, 1,2,3-trichloro-
O,O,O-Triethyl phosphorothioate	Phosphorothioic acid, O,O,O- triethyl ester
sym-Trinitrobenzene	Benzene, 1,3,5-trinitro-
Vanadium	Vanadium
Vinyl acetate	Acetic acid, ethenyl ester
Vinyl Chloride; Chloroethene	Ethene, chloro-
Xylene (total)	Benzene, dimethyl-
Zinc	Zinc

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Attachment VI

Tennessee Rule Chapter 1200-1-7-.13

Land Application Regulatory Language

Substance of Proposed Rules

Paragraph (2) of rule 1200-1-7-.01 Solid Waste Management System: General is amended by deleting the definition of “land application” and substituting the following definition:

“Land application” means a facility where solid wastes are applied onto or incorporated into the soil surface (excluding manure spreading operations) for agricultural purposes.

Regulatory Authority: T.C.A. §§ 68-203-103(b)(3), 68-211-102(a), 68-211-105(b), 68-211-106(a)(1), 68-211-107(a), 68-211-111(d)(1), and 68-211-111(d)(2).

Part 1 of subparagraph (c) of paragraph (1) of rule 1200-1-7-.02 Permitting of Solid Waste Storage, Processing, and Disposal Facilities is amended by adding a new subpart (vi) to read as follows:

- (vi) A land application facility, if:
 - (I) The operator complies with the notification requirements of Part 2 of this subparagraph;
 - (II) The operator attaches to his notification all attachments required at rule 1200-1-7-.13 (2);
 - (III) The facility is designed and operated in compliance with rule 1200-1-7-.13.

Regulatory Authority: T.C.A. §§ 68-203-103(b)(3), 68-211-102(a), 68-211-105(b), 68-211-106(a)(1), 68-211-107(a), 68-211-111(d)(1), and 68-211-111(d)(2).

1200-1-7-.13 Requirements For Land Application Facilities

- (1) General
 - (a) Purpose – The purpose of this rule is to establish procedures, documentation, and other requirements which must be met in order for a person to design, construct and operate a land application facility in Tennessee.
 - (b) Scope/Applicability
 - 1. The requirements of this rule apply to land application facilities in Tennessee. Except as specifically provided elsewhere in these rules, no facility may land apply solid waste without a permit as provided in rule 1200-1-7-.02(1)(b)1.
 - 2. The land application of landscaping and landclearing wastes and farming wastes are exempt from the permit requirements of this rule.
 - 3. The land application of solid wastes from food processing facilities are subject to the requirements to have a permit-by-rule.
 - 4. Land application of all other solid wastes will be subject to rule 1200-1-7-.02(1)(b)3(xxii).
 - (c) Notification Requirements – The operator must comply with the notification requirements of rule 1200-1-7-.02(1)(c)1(vi). The operator must make attachments to the notification as follows:
 - 1. The operator attaches a written narrative to his notification describing the specific manner in which the facility complies with rule 1200-1-7-.13 paragraph (2)(a) through 1200-1-7-.13 paragraph 2(g) – inclusive.
 - 2. The operator attaches any sampling, monitoring, or other plans required by these rules or by the Commissioner.

3. The operator of an existing permit-by-rule land application facility must modify the notification if:
 - (i) Adding a waste stream from a new generator, or a waste stream from an existing generator which has not been previously approved for land application at that site; or
 - (ii) Adding new acreage to the land application operations.
- (2) Unless specifically noted otherwise, the standards of this paragraph shall apply to all land applications subject to a permit-by-rule as provided at rule 1200-1-7-.13(1).
- (a) Performance Standards
 1. The facility must be constructed, operated, maintained, and closed in such a manner as to minimize:
 - (i) The propagation, harborage, or attraction of flies, rodents, or other disease vectors;
 - (ii) The potential for releases of solid wastes or solid waste constituents to the environment except in a manner authorized by state and local air pollution control, water pollution control and/or waste management agencies;
 - (iii) The potential for harm to the public through unauthorized or uncontrolled access;
 - (b) Design Standards – In addition to satisfaction of the performance criteria detailed in paragraph (2)(a) of this rule, land application facilities must be designed, constructed in compliance with Tennessee rule 1200-1-7-.13.
 1. The facility must designate and describe in the attachments to the permit-by-rule notification any on-site storage of solid wastes at the land application facility. Any storage must be restricted to containers, bins, lined pits or on paved surfaces, designed for such storage, or other storage provisions approved by the Commissioner. Any lagoons/surface impoundments must be of an engineered design. Such design must include a synthetic liner and groundwater monitoring system capable of detecting leakage from the storage unit. Additionally, detailed engineering drawings and a design/operational narrative must be provided to the Division as an attachment with the permit-by-rule notification for review and approval.
 2. The facility must not be located in a floodplain unless it is demonstrated to the satisfaction of the Commissioner that the land application area is operated and maintained to prevent washout of any solid waste.
 3. Land application facilities shall not be located in wetlands.
 4. If a facility is proposed in an area of highly developed karst terrain, the applicant must demonstrate to the satisfaction of the Commissioner that the facility will not cause any significant degradation to the local groundwater resources.
 5. The facility must be located such that the waste application boundaries are greater than:
 - (i) 500 feet from a dwelling;
 - (ii) 500 feet from any domestic water supply well;
 - (iii) 100 feet from a stream;
 - (iv) 1000 feet from a public water supply well; and
 - (v) 20 feet from a public roadway.

6. There must be a vegetative buffer zone between the land application facility and any wet weather conveyance, stream, or karst feature.
 7. Analytical data for each of the waste streams proposed for land application must be submitted to the Division. The analytical data must completely characterize the wastes proposed for land application.
- (c) Operational Standards – In addition to satisfaction of the performance and design criteria detailed in paragraph (2)(a) and (2)(b) of this rule, land application facilities must be operated in compliance with Tennessee rule 1200-1-7-.13.
1. Facilities at which wastes are to be land applied for agronomic benefits, must demonstrate that the rate at which waste is to be land applied will benefit crop production without exceeding crop nutrient needs or hydraulically overloading the receiving soils.
 2. For wastes which are to be land applied for soil amendment benefits, the facility must demonstrate the amendment value of land application by soil and waste analysis, and that application rates must not exceed the soil amendment needs of, or hydraulically overload the receiving soils.
 3. The land application of waste must not result in an accumulation of harmful levels of waste constituents in crops or in the environment. It must be demonstrated that the rate at which waste is to be land applied will not result in an accumulation of harmful levels of waste constituents or waste degradation by-products in the receiving soils, produced crops, or in the environment.
 4. The soils analytical data, the waste constituent analytical data and waste application rate calculations must be included as an attachment to the permit-by-rule notification.
 5. Land application methods must be appropriate for the waste being land applied. Wastes which have a potential for attraction of vectors, or for the generation of objectionable odors must be immediately incorporated into the soil matrix, either through direct injection or tilling.
 6. Except as provided at subparagraph (b)1 of this paragraph, there must be no storage of solid wastes at the facility.
 7. Wind dispersal of solid wastes at or from the facility must be adequately controlled.
 8. The facility must be operated in a manner such that the rate at which waste is to be land applied would be at a rate beneficial to crop production.
 9. The facility must submit a sampling plan for the periodic monitoring for waste materials, waste constituents in soil, and in surface waters. In this plan, the facility must propose a sampling frequency, proposed parameters and indicate the report format in which it will be submitted.
 10. Ground water monitoring may be required by the Commissioner. If groundwater monitoring is required by the Commissioner, a groundwater monitoring plan must be submitted for approval.
- (d) Recordkeeping Requirements – The operator must maintain, for the operational life of the facility, the following records:
1. A list of all generators of solid wastes land applied by the permittee;
 2. For each solid waste stream land applied, the total quantity applied, and the n number of acres to which the waste was applied.

(e) Reporting Requirements

1. Annual Reporting – On or before March 1 of each year, the operator must submit to the Division an annual report. This annual report must contain, at a minimum, the following information:
 - (i) The full name and permanent mailing address of the permittee;
 - (ii) The street address(es) for all locations at which the permittee has land applied solid wastes during the previous calendar year;
 - (iii) A list of all generators of solid wastes land applied by the permittee during the previous calendar year;
 - (iv) For each solid waste stream land applied during the preceding year, the total quantity applied, and the number of acres to which the waste was applied;
 - (v) Copies of any analytical data generated during the preceding year for any solid waste materials that the permittee has land applied; and
 - (vi) Copies of any analytical data generated during the preceding year from surface waters, groundwater monitoring or soil samples at each site where solid waste materials have been land applied.
- (f) Financial Assurance – Financial assurance is intended to ensure that adequate financial resources are available to the Commissioner for the proper operation and closure of the facility. The types of financial assurance instruments that are acceptable are those specified in 1200-1-7-.03(3)(d). Such financial assurance shall meet the criteria set forth in T.C.A. §68-211-116 and Tennessee Rule 1200-1-7-.03. Financial assurance must be provided for land application facilities having a waste storage capacity in excess of 100,000 gallons for liquids and/or sludges, or 1000 cubic yards for solids. The applicant shall file with the Commissioner a performance bond or equivalent cash or securities, payable to the State of Tennessee.
- (g) Duty to Comply – The permittee must comply with all relevant notification and permit-by-rule requirements, unless otherwise authorized in writing by this Department. Any permit-by-rule condition noncompliance, except as otherwise authorized by the Department, constitutes a violation of the Act and is grounds for enforcement action, or for termination of the permit-by-rule, revocation and reissuance, or modification.

Regulatory Authority: T.C.A. §§ 68-211-102(a), 68-211-105(b), 68-211-105(c), 68-211-106(a)(1), 68-211-107(a), 68-211-111(d)(1). Regulatory History: New rule filed November 17, 2004; effective January 31, 2005.

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