DIVISION OF WATER
Ground Water Discharges Section

7103 Guidance and Regulations Governing the Land Treatment of Wastes

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Foreword

Statewide regulations governing the land treatment of wastes have existed since 1974. The State's efforts to improve water quality through the collection and centralized treatment of wastewaters have resulted in the rehabilitation of existing treatment works and the construction of new facilities. These facilities generally utilize biological processes to treat the wastewaters from residences, commercial establishments, and industry. In addition to providing the required treatment, sludges are generated. This residual material is a slurry of water and solids that can be 100 times more concentrated than untreated wastewater. Inadequate treatment of sludge and poor operation and maintenance practices have resulted in the contamination of the state's groundwaters and presented a threat to the public health, safety and welfare.

Animal manures tonnage in the range of 600-800 thousand are produced annually in the State. Enough manure is produced to supply all the nitrogen for all the corn grown in Delaware. Over application, improper storage and timing of manure applications have contributed to contamination of both surface and groundwaters in the State. When properly managed, animal manures can provide substantial benefits to the agricultural community with minimal impacts on public health, safety, and welfare.

The purpose of this document is to prevent the problems listed above. The guidance and regulations are based upon the best information available. They provide the waste management actions necessary to achieve U.S. Environmental Protection Agency Drinking Water Standards on an average annual basis. This conforms with the State policy which was recommended to the Department and adopted from the 1983 Final Report of the Comprehensive Water Resources Management Committee.

All options for use and disposal of these waste materials have costs, benefits, and risks. The Department believes that guidance and regulations are the best way to promote good practices for utilization and disposal that minimize the potential adverse impacts on public health and the environment and maximize the potential benefits. The benefits potentially gained through waste utilization include energy and nutrient recovery, soil improvement, and the conservation of valuable natural resources.

Part I. Policies and Procedures for Land Treatment of Wastes

1.0 Introduction

1.1 The attainment of water quality goals in the face of economic uncertainties, reduced government subsidies, and rising construction costs imposes a heavy responsibility on public officials, industrial personnel, and consulting engineers. It is not enough to provide facilities that will meet effluent and ambient water quality standards; a rigorous search for least-cost solutions to water quality problems is also needed. Project designs should minimize capital and operational costs when compared to other alternatives for the entire life of the project.

1.2 Land treatment of wastewaters, sludges and other residual wastes is a proven and cost-effective alternative to traditional technology over a wide range of circumstances where the necessary land is available at reasonable cost. For effluents and sludges, it is particularly attractive at locations where the design flow of receiving waters is low, waste treatment requirements are high and suitability of landfills is low. The full advantages of land treatment will not be realized, however, unless there is a concerted effort to focus the designs on essential features. Groundwater quality and public health must be protected, but treatment hardware and operational criteria should be based on firm evidence of need. Lined earthen lagoons should be used whenever possible and concrete, steel, and firm-set structures limited except where fully justified. All persons involved in the planning, review, and supervisory processes should take steps to assure that these objectives are realized.

1.3 The general guidelines associated with this document provide a sound technical basis for the design of land treatment systems. These systems encompass new opportunities for wastewater conservation, utilization of sludge, and the support of improved stewardship of land and water resources. Land treatment offers important cost-effective alternatives for wastewater management.

2.0 Program Scope

Wastewater and sludge generators are often forced to use only conventional waste treatment and disposal technology because of difficulties in understanding policies and procedures for the evaluation and approval of land treatment systems. The program presented in this document and the series of general technical guidelines provide assistance with policies and procedures, regulatory requirements, advisory services, design procedures and technical evaluation of land treatment systems.

General technical guidelines have been developed for the following three categories of land treatment systems:

- Land Treatment of Wastewater;
- Land Treatment of Sludge and Sludge Products; and,
- Land Treatment of Agricultural Residuals.

These three topics have been selected because of existing technical knowledge, regulatory requirements, and perception that a need exists for a better public understanding of these waste treatment categories. Municipal or sewage sludges and wastewaters are given substantial attention in the documents; however the modifications to address industrial wastewaters and sludges are also included.

3.0 Statement of Regulatory Objectives for Land Treatment in Delaware

A general statement of purpose is to protect and improve environmental quality in Delaware by providing further treatment and recycling of wastes. The objectives are:

- To regulate and manage land treatment of wastewater and sludge.
- To assure long-term land productivity, such that no land is irreversibly removed from significant potential agricultural land use.
- To protect groundwater quality and assure that drinking water quality standards are met.
- To safeguard public health within reasonable standards.
- To improve the regulatory climate for land application of wastes, public understanding, and implementation of current and evolving technology by municipalities and industries.

Specific objectives in using land treatment technology are:

- To establish criteria for the application of wastes to the plant-soil system at such rates or over such limited time span that no land is irreversibly removed from some other potential societal usage (agriculture, development, forestation, etc.).
- To establish a methodology for the intimate mixing or dispersion of wastes into the upper zone of the plant-soil system with the objective of microbial stabilization, immobilization, selective dispersion, or crop recovery leading to an environmentally acceptable assimilation of the waste.
- To promote effective regulation, public understanding, and implementation of current and evolving technologies by governmental units and industries in the State.
- To establish reasonable measures of protection for the environment and public health, safety, and welfare by providing for the proper design, operation, and management of land treatment systems; and the proper treatment, transport, handling, and beneficial use of wastes.
- To require the use of plant-soil and waste management practices and technology that will function according to the performance criteria without causing the State's groundwater resources to violate duly promulgated drinking water standards on an average annual basis.
- To dispose of non-hazardous sludges in landfills is an inefficient use of resources. Pretreatment programs and sludge management programs should be directed to provide adequate treatment for land application.

4.0 Public Acceptance

4.1 The importance of a comprehensive and well-coordinated public acceptance program for the implementation of land treatment systems may be described by the old adage, "an ounce of prevention is worth a pound of cure." Good documentation exists for many fine land treatment systems which have operated successfully for many years. Yet, public resistance may develop when new systems are proposed for individual communities unless preparatory steps are taken.

4.2 The public education and acceptance program should be one of the first activities in the process to implement a land treatment system. Citizens should be encouraged to weigh the relative capabilities, advantages and disadvantages, and costs of alternative solutions. An educational program to assist in the collection and presentation of this information is a vital part of the public acceptance activity. Relevant information and participation may be obtained locally from citizens with high interest or appropriate expertise; technical institutes and university personnel; local representatives from agencies such as the Cooperative Extension Service, Soil Conservation Service, and Soil Conservation Districts, as well as supportive state staff for these agencies; local government planning agencies; and appropriate environmental organizations. Involvement of such resources and agency representatives can serve to coordinate and expand the program reach to involve all interested groups and concerned citizens.

4.3 Four major sectors of the public should receive particular attention in the public acceptance program:

4.4 The land owners or farmers who are to receive the waste, their neighbors, public interest groups, and the broader range of citizens who must provide the resources and assume ultimate responsibility for decision-making. The farmers may be unfamiliar with the effects of wastes on crop production and land value. They need to be informed of the economic and environmental benefits of land treatment and the essential soundness of the practice.

4.5 Their neighbors, public interest groups, and other community citizens may be sensitive about "dumping" urban wastes in their neighborhood and have concerns about odor, health problems, and groundwater pollution. Finally the citizens in a broader area are concerned that adequate design, appropriate legal compliance, and a blend of fiscal responsibility and environmental protection are achieved.

4.6 Many benefits result when the public acceptance program is planned and conducted by involved citizens. Such local leadership will facilitate consideration of issues perceived by involved individuals to be most important and the utilization of resource agencies, people, and printed material of highest relevance and interest. The public acceptance program should be conducted in close cooperation with or under the supervision of the overall land treatment project.

4.7 Educational activities and materials that may be helpful for the public acceptance program include: Individual presentations and open discussions, assembly and review of appropriate written material, slide and movie presentations, seminars by recognized state and national leaders, and trips to similar sites in both the state and region. Workshops should be held to encourage the evaluation of alternative possibilities on a technical, cost, environmental, and social basis. Good media relationships, assistance of respected experts, and test plot demonstrations may also be important components of a comprehensive public acceptance program.

4.8 The purpose of the public acceptance program is to assist involved citizens in making an unemotional, informed, and objective evaluation of alternatives available to solve a clearly defined need or problem. Program components should provide an opportunity for every person who desires to be involved to receive desired information, upgrade their understanding of alternatives, and personally become part of the planning and evaluation process. The end goal is to develop recommendations that will encourage the best possible final decision.

5.0 Delaware Statutes and Regulations

The construction and operation of waste collection, treatment, and disposal systems and facilities discussed within this document are regulated by the Department of Natural Resources and Environmental Control. The Delaware Environmental Protection Act requires that a valid permit shall be obtained for collection, treatment, and disposal of waste. This statute grants authority to the Department to develop rules and regulations to carry out its regulatory duties.

5.1 The Regulations specify minimum requirements needed to protect the public health and environmental quality. The technical guidelines provide guidance on system planning and design.

5.2 Several other agencies are involved with waste management in Delaware. Inquiries should be made to assure compliance with all applicable requirements. Information about additional requirements which might apply may be obtained from the Department, Delaware Division of Public Health, county planning and zoning agencies, and the advisory groups listed in a later section of this document.

6.0 Administrative Permitting Procedures and Requirements

The administrative permitting procedures for land treatment systems vary depending on the type of permit required. The rules of practice contain the requirements for the respective permitting procedures. Municipal wastewaters and sludges are regulated herein, but specific deviations are noted when wastewaters and

sludges are directly from an industry. A brief description of the relevant administrative process are listed below for each type of facility:

6.1 Land Treatment of Wastewater

A State Permit is required for the construction and operation of these facilities. The completed application package must be submitted to the Department for technical review. During the evaluation of these applications, the Department's staff will perform site investigations and review of the technical aspects of submitted plans and specifications.

6.2 Land Treatment of Sludge and Sludge Products

A State Permit is required for land application of sludge from water or wastewater treatment plants. The completed application will be submitted to the Department for technical review. A site inspection and preliminary concurrence by the Department is part of the evaluation process. A copy of the toxicity test analysis of the sludge must verify that the sludge does not qualify as a hazardous waste. If the sludge is deemed hazardous, it must be managed following hazardous waste regulations implemented by the Department. The Department also regulates landfilling and land treatment of nonhazardous industrial sludges.

6.3 Land Treatment of Agricultural Residuals

The Delaware Environmental Protection Act requires under Section 6003(a) that "No person shall, without first having obtained a permit from the Secretary, undertake any activity: (2) in a way which may cause or contribute to discharge of a pollutant into any surface or groundwater; ...". Over application, improper storage and timing of land application of agricultural residuals have contributed to contamination of both surface and groundwaters in the State.

6.4 The Division of Water Resources is currently studying alternative management programs for the land application of agricultural residuals. A proposed management program is expected to be circulated for public review by 1989. For the interim operators of systems which generate such residuals should consult their local conservation district for assistance in employing the guidance contained in this document and utilizing currently accepted residual management practices.

6.5 The Department recognizes that the general and technical public (i.e., consulting engineers, developers, local governments, public interest groups, etc.) may not be well informed concerning the requirements for obtaining appropriate permits for land treatment systems. The staff of the agency is available to provide assistance in determining permit application requirements, and administrative procedures for processing permit applications for the types of facilities discussed in these Regulations for land treatment of wastes.

7.0 Structure of Regulatory Documents and Procedures

Regulations and Guidance information are contained in a single document for easy use.

7.1 The requirements for sludge land treatment focus on:

7.1.1 the overall process for obtaining a permit

7.1.2 the reports and materials to be submitted

7.1.3 appropriate requirements for:

7.1.3.1 agricultural and silvicultural utilization

7.1.3.2 land reclamation sites

7.1.3.3 surface land disposal systems

7.1.3.4 sludge distribution systems

7.1.3.5 utilization or disposal at landfills

7.1.3.6 innovative systems

7.1.4 The actual soil science, agronomy, and land treatment science which are necessary to produce a Project Development Report are given before the Regulations in the guidance section of this document.

7.2 The requirements for land treatment of wastewaters follow a similar organizational framework. Requirements are established for:

7.2.1 the complete State review and permit approval process

7.2.2 the reports and materials to be submitted

7.2.3 the operational requirements

7.3 A detailed guidance document is also included to describe the soil science, hydrology, agronomy, and land treatment science necessary to produce the design reports used in the Department permit review process.

7.4 The Land Treatment of Agricultural Residuals follows a similar format. The initial section provides guidance on animal wastes. Preliminary application procedures that include soil testing and manure nutrient analysis are covered along with rates, timing, and methods of application. Regulations for the Land Treatment of

Agricultural Residuals have been reserved to allow time for further study and research on appropriate residual management alternatives. Principal areas of study for future action are:

7.4.1 Siting of Animal Feeding Operations

7.4.2 Design and Management of Systems to Land Apply Livestock Manure

7.4.3 Control of Manure Odors

7.4.4 Disposal of Dead Livestock

A strong need to assess each site and waste type using the same decision process is thus built into this process. In this manner the diverse conditions in the State of Delaware can be routinely evaluated and an optimal design achieved to provide cost-effective land treatment which protects the environment.

8.0 Advisory and Technical Assistance

The assistance of one or more of the following technical groups will be helpful in any consideration of land treatment systems:

8.1 Cooperative Extension Agent

8.1.1 The extension office in each county of the state can serve as an early contact for discussions and information on land treatment systems. A call to this office will provide specific local information and access to state specialists on the extension staff at the University of Delaware. The extension staff periodically receives training on agricultural waste management and land treatment of wastes from specialists at the University of Delaware so that they may provide first-hand assistance. An early contact with the county extension office will provide a mechanism for gaining immediate assistance at the county level and obtaining in-depth help from state specialists in appropriate discipline areas such as engineering, soil science, crop science, economics, and community and resource development. Assistance for taking soil samples can be obtained from several county agricultural agencies including the county extension office. A copy of the soil test results is routinely sent to the county extension office to assist in understanding and implementing test recommendations.

8.1.2 The Cooperative Extension Service has a long history of helping individuals at the county level with program activities in agriculture, home economics, community and rural development, and youth work. Cooperative relationships have been developed with other agricultural service agencies and with the Department of Natural Resources and Environmental Control. The cooperative program to set the criteria and recommendations for livestock waste management systems which satisfy regulatory criteria, enhance environmental quality, and result in more efficient agricultural production serves as a model for assistance available for land treatment of wastes through the county extension office.

8.2 Soil Conservation Service

8.2.1 The Soil Conservation Service can help provide site evaluation assistance for land treatment of waste products including soil and other landscape limitations. SCS can provide detailed on-site planning, design, installation, operation, and maintenance assistance for agricultural waste management system.

8.2.2 SCS can also provide financial assistance for installing agricultural waste management facilities through long-term contracting with landusers. This financial assistance is available only within certain designated project areas where water quality degradation or other natural resource concern requires special emphasis. Assistance is provided through the watershed protection provisions of Public Law 83-566.

8.2.3 SCS technical assistance is provided through Soil Conservation Districts. Requests for this and other kinds of technical assistance should be directed to the district board of supervisors. Those with continuing need for assistance will find it worthwhile to enroll as a cooperator. A district has been established to serve each county of the State. The district office is usually located in conjunction with the SCS office in the county seat.

8.3 Consulting Engineers

8.3.1 There is a wide range of consulting engineers with experience in the design of waste treatment facilities. A listing of individual professional engineers and engineering firms can be obtained from the Delaware Association of Professional Engineers, 2005 Concord Pike, Wilmington, Delaware 19803 or the Consulting Engineer's Council of Delaware, 1300 North Market Street, Suite 501, Wilmington, Delaware 19801. A number of disciplines are required in the design of land application systems and a consultant with a variety of specialized skills should be solicited.

8.4 Soil Scientists and Agronomists

8.4.1 Rosters of registered or certified soil scientists and agronomists can be obtained from the American Registry of Certified Professionals in Agronomy Crops and Soils (ARCPACS), American Society of Agronomy, 677 South Segoe Road, Madison, Wisconsin 53371. Another source of information would be

the University of Delaware, College of Agricultural Sciences Department of Plant Science, Newark, Delaware 19703.

8.5 Land Treatment Specialists

8.5.1 Several firms in Delaware have specialized in the evaluation and design of land treatment systems. Their staffs generally include engineers, soil scientists, agronomists, and other specialists who work almost exclusively on such systems. Firms which provide material testing, soils testing, and agronomic evaluations may be well suited to evaluate land treatment systems. Contact the Department for a current list of such firms.

8.6 Delaware Geological Survey

8.6.1 The Delaware Geological Survey (DGS) conducts systematic investigation of the geology of Delaware; exploration and research pertaining to the water, mineral and other earth resources of the State; preparation of reports and maps presenting its findings; and, provision of actual geologic and hydrologic information and advice to the citizens of Delaware. The DGS may be contacted at the University of Delaware, 101 Penny Hall, Newark, Delaware 19716, telephone number (302) 451-2833.

8.7 Other Appropriate Technical Experts

8.7.1 Other experts with experience in land treatment may also prove to be valuable. An experienced wastewater treatment plant operator who has direct "hands-on" knowledge of land treatment system operation should be consulted to understand the daily requirements and operating costs associated with such operations. Such an individual can advise the system owner on the proper training and abilities which will be required for a full-time operator once the system is constructed. Local farmers may be consulted with respect to management plan development. Their knowledge of crop planting, harvesting, and soil protection can prove to be invaluable as a first start in the evaluation of system design. Equipment manufacturers often offer training courses or literature which are available to the public. These manufacturers may be contacted if information is needed on specific or general equipment design or use.

9.0 Conclusion

9.1 The use of land treatment systems in Delaware is increasing because these systems provide a safe, economical, and environmentally sound method of waste management. Federal and State funds for the construction of municipal waste treatment facilities have begun to diminish. This reduction in federal government support creates a purpose to reevaluate the need for conventional "concrete and steel" wastewater treatment facilities. It is imperative that an expanded list of alternatives be made available.

9.2 This Policies and Procedures document has briefly introduced the subject of land treatment systems. More detailed information is presented in the following general technical guidelines:

Land Treatment of Wastewaters	**Part II**
Land Treatment of Sludges and Sludge Products	**Part III**
Land Treatment of Agricultural Residuals	**Part IV (deleted)**
Land Treatment of Waste Products	**Part V**

These sections are intended to provide procedural and technical assistance for the evaluation and implementation of land treatment systems.

Part II Lane Treatment of Wastewaters: Guidance for Slow Rate Land Treatment

10.0 Purpose

10.1 This section presents a discussion of land treatment of wastewater in Delaware and general guidelines for designing land treatment systems for both municipal and industrial wastewater.

10.2 The biological, chemical and physical processes involved in land treatment are varied, interrelated and complex. Since our knowledge of these processes and their application in practice is continually increasing, it is anticipated that this discussion will be revised periodically to keep it up to date with the state of the art.

10.3 The Department determines the minimum requirements for applying for a permit for land treatment of wastewater through the establishment of appropriate regulations. These minimum requirements are also

subject to change as knowledge about land treatment increases. These specific requirements are not listed in this guidance section.

11.0 Introduction

11.1 Application of wastewater to land can be a viable alternative for treatment and disposal of municipal and many industrial wastewaters. The constituents in the wastewater are taken up by plants, fixed in relatively insoluble forms in the soil, evolve as gases, or leach into the groundwater. The basic performance criteria for a land-treatment system are that: (a) quality standards for ground water and surface waters are not exceeded, (b) the system does not present a significant health problem, and (c) the soil is not degraded so as to prevent future use for agriculture, forestry or other planned development.

11.2 This section discusses general principles of land treatment of wastewater, the basic considerations for designing, managing and monitoring a land treatment system, and the basic performance criteria for a land-treatment system. Specific technical information for design of land treatment systems should be obtained from the technical support agencies and technical references listed in the Appendix. The EPA Process Design Manual on Land Treatment of Municipal Wastewater (7) presents three types of application methods (treatment processes) for land treatment of wastewater: (1) slow-rate process, (2) rapid infiltration, and (3) overland flow. The slow-rate process using spray irrigation technology is most applicable to Delaware conditions and has been demonstrated to achieve water quality goals. It is therefore the focus of the following discussion.

12.0 Basic Considerations for Design

12.1 Design of any land-treatment system will need to consider the following items:

12.1.2 Wastewater characterization; volume and composition (including seasonal fluctuations);

12.1.3 Land requirements; land selection and evaluation of land's assimilative capacity for the wastewater; land area required; land acquisition; land preparation; adjacent land uses

12.1.4 Pretreatment requirements before land application; design of total system (pretreatment and land application)

12.1.5 Storage requirements

12.1.6 Application equipment and controls

12.1.7 Groundwater quality and use

12.2 Vegetation and site management; liming, pest management, harvesting, etc.; equipment requirements; crop or forest utilization potential; crop or forest production costs and returns

12.3 Buffer zones

12.3.1 Monitoring

12.3.2 Security

12.3.3 Overall operations and maintenance

12.4 A flow chart briefly outlining system design and approval is shown in Figure 1.

13.0 General Design Principles

13.1 The wastewater must be characterized, and the available land must be evaluated to calculate the allowable loading rate of each constituent in the waste, including the hydraulic loading. For certain heavy metals, the loading rate is determined from maximum allowable accumulative applications for a chosen life expectancy over which the system should operate without any irreversible degradation of the soil for agricultural purposes. From the calculated loading rates, the limiting constituent (the one requiring the most land) is determined.

13.2 As this point, pretreatment options can be considered to reduce the amount of land required. Management of the land treatment system must also be considered in setting loading rates and application limitations. Management of vegetation and sale or disposal of crops or trees must be considered. Application equipment must be chosen appropriate for the site, application rate and overall system operation, including crop or forest management. Storage should also be designed to provide safe retention during periods when application may not be possible.

13.3 The design should also preclude runoff of wastewater during application, minimize surface runoff transport from the site, preclude extended ponding, allow for appropriate buffer zones at the site perimeter, and allow for operation during freezing weather (unless it is opted to store wastewater during winter months), and include alarms and safety features that prevent over application and system failure. Also, odors must be controlled. Good standard operating procedures and monitoring plans should be designed to insure safety of workers and prevent environmental degradation of soil and water resources.

14.0 System Alternatives

14.1 To properly compare the costs of a land treatment system to alternative conventional treatment systems' costs, land treatment system costs should be based on optimal combinations of pretreatment and land treatment options. The pretreatment requirements for some constituents such as nitrogen and phosphorus will be less for land treatment than for conventional treatment processes. Pretreatment costs for additional removal of the limiting constituent should be compared to costs of acquiring more land for treatment.

Waste Characterization		
Generator		
Preliminary Site Selection	Site Evaluation	Site Selection - loading rates - area req'd
Owner	County Extension Agent	
Generator	Soil Cons. Service	
Public Health	DNREC	
Rep. of Local Gov't	Consulting Engineers, Agronomists, Soil Scientists	
DNREC	Site Approval	
LEGEND		
Flow of procedure		
Persons/agencies involved		
Feedback for revision	DNREC - - - - Permit Issued	

Figure 1. Flow Chart for land treatment system design and approval

14.2 Several alternatives exist as to management of the land and vegetative cover. Vegetative options include forage crops, grain crops, rotation cropping and trees. The required management intensity varies for different systems and is normally lower for trees and forage crops than for row crops. Realistic utilization potential and costs of production must be estimated to evaluate economic returns from the crop.

14.3 Various management and equipment options should be evaluated. There are various irrigation system alternatives such as center pivot, solid set sprinkler, and traveling gun. Various alternatives in storage requirements and disinfection requirements should also be evaluated to minimize costs while maintaining a safe system.

14.4 The options of buying or leasing land or farmer contracts should also be considered. For many municipalities and industries, buying the land and operating the system as a dedicated site for wastewater treatment (without environmental degradation to prevent further use for agriculture, forestry or other planned development) is likely most desirable. However, in some situations land lease agreements or farmer contracts may be less costly. Sites owned and operated by the wastewater generator will use the highest possible wastewater application rate compatible with waste treatment goals and protection of the environment. Sites which are privately owned may utilize application rates necessary only to supplement nutrient and water needs of the crops being grown.

15.0 Wasterwater Characterization

The first step in designing land treatment systems is to determine the composition of the wastewater so a judgment can be made if it is suitable for land treatment. If it appears suitable, then composition and annual generation rate can be used with site assimilative capacity to determine land area required.

16.0 Generating Source

Wastewater considered for land application usually is from municipal or industrial wastewater treatment plants. Wastewater and sludge from municipal plants may be relatively innocuous if the raw sewage is domestic. The potential for increased concentrations of metals, organics, etc. increases as industrial input to the system increases. Industrial wastewater ranges from relatively clean by-products such as those from certain food processing and fermentation industries to those which are toxic or hazardous even in small amounts and require special attention.

17.0 Characterization Parameters

17.1 Generation Rate. The quantity of wastewater generated per year must be determined so annual generation rate of constituents can be calculated. Variability in rate must also be considered because this variability can affect storage, cropping systems and land requirements. Most municipal treatment plants have a constant flow. However, those in seasonal use areas such as beach resorts will have large seasonal fluctuations. Industrial waste flows may be constant but will vary during plant shutdown periods or if batch processes are used.

17.2 Composition. The solids content of municipal wastewater does not pose a problem, however, screening may be necessary to remove trash introduced in ponds, storage lagoons, etc., so pumps and sprinklers are not damaged or clogged. Solids content of certain industrial wastewater may affect the selection of crops and the possible need to flush the system and the crop with clear water after irrigation.

17.3 Plant nutrient content must be determined so wastewater rates may be applied to supply adequate nutrients for good crop production but to prevent excess rates which exceed the assimilative capacity of the soil-crop system.

17.4 Salts are important from two standpoints. High concentrations of total dissolved salts can cause crop injury due to osmotic effect. High concentrations of Na in the absence of adequate Ca and Mg (expressed as sodium adsorption ratio [SAR]) will reduce soil permeability due to clay dispersion.

17.5 The trace metal concentrations are important because of their effect on crop production and on animal or human health. High accumulations of copper, zinc and nickel will cause crop injury before concentrations in the crop are high enough to be toxic to consumers of the crop. Lead has never been shown to cause toxicity in crops; and since plants normally do not translocate high amounts of lead to their shoots, there is little danger of lead injestion by consumers of the crop unless it is present on leaf surfaces.

17.6 However, in most crops cadmium can accumulate to concentrations that are not toxic to the crop but may be harmful to consumers of the crop. The most prevalent problems in humans due to excess cadmium ingestion are kidney and bone disorders.

17.7 It is important to know the organic content of wastewater (usually measured as COD[1]). Excessive COD loadings can cause anaerobic conditions at the soil surface, greatly reduce infiltration, and cause unpleasant odors.

17.8 Wastewater may contain specific organics that are resistant to decomposition or may be toxic or carcinogenic. Resistant organics such as chlorinated hydrocarbons, some halogenated insecticides, PCB's and PBB's may be present. These compounds are not absorbed from soil by plants, but irrigation may leave them on leaf surfaces which may be later ingested by animals fed hay from the site. Thus, if vegetation from the site is to be fed as hay and these constituents are known to be present, then the vegetation should be analyzed before use as livestock feed.

17.9 Experience over many years has shown the health hazard associated with land treatment of wastewater to be very low. However, an analysis for fecal coliforms in wastewater is generally required. Normal sanitation practices by workers and prohibition of growing crops for direct human consumption help alleviate concerns about the health hazard.

17.10 Representative Sampling. It is important that the wastewater sample analyzed be representative of the entire flow; thus, a scheme of periodic or composite sampling should be used. After the land treatment system is in operation, a regular analysis program should be set up so land treatment can be modified if wastewater composition changes significantly.

17.11 Wastewater Analysis Analysis of wastewater should be completed to determine essential plant nutrients, solids content, oxygen demand, important trace metals, pH and other critical constituents dictated by the type of industrial input. If it is suspected or known that inputs to the wastewater treatment system contain other potentially toxic substances or substances which would affect system design, the wastewater should be analyzed for these also.

17.12 [1]COD is more appropriate than BOD for land treatment system design.The microbial population in soil is much more diverse than the population in water and can bring about greater rates of organic matter decomposition.

17.13 Pretreatment and Source Reduction. In general, the principal objectives of pretreating wastewater prior to land treatment are to reduce solids and any toxic substances associated with the solids (e.g. heavy metals), reduce pathogens, and minimize or control odors. Also, for nitrogen containing wastewaters, the pretreatment method that results in the lowest production of nitrate is the most preferred method.

17.14 After wastewater analysis, one may find one or two constituents that reduce or limit the suitability of the wastewater for land treatment. Industries may find it economically feasible to make changes in their processes or increase the degree of pretreatment to reduce the concentration of the limiting constituent.

18.0 Site Evaluation and Section

Once the wastewater generation rate and composition are known, it is possible to determine the mass of constituents generated and to make a rough estimate of land area required. With this information in hand, one can begin to look for potential land treatment sites.County soil survey reports (if available) or soil maps from the local Soil Conservation Service (SCS) office and U.S. Geological Survey (USGS) topographic maps can be used to make an initial screening of potential sites.

19.0 Evaluation of Potential Sites

19.1 Parties Involved. The word "wastewater" has negative connotations for most people with little knowledge of waste treatment. Rumors that a land treatment system is being proposed in a given area can cause an emotionally charged condition among residents of that area. Therefore, it is important to involve a number of people in the site selection process so an environmentally acceptable site will be selected, residents of the area can be educated about land treatment and lines of communication can be kept open.

19.1.1 A representative of local government should be involved early in the planning stage so he will be informed and can communicate with concerned residents. He can also determine if the proposed site is compatible with the local land use plan.

19.1.2 The county agricultural extension agent can assist in agronomic or forest recommendations for the site and perhaps can also provide with the help of state extension specialists an educational program for public meetings to inform area residents about land treatment.

19.1.3 The local SCS office can provide information on soils on the proposed site and can develop a soil map of the area if one is not available.

A representative of the Division of Water Resources, Water Pollution Control Branch must be involved. They will conduct a site inspection to determine if the site is suitable. This office will receive the permit application.

19.1.4 It is the responsibility of the waste generator and his consultant to coordinate the site evaluation and selection. Obviously, the land owner will be involved by offering the land for sale, lease or use.

19.2 Site Identification and Screening. Potential land treatment sites are identified using existing soils, topography, hydrogeology and land use data. Usually, land areas near where wastewater is generated are evaluated according to their land treatment suitability. A deductive approach is used in that, first, any constraints that might limit site suitability are identified. Some of the main factors to consider are current and planned land use, topography, soils, groundwater depth and quality, surface water sources, flooding hazard, and size of site required.

19.2.1 Eventually, for permit application the location of the site shall be indicated on topographic and soils maps.

19.3 Field Investigations. Although much of the preliminary screening of potential sites is based on existing field data available from an SCS county soil survey or other sources, some level of field investigation is necessary. This starts with a visual exploration of the site to identify any possible site limitations such as presence of wet areas, rock outcrops, and locations of streams. The visual exploration is normally followed by a site-specific field investigation to define assimilative capacities and other design related factors. However, the amount of additional field investigation needed will depend on the site characteristics and where uncertainty exists. Too little field data may result in using incorrect values for design while too much will result in unnecessarily high costs with little refinement in the design.

19.4 The allowable wastewater loading is often dependent upon the drainage characteristics of the site. The importance of evaluating the total pathway of movement of the wastewater from the soil surface to groundwater or surface water outlets is discussed in Chapter 4 under "Removal by Drainage." The field measurements needed to evaluate drainage will depend on the site characteristics. A deep soil with high permeability and low slope will be easier to evaluate than a soil with moderate slope and restrictive layers near the soil surface. The potential for groundwater mounding or perched water tables near the soil surface should also be evaluated. If applied properly, the USDA watershed model DRAINMOD can provide estimates of lateral migration of shallow groundwater. The EPA design manual (7) discusses methods for estimating hydraulic loading based on: (a) vertical hydraulic conductivity of the most restrictive layer, (b) limitation on percolate nitrate concentrations, and (c) groundwater mounding near the surface. If the soil characteristics indicate that infiltration capacity of the soil surface may restrict hourly application rates of the sprinkler system, then the application rate must be reduced or a crop management scheme to enhance infiltration must be considered.

19.5 Again, requirements for field measurements will vary at each site, but an order of sequence of investigations that may occur as suggested in the EPA manual (7) is given in Table 1.

TABLE 1

Field Investigations in Typical Order of Testing and Information to Obtain

Field Test	Information to Obtain
1. Test pits and/or hand auger borings	Depth of profile, texture, structure, soil layers resticting percolation
2. Bore holes	Depth to groundwater, depth to impermeable layers.
3. Permeability	Expected minimum permeability of restrictive horizon.
4. Soil Chemistry	Specific data relating to crop and soil management, phosphorus and trace metal retention.

19.6 Although soils information from the SCS county soil surveys or previous farming or forestry records will indicate the productivity potential of the soil, soil samples must be taken from the site to determine soil chemistry and the soil's present status for growing the intended vegetation. From the results of the soil chemical analysis knowledge of vegetation and site management procedures and long-term erosion rates, the assimilative capacity for each of the important wastewater constituents can be determined.

19.7 The site should also be evaluated for land clearing requirements and possible drainage requirements. If land clearing is necessary, it should be done with minimal soil disturbance. Land should not be graded (e.g. to reduce slope) in land preparation because this will likely reduce permeability. If artificial drainage is necessary, the pollution impact of the drainage water discharge must be determined.

19.8 If a groundwater and/or surface water monitoring program is required for the particular system, monitoring points should be established early so background data can be collected before wastewater is applied.

20.0 Site Assimilative Capacity and Land Requirement

Each wastewater application site has a capacity to accept wastewater, bring about treatment, and channel decomposition products into environmentally sound pathways. One important step in land treatment design is to determine the site assimilative capacity so appropriate loading rates can be determined for each of the major waste constituents and from that the amount of land required. Municipal wastewater application is usually limited by hydraulic loading and/or nitrogen. The limiting constituent in industrial wastewater may be nitrogen, heavy metals or other constituents. The limiting constituent must be determined using the site assimilative capacity and waste generation rates.

20.1 The three basic types of site assimilative capacity are (Figure 2):

20.1.1 Above-ground removal of decomposition products from the site. This includes nutrient removal by crop uptake and subsequent harvest, CO_2 and NH_3^+ volatilization, N_2 or NO_x loss from denitrification and loss of applied water by evapotranspiration.

20.1.2 Permanent storage in the soil. The most important examples are P fixation by reaction with Al and Fe and trace metal fixation by reaction with organic matter and various mineral fractions of the soil.

20.1.3 Removal from the site by drainage. Both anions (NO_3^- Cl^- $SO_4^=$) and cations (Na^+ K^+ Ca^{++} Mg^{++}) move with drainage water, but the anions move more rapidly since they are not attracted to the negatively charged soil particles. A portion of the applied water leaves the site by draining into the groundwater.

20.2 These three pathways must be considered in detail for each system design since the importance of each is a function of the site and the waste being applied.

21.0 Above-Ground Removal

21.1 Crop uptake of applied nutrients and subsequent removal by harvest is one of the main mechanisms of above-ground removal. This is the main way that N is removed from the site as long as N application rates are not much in excess of normal crop fertilization rates. If the soil on the site has a high P fixing capacity, crop removal may not be the most important method of P removal.

21.2 Removal of nutrients is a function of crop yield and nutrient composition. Consequently, any environmental factor that reduces yield (unbalanced fertility, low pH disease, etc.) will also reduce nutrient removal from the site. It must be recognized that as a crop is supplied with increasing amounts of a nutrient, the crop will use that nutrient with decreasing efficiency. Thus, although a crop may take up 400 lb N/acre per year,

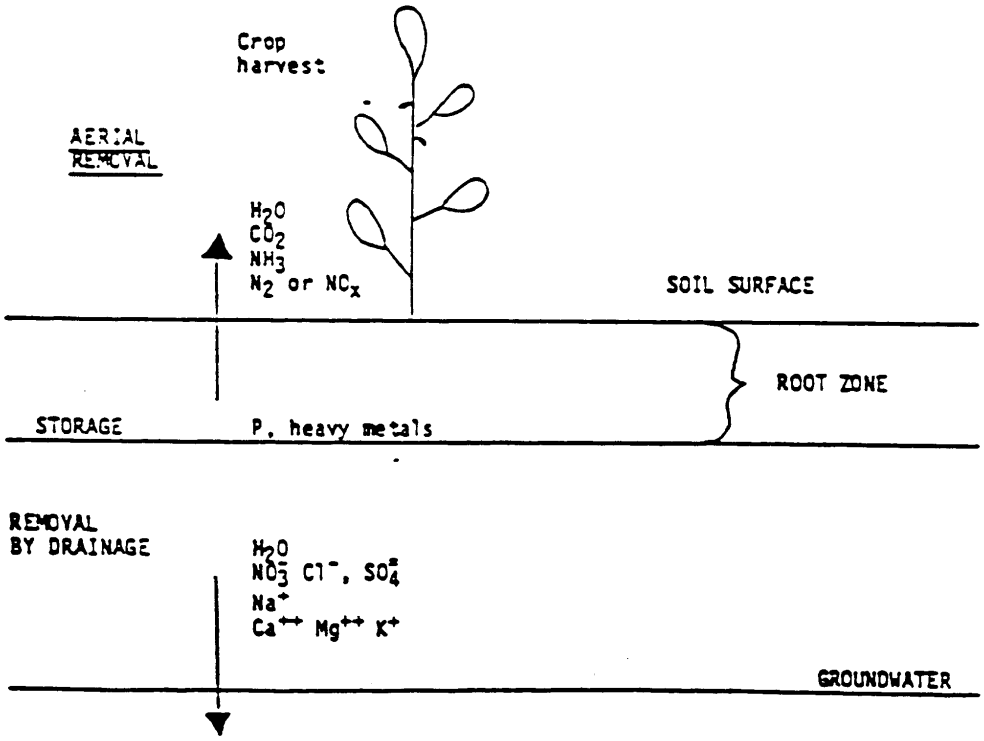

Figure 2. Schematic of site assimilative capacity.

21.3 this uptake may have been attainable only when higher amounts were applied. Tables of crop nutrient uptake seldom contain information on quantity of nutrient applied, length of growing season (e.g. Delaware vs. Florida), whether the crop was irrigated, etc. The designer must consider this information when preparing nutrient balances and vegetation management schemes.

21.4 For design purposes loading rates that supply available nutrients at a rate that has been shown or that can be logically estimated to pose no pollution hazard should be used. Current fertilizer recommendations for crops in Delaware (11) are probably a good baseline for setting wastewater-applied nutrient uptake rates for most

nutrients. Adjustments in rates can then be made based on ammonia volatilization losses, increased denitrification potential, P fixing potential of the particular soil, increased crop uptake due to irrigation and local experiences with similar soils (and similar management, if possible). Adjustments in yield, crop uptake and fertilization for irrigation should be made using data for the same crop and similar soils and climate if available. Also, N applications (and hydraulic loading) may have to be adjusted because of excess nitrate in drainage water. Nutrient uptake rates to trees are less well established than for forage and row crops.

21.5 Generally, much of the N in wastewater is in the NH_4^+ or NO_3^- form which is available to plants. Also, it is likely that most of the organic N in wastewater will become available during the growing season when soil organisms are active. However, if the wastewater is high in organic N and comes from a source that indicates the organic N will be slow to mineralize, then a laboratory incubation of the soil-wastewater mixture may be needed to determine N availability.

21.6 Phosphorus availability is more difficult to determine because of its fixation by soil. However, if incubations are conducted with soil from the proposed site, P as well as N availability could be estimated.

21.7 Gaseous loss of waste constituents is another mechanism of above-ground removal. Evapotranspiration (ET) of applied wastewater is determined by climate and soil moisture content. Data on potential ET (PET)[1] are available for Delaware and can be used to calculate water loss by this mechanism. 21.8Release of carbon dioxide (CO_2) by microorganisms decomposing organic matter in wastewater is the mechanism for carbon removal from the site. Consequently, the soil must be kept aerobic to facilitate decomposition and to prevent odors and sealing that occur when the soil is anaerobic. Assimilative capacity of soil for organic matter can be estimated using the oxygen (O_2) diffusion rate in soils as a function

21.8 [1]PET is the rate of ET when the site is completely vegetated and soil moisture does not limit ET. This is generally the case with land treatment systems for wastewater since irrigation keeps soil moisture high. of soil moisture content. Organic loading rate can be critical if high organic matter wastewater is irrigated because O_2 supply is decreased not only by the increase in soil moisture (thereby reducing O_2 diffusion rate) but also by the high biological and chemical O_2 demand of the wastewater.

21.9 Certain industrial wastes contain organic compounds that may be resistant to decomposition and/or toxic to vegetation. Potential toxicity and rate of decomposition of these compounds must be determined from the literature or from actual tests so the site assimilative capacity can be determined.

21.10 Significant quantities of NH_3 may be lost from the site by volatilization. If wastewater contains appreciable quantities of NH_4^+, then NH_3 may volatilize during irrigation depending on wastewater pH, temperature, wind speed and droplet size. The EPA design manual (7) states that losses can be up to 10 percent of applied N if wastewater pH is 7.0 or above.

21.11 Gaseous N losses also occur when NO_3^- is reduced to N_2 or oxides of N via microbial activity (denitrification). Several conditions must be met for denitrification to occur: anaerobic conditions, available carbon as an energy source for the organisms and a source of NO_3^-. Although land treatment systems must remain aerobic to function in the soil, denitrification can occur if carbon is available and NO_3^- diffuses into the site. Denitrification losses are difficult to measure under field conditions, but there is some evidence from research that wastewater irrigation increases denitrification rates. Denitrification can be affected by frequency of application, hydraulic loading, nitrification, and the inherent denitrification potential of the soil at the site. Denitrification losses are generally reported to vary between 10 and 35 percent of the applied available N. Most soils suitable for wastewater application have denitrification potentials less than 100 lb/acre per year.

21.12 The N assimilative capacity of the site is the sum of the fertilizer N recommendation (under irrigated conditions) and the denitrification potential (and any waste or management-induced denitrification if it can be shown to be appreciable), with adjustments for ammonia volatilization losses at application.For general guidelines in design, the EPA design manual (7) recommends that the sum of volatilization losses and denitrification be assumed to be in the range of 15 to 25 percent of the applied N. Certain conditions may exist which denitrification is appreciable in areas adjacent to the irrigated site that receive drainage water. Recent research has shown that nitrate in drainage water from well-drained areas will be denitrified if it moves through adjacent poorly drained areas (e.g. marsh, swamps, base of slopes, etc.).This process may be designed into the N balance for the land treatment system if the necessary conditions exist.

22.0 Permanent Storage in Soil

22.1 Most soils in Delaware have high P-fixing capacities because of their high Fe and/or Al content. Reaction products of P with Fe and Al are relatively insoluble so P does not move appreciably when applied to soil. The P fixation capacity of the soil is mainly a function of soil texture, to some extent drainage class, and previous P fertilization. The high P fixation capacity of Delaware soils will prevent P from leaching to the groundwater except in very sandy soils (e.g. Coastal Sussex) or at very high P loading rates.

22.2 A greater potential hazard than leaching to groundwater is P enrichment of surface water by P carried in eroded soil or runoff from fields receiving wastewater. Since the ratio of P/N in many wastewaters is much higher than the P/N ratio required by crops, application at rates to supply the N needs of the crop will result in application of large excesses of P. Consequently, the P concentration in topsoil will increase rapidly.

22.3 To minimize the potential P enrichment of surface waters, it is important that conservation measures be used to minimize erosion and adequate buffer zones be maintained between the site and surface water so sediment in runoff will be redeposited prior to reaching the watercourse. For this reason grass and forest vegetation are preferred over row crops that have exposed soil throughout the growing season.

22.4 Heavy metals react with a variety of soil constituents to form relatively insoluble compounds. The cation exchange capacity (CEC) is currently used as a measure of the soil's potential to tie up heavy metals. Table 2 presents current USEPA guidelines (and regulation for Cd) for land application of wastes containing heavy metals. Notice that soil pH must be kept at or above 6.5 for these rates to be used.

22.5 Since soils have finite capacities to retain phosphorus and trace metals, a useable site lifetime may be defined. For typical municipal wastewaters with low industrial input the site lifetime may exceed 100 years for phosphorus and several hundred years for trace metals. Site life for industrial wastewater systems must be evaluated on a constituent by constituent basis and site assimilative capacity for each. The concept of "site life" should not be interpreted to mean that at the end of the site life the land is no longer useable for agriculture. Quite the contrary. Sufficient safety factors have been incorporated into the guidelines so normal agricultural production can continue after waste additions are stopped.

23.0 Removal by Drainage

An important mechanism of removal of wastewater from a site is downward movement through the soil to the groundwater. To adequately estimate a hydraulic loading that will not result in site failure from overloading, one must consider the entire pathway from soil surface to outflow of groundwater through natural discharge areas or artificial drains. For analysis the pathway can be divided into three sections:

23.1 Infiltration and storage in the topsoil.

23.2 Downward movement through the soil and parent material to the groundwater

23.3 Movement of groundwater to an outlet and into surface water.

23.4 Most Delaware soils consist of a fairly permeable A horizon over a B horizon with somewhat lower permeability. Irrigated water enters the A horizon at a relatively rapid rate and is temporarily stored there until it can move slowly through the B horizon or, on sloping areas, move laterally along the top of the B. During wet periods or with high loading rates, this laterally moving water may appear at seeps or springs at the bottom of a slope.

23.5 In determining a hydraulic loading and an application rate, one must be certain that the soil has sufficient infiltration capacity and storage capacity in the A horizon to accept water, store it and then permit drainage at a rate which allows the soil to reaerate rather rapidly. Reaeration is necessary to assure aerobic decomposition of the organic material in the wastewater. Otherwise, anaerobic conditions will exist with subsequent nuisance odors and possibly sealing the soil by slimes formed during anaerobic decomposition.

23.6 Infiltration capacity is a function of soil texture and structure, initial moisture content, vegetative cover, and temperature (e.g., frozen soil). Storage capacity is a function of pore size distribution.

23.7 The rate of vertical movement through the soil is controlled by saturated hydraulic conductivity or permeability (K_{sat}) of the most restrictive soil layer. Procedures developed by EPA for estimating this downward movement use 4 to 10 percent of the K_{sat} of the restrictive horizon as the drainage rate (percolation) used in calculating allowable weekly or monthly hydraulic loading rate (7). EPA's procedures (7) for calculating design hydraulic loading rate uses a monthly water balance for precipitation, evapotranspiration (ET), and percolation (with adjustments for periods of non-operation due to management activities). The results of this monthly water balance should also be compared with the results of the monthly percolate nitrate concentration calculations to determine which is limiting, especially when vegetation is not present. Also, in some cases, the reaeration requirement and the A-horizon storage mentioned previously can be more limiting than the K_{sat} of the most restrictive layer.

TABLE 2

Current USEPA Guidelines(5) For Zn, Cu, Ni, and Pb and Regulations(3) for Cd Application to Land Used for Production of Food-chain Crops

Soil Cation Exchange Capacity (meq/100g)(1)

Metal	0-5	5-15	>15
	Cumulative Limit - lb/ac (Kg/ha)		
Pb	500(560)	1000(1120)	2000 (2240)
Zn	250(280)	500 (560)	1000 (1120)
Cu	125(140)	250 (280)	500(560)
Ni	125(140)	250 (280)	500(560)
Cd	404(5)	8.9 (10)	17.8 (20)

Annual Cd application rate not to exceed 0.44 lb/ac (0.5 Kg/ha)

NOTE: SOIL MUST BE MAINTAINED AT pH 6.5 OR ABOVE WHENEVER FOOD- CHAIN CROPS ARE GROWN UNLESS PLANT NUTRIENT NEEDS AND SOIL CHEMISTRY PRECLUDE SUCH VALUES WITHOUT EXCESSIVE LIME ADDITION, BASED NOT ON COST BUT ON UNREALISTIC TONNAGE OF LIME/ACRE. In such cases, lime additions suitable to the vegetation used are to be applied in conjunction with annual metal monitoring of the vegetation.

23.8 On sloping sites which have subsoils with lower values of K_{sat}, some of the applied water will move laterally above the zone of restricted K_{sat}. In this case water may move through a relatively small cross-sectional area. Thus, application rates have to be limited to prevent prolonged saturation of the topsoil down slope with subsequent surfacing of the water before adequate treatment has occurred.

23.9 Rate of movement of groundwater from the site to an outlet is controlled by the groundwater gradient (i.e. difference in elevation of the groundwater under the site and at the outlet) and the K_{sat} of the material through which it is moving. The groundwater level under the site may rise due to irrigation leading perhaps to a mounding condition. One must select a loading such that the groundwater does not rise so close to the surface that wastewater does not receive adequate treatment prior to entering the groundwater. The EPA design manual on wastewater (7) gives methods for calculating: (a) subsurface drainage rates to surface water (ditches) and (b) groundwater mounding, or perched water table. Although these topics are presented in the EPA design manual mainly for high infiltration process design (very high application rates), the methods are applicable to slow rate systems as well.

23.10 Drainage water moving to the groundwater also carries with it waste constituents not removed by storage in the soil or above-ground removal. To protect groundwater quality, concentrations of these constituents must not exceed allowable limits determined by groundwater classification (e.g. 10 mg/L for NO_3^--N in potable groundwater). Concentrations of waste constituents not specifically covered in these regulations must not exceed concentrations in the National Interim Primary and Secondary Drinking Water Regulations (2). The EPA design manual on wastewater irrigation (7) contains an annual mass balance method[1] of determining loading rates which will prevent excess concentrations of NO_3^--N from entering the groundwater. This method can also be used for some other constituents as well, e.g. Cl^- and $SO_4^=$.

23.11 It is important that if a wastewater containing an imbalance of sodium to calcium and magnesium is applied that sodium not be allowed to accumulate appreciably on the cation exchange sites. If excessive accumulation of Na does occur, clay particles disperse and hydraulic conductivity is reduced. The dispersion hazard increases as the clay content of the soil increases and as the ratio of Na to (Ca + Mg) in the wastewater increases. This ratio, the sodium adsorption ratio (SAR), influences the extent of retention of Na on the exchange complex.

23.12 Wastewater with an SAR greater than 15 will cause reduction in hydraulic conductivity in all but very sandy soils. Over long periods of time wastewaters with SAR's less than 15 can cause reduced hydraulic conductivity.

23.13 [1]N draining to groundwater = N applied minus N removed by crop harvest, NH_3 volatilization, and/or denitrification (i.e. above-groundremoval, Fig. 4-1).

23.14 Gypsum ($CaSO_4^{=}$. $2H_2O$) may be used to supply a source of relatively soluble Ca to prevent Na accumulation in the soil. However, gypsum rates must be limited to those that will not raise groundwater $SO_4^{=}$ concentrations above 250 mg/L. Municipal wastewaters with little industrial input rarely have SAR's above 2 to 5 and therefore do not represent a design limitation.

24.0 Land Requirement

24.1 After the wastewater has been analyzed for appropriate constituents and the site assimilative capacity for those constituents determined, the amount of land needed for environmentally sound wastewater application can be calculated.

24.2 The quantity of each wastewater constituent generated per year is calculated using annual wastewater generation rate and constituent concentrations. These values divided by the annual site assimilative capacity yield the land area required. After the area required for each constituent is determined, the limiting constituent, i.e., the constituent requiring the most land, determines the amount of land needed for the land treatment system.

24.3 Hydraulic loading is often the limiting factor with municipal wastewater. Typically, the amount of land required for 1 M gal/d of wastewater based on hydraulic loading may vary between 120 and 300 ac. depending upon the hydraulic properties and management of the site. After the area required for actual application is determined, additional area for buffer zones must be determined.

25.0 Systems Management

25.1 Lack of proper management of land treatment systems can result in environmental degradation and possible irreversible damage to the land. Various management schemes may be used to obtain the same level of waste application and treatment. Therefore, the land treatment system manager must be knowledgeable about all phases of the system to know how changes in management or operational performance of one system component affects other system components. He must be particularly knowledgeable about application hardware and agronomic or forest management. The objective of this chapter is to present basic considerations in choosing the application method, application equipment, storage requirements, cropping system, and application schedules.

[1]For constituents stored in the soil, the annual site assimilative capacity is determined using the site life.

26.0 Storage Requirements

Sufficient storage capacity must be provided for the maximum amount of wastewater generated over the maximum length of time for which irrigation is impractical. Non-application periods depend primarily upon the climate (e.g., excess soil moisture due to precipitation; freezing conditions) and the crop grown (e.g., crop growth stages that prohibit wastewater application). The storage facility capacity must consider a minimum reserve volume, rainfall storage for the design storm, volume for sludge accumulation and storage for non-application periods such as crop harvest and establishment, inclement weather, frozen soil, equipment breakdowns and flow equalization to name a few. The storage facility should be constructed properly to preclude seepage to groundwater and to preclude overflow except when rainfall exceeds design basis, in which case the possible impact of potential overflow must be considered.

27.0 Application Equipment

27.1 There are two basic types of irrigation systems: stationary (permanent) and mobile. The stationary system requires a higher initial investment but less annual labor. Mobile irrigation systems may be moved either manually from site to site or may traverse areas of land using a guidance system. Overall application amounts are controlled by the amount of time the system is in operation since the rate of application is generally fixed by the system design and the equipment chosen.

27.2 Drift of spray and aerosols should be minimized by selecting proper equipment, good application times (low wind) and adequate buffer zones. Runoff should be avoided, and this is dependent mainly upon application rate and moisture condition of the soil at the time of application. Uniformity of application can be affected by wind (drift), vegetation and uneven topography. Also, uniformity of application varies with type of irrigation system and sprinklers. Lack of uniformity should be considered in the design to prevent localized ponding or runoff.

28.0 Crop-Soil Management and Scheduling

28.1 The cropping system and soil hydraulic properties largely determine when and how much wastewater may be applied. Crops vary in their consumptive use of water (evapotranspiration), water tolerance for wet conditions and nutrient requirements. Different crops also require various degrees of management intensity and diversity of equipment and have varying potential economic returns for reducing the costs of the land treatment system. Forests and forage crops are attractive for wastewater treatment because of relatively low management requirements compared to row crops. Further, constant vegetative cover by trees or grasses promotes high infiltration and evapotranspiration and reduces potential for erosion and runoff. Although there may be more potential economic return from row crops or a diversity of crops rather than just trees or forages, the required intensity of management and the farm equipment requirements increase with row crops. Markets must also be considered when selecting the vegetation.

28.2 Whether the crop is trees, forage, or row crops, all have requirements for site preparation, planting, crop maintenance, weed and pest management, harvesting, and sale or disposal of harvested material. Wastewater application will not be possible during certain periods because of required tasks, e.g. cutting and baling hay, or restrictions such as the minimum period between application and harvesting. Wastewater application scheduling must mesh with the crop management scheduling.

28.3 Wastewater application and schedules and any supplemental fertilization must be matched to the crop's nutrient needs. Application of nutrients during non-growing periods can be accomplished if the form of nutrient applied is primarily one that is stored and not available for movement in percolating water. For instance, irrigation of nitrogen principally in the organic and ammonia forms results in storage on site. Whe nitrification occurs, presumably due to warmer soil temperatures and microbial activity, plants will also be actively taking up nitrate and/or denitrification will occur.

28.4 Fertilizer recommendations for P_2O_5 and K_2 O should be regularly determined by soil tests. The University of Delaware College of Agriculture Soil Testing Laboratory, Department of Plant Science, routinely runs soil tests. Fertilizer N recommendations are based on the crop being grown with allowance for residual N from the previous crop in some cases. Consequently, fertilizer recommendations on their soil test reports will always indicate that N fertilization is needed. Ignore this recommendation and apply wastewater based on design loading rates. Also, the P_2O_5 recommendation may need adjustment based on the design loading rate for the particular soil's P adsorption capacity and chosen site life.

28.5 Fewer data are available on growth response to wastewater fertilization of forests. Infiltration rates are normally high for forest soils, but the uptake of nutrients is normally lower for trees than for forages or row crops. Forestry specialists should be consulted for managing forest land treatment sites because there is relatively little information available in publications on forest management compared to the Delaware Agricultural Extension Service's bulletins on forage and row-crop management.

28.6 Irrigation scheduling must also take into consideration the soil moisture conditions and adjust scheduling or amount of application when necessary to prevent surface runoff or ponding and to allow adequate reaeration of the soil's A horizon for proper crop growth and wastewater treatment. Soil moisture measurements or tensiometers may be helpful in making irrigation decisions for sensitive crops.

28.7 Regardless of what crop is grown, land treatment systems must be managed in accordance with good agricultural practice. Sites receiving a high hydraulic loading will require careful management not common to normal farm operations due to the constant wet soils and need to control equipment access. It is advisable to hire a capable manager and require the manager to be familiar with and operate the system in accordance with a detailed "Operations and Management" manual. Adequate safety allowances should be built into the design to allow for a range of expected management capabilities as well as variability in crop yield and uncontrollable variables such as weather. The system should be designed using realistic average crop yields and nutrient uptake, not the maximum which may occur only one year in ten. If the crop removal of nutrients is not as much as designed for, then there is potential for environmental degradation. To assure nutrient removal from the site, marketing or utilization of harvested crops should be planned in advance. Timely crop harvest and removal from the site is necessary to maintain design nutrient balances.

29.0 Monitoring Guidelines

A monitoring program serves several purposes and may include several or all of the following:

29.1 To verify system performance as designed relative to wastewater treatment and environmental impact as prescribed in the permit.

29.2 To assess the vegetative-soil system to insure that viable vegetative cover is maintained and to provide information for effective site and vegetation management.

29.3 To determine safety of utilization of any vegetation harvested from the site or consumed by animals.

29.4 To monitor effectiveness of pretreatment processes and the generation rate and composition for any significant changes.

30.0 Record Keeping

The monitoring requirements and record-keeping requirements should be specified in the system design before it is approved. Record keeping is the responsibility of the operator or manager of the land treatment system, but records will be checked by Department personnel for accuracy and completeness.

31.0 Background Data

For certain items, monitoring should begin before the initiation of land application of wastewater. Such items may include phosphorus level in the soil, nitrate in the groundwater, and depth to groundwater. The background monitoring period and the amount of data required will depend upon the potential problems identified for the wastewater constituents to be applied and the characteristics of the site.

32.0 Waste Stream Monitoring

The wastewater production rate and composition should be determined routinely. The frequency of sampling and number of constituents to be analyzed will depend on the variability of the wastewater over time and the pollution potential of various waste constituents.

33.0 Groundwater and Surface Water Monitoring

33.1 Groundwater should be monitored on a periodic basis to evaluate increased levels of potentially mobile pollutants such as NO_3^--N. The number and location of wells required will depend on site characteristics, present groundwater quality and potential for groundwater degradation beyond allowable limits. Wells should be cased to prevent contamination from surface water. Groundwater monitoring is generally conducted in three primary areas:

3.1.1 up-gradient of the land treatment site to provide background information,

3.1.2 directly beneath the site, and

3.1.3 down-gradient of the site.

33.2 Parameters should be classified in priority levels and monitored at different frequencies depending upon priority level. Operational changes in the treatment process and/or waste stream character may dictate moving parameters from one priority level to another.

33.3 Surrounding surface waters should be monitored essentially for the same parameters as measured in groundwater, plus constituents that may move in surface runoff and erosion such as P and NH_4^+ N. Sampling locations will depend upon the hydrologic characteristics of the site. Channels or ditches and subsurface drains which drain the site should be sampled as a high priority.

34.0 Soil Monitoring

Soil should be monitored for the key constituents which accumulate in the soil and are potentially harmful. Incremental sampling depths should be small enough to accurately determine changes in concentration, particularly near the soil surface. Also, sampling for agronomic parameters should be conducted routinely to ensure optimal performance of the soil/plant system and that the required pH is maintained.

35.0 Crop Monitoring

Crop monitoring should evaluate potential utilization problems of the harvested forage or grain, such as trace metals and PCB's if present in the waste. Frequency of sampling and parameters to be monitored will depend upon the utilization of the crop and the wastewater constituents being applied. For example, forages being harvested as hay to feed livestock should be monitored for PCB's and cadmium if PCB's and cadmium are applied in the wastewater and can accumulate on the leaf surfaces. Crop monitoring may also be used to evaluate nutrient deficiencies of minor elements or other vegetative growth problems so supplemental additions can be made to achieve optimum plant growth and wastewater nutrient uptake.

36.0 Public Health Protection

36.1 Many wastewater land treatment systems have operated successfully for years without public health problems. However, the public must be educated about the effectiveness of these systems in treating wastewater while minimizing public health hazards. Public health protection sometimes becomes the major issue in choosing land treatment over conventional waste treatment which discharges wastewater to rivers or streams. The EPA design manual (7) has a chapter on "Health and Environmental Effects." The possible health effects considered to be the major ones are presented here.

36.2 The main public health concerns that must be considered in designing and managing land treatment sites are:

36.2.1 microorganisms surviving to enter drinking water, transferred by grazing animals or inhaled in aerosols leading to possible infection or disease

36.2.2 trace elements such as cadmium getting into food chain or drinking water leading to possible toxicity levels

36.2.3 trace organics and synthetic organic compounds getting into drinking water or the food chain leading to possible toxicity levels and carcinogenesis nitrate nitrogen additions to drinking water aquifers leading to potential health problems or methemoglobinemia (blood disorder) in infants.

36.3 Low numbers of pathogenic bacteria and viruses and some intestinal parasites may survive the sewage treatment process and be present in wastewater. Bacteria and viruses are greatly reduced by primary and secondary treatment, but as a general policy, active disinfection is required in Delaware as an additional precaution (see Subsection 303 of these regulations). The Department will determine disinfection requirements for irrigation of wastewater on a case-by-case basis. When "active" disinfection is not proposed by the applicant or consulting engineer, adequate justification must be submitted for consideration.

36.4 The EPA has issued general guidelines for pre-irrigation treatment of municipal wastewater (7) which are less stringent than Delaware's requirements. EPA's general guidelines are listed here as a matter of information:

36.4.1 Primary treatment - acceptable for isolated locations with restricted public access and when limited to crops not for direct human consumption.

36.4.2 Biological treatment by ponds or inplant processes plus control of fecal coliform count to less than 1,000 MPN/100 mL - acceptable for controlled agricultural irrigation except for human food crops to be eaten raw.

36.4.3 Biological treatment by ponds or inplant processes with additional BOD or suspended solids control as needed for aesthetics plus disinfection to log mean of 200/100 mL (EPA fecal coliform criteria for bathing waters) - acceptable for application in public access areas such as parks and golf courses.

36.5 Concerning chlorination for disinfection, trace organics (e.g. trihalomethanes) may be produced when wastewaters containing organic material is chlorinated. More research is needed in this area, but chlorination should be used with caution where drinking water supplies are potentially affected.

36.6 Several measures in addition to disinfection can be used to reduce bacterial and viral exposure through aerosols. These measures include:

operating sprinklers during daylight hours increases the number of microorganisms killed by ultraviolet radiation and drying;

36.7 use of downward-directed, low-pressure sprinklers results in fewer aerosols than upward-directed, high-pressure sprinklers;

36.8 buffer zones may be used to separate the spray source and the general public;

36.9 planting vegetation, particularly trees, around the site in the buffer can reduce the aerosols leaving the site by causing vertical dispersion and trapping.

36.10 Growing vegetables or grazing animals on an actively irrigated land treatment site is generally prohibited because of the potential for transfer of pathogens and intestinal worm eggs (see Subsection 308 of these regulations). Other considerations that prohibit grazing are soil compaction by animals, which affects infiltration rates, and the problem of essentially little net removal of nutrients during grazing. If wastewater applications are terminated, the following precautions are recommended when a wastewater with domestic sources is irrigated:

36.11 Grazing by animals (other than lactating dairy cows) whose products are consumed by humans should be prohibited for at least one month after irrigation ceases.

Grazing by lactating dairy cows should be prohibited for at least one year because of the potential of intestinal worms being transferred into milk by udder contamination.

36.12 Growing vegetables and root crops, which are eaten raw, should be prohibited for at least 18 months.

36.13 For pathogen considerations (when the wastewater contains domestic wastes), hay should not be cut for at least four days after application of disinfected secondary effluent. If the wastewater contains appreciable amounts of synthetic organic compounds or cadmium (or other potentially harmful trace elements), then the forage should be monitored for potential toxicity problems to animals or possible food-chain effects, especially in the case of feeding hay to lactating dairy cows.

36.14 EPA requirements for limiting cadmium application to land (Table 2) and design considerations to prevent nitrate pollution of groundwater have been previously discussed in Chapter 4.

37.0 Economic Considerations

37.1 The number of publicly owned municipal wastewater irrigation systems in the United States was reported by EPA to be 839 in 1981 (7). The addition of industrial and privately owned land treatment systems and the publicly owned systems installed since 1981 likely brings the total number of land application systems to over

2,000 systems in 1987. Therefore, many communities and industries have found land treatment to be an economical waste treatment alternative.

37.2 There is not a good summary of economic data on land treatment systems in Delaware. However, enough systems have been installed in other states to provide example calculations for a range of community sizes and situations where a land treatment system may be considered. he best sources of this information are other municipalities and industries that have land treatment systems and engineering consultants who have designed these systems.

37.3 Some EPA and U.S. Dept. of Agriculture (USDA) publications provide economic analysis of land treatment systems (8, 9, 10) for municipal wastewater. The EPA Process Design Manual (7) provides an example for wastewater irrigation which includes economic analysis based on the techniques presented in reference (8).

37.4 The USDA publication's cost analysis (10) resulted in the following conclusions for land treatment of municipal wastewater:

37.5 Land application of wastewater is a cost-effective method for advanced wastewater treatment.

37.6 Compared with conventional advanced wastewater treatment technologies, land application is less expensive for facilities treating less than 5 million gallons of wastewater per day and may be cost-effective for larger systems depending on land availability and distance from the treatment plant.

37.7 The publication also analyzes factors such as crop selection, land costs, effluent transmission, public health constraints, storage and hydraulic loading. This type of publication is limited in its applicability of economic data to situations other than those specifically used in its analysis, but the concepts of what economic factors and analysis techniques to use are applicable to other situations.

38.0 Appendices

38.1 Sources of Materials and Information Useful in Designing Land Treatment Systems (Subsection 1001)

38.1.1 County roadmaps

Maps, Delaware Dept. of Transportation

Division of Highways

Dover, Delaware 19903

38.1.2 Topographic maps

38.1.2.1U.S. Geological Survey

38.1.2.2These maps are also available from some engineering supply stores and the Government Printing Office

38.1.3 Aerial photographs

38.1.3.1County Soil Conservation Service Office or

38.1.3.2County Agricultural Stabilization and Conservation Service Office

38.1.3.2Commercial aerial photographers

38.1.4 Soil maps, soil survey reports, soil series description sheets

38.1.4.1County Soil Conservation Service Office

38.1.4.2Some consulting firms have soil mapping capabilities

38.1.5 Technical manuals

38.1.5.1See the "Literature Cited" and "Additional Literature on Land Treatment" sections at the end of the booklet.

39.0 Literature Cited

39.1 Chapman, H. D. 1965. Cation-Exchange Capacity. In C. A. Black (ed.) Methods of Soil Analysis. Amer. Soc. Agron. Madison, WI.

39.2 Code of Federal Regulations, Title 40, Protection of Environment, Part 141. 39.3National Interim Primary Drinking Water Regulations. July 1, 1982.

39.4 Federal Register, Thursday, September 13, 1979. Part IX, EPA, Criteria for Classification of Solid Waste Disposal Facilities and Practices; Final, Interim Final and Proposed Regulations (as corrected in the Federal Register of Sept. 21, 1979) Vol. 44, pp. 53438-53468.

39.5 Jacobs, L. W. (ed.) 1977. Utilizing municipal sewage wastewaters and sludges on land for agricultural production. North Central Regional Extension Publication No. 52. Michigan State Univ., East Lansing, 48824.

39.6 Knezek, B. D. and R. H. Miller. 1978. Application of sludges and wastewaters on agricultural land: a planning and educational guide. EPA Report MCD-35.

39.7 Soil Conservation Service, USDA. 1975. Agricultural waste management field manual.

39.8 USEPA. 1981. Process Design Manual for Land Treatment of Municipal Wastewater. EPA 625/1-81-013.

39.9 USEPA. 1975. Cost of land treatment systems. EPA 430/9-75-003.
39.10 Young, C. E. 1976. The cost of land application of wastewater: a simulation analysis. Technical Bulletin 1555, ESCS, USDA, Washington, DC.
39.11 Young, C. E. 1978. Land application of wastewater: a cost analysis. Technical Bulletin 1594, ESCS, USDA, Washington, DC.
39.12 Parker, David R. and Leo J. Cotnoir, Jr. 1984. Fertilizer Recommendations for Delaware. Cooperative Bulletin No. 7, University of Delaware Cooperative Extension Service, Newark, Delaware.

PART II Land Treatment of WasteWaters Regulations for Slow Rate Land Treatment

40.0 Introduction

40.1 (Subsection 101) Purpose

40.1.1 This document provides regulations for the planning, design, and operation of slow rate land treatment systems for wastewaters in Delaware. These guidelines and regulations do not apply to overland flow or rapid infiltration systems. Furthermore, these regulations supersede Section 9 - Effluent Limitations for Land Disposal of Liquid Waste - Part I regarding Spray Irrigation of Liquid Waste as set forth in the Department's Regulations Governing the Control of Water Pollution, adopted March 15, 1974 and amended on June 23, 1983.

40.1.2 The Delaware Department of Natural Resources and Environmental Control encourages slow rate land treatment as an alternative to advanced wastewater treatment, particularly in environmentally sensitive areas of the State. In addition, slow rate land treatment, or wastewater irrigation, is encouraged for wastewater treatment in small to medium sized communities and industries where appropriate.

40.1.3 The term slow rate land treatment as used in these regulations refers to the advanced treatment of wastewater by irrigation onto land to support vegetative growth. These systems are designed and operated so there is no direct discharge to surface waters. The irrigated wastewater evaporates and transpires to the atmosphere or enters the groundwater through percolation. Organic constituents in the wastewater are stored in the soil or stabilized by soil bacteria. Organic and ammonia nitrogen are taken up by plants, nitrified by soil bacteria, lost to the atmosphere through denitrification, and leached groundwater. Phosphorus and other constituents are adsorbed in the soil profile and/or taken up by plants. Properly designed and operated wastewater irrigation systems produce a percolate water of high quality and thus protect ground and surface water resources.

40.1.4 The regulations outlined herein apply to wastewaters with and without domestic wastes. A distinction is made between the two types of wastewaters because of the public health issues associated with domestic wastes. Wastewater irrigation systems for industrial and animal wastes may depart somewhat from these regulations and, if so, will be evaluated by the Department on an individual basis.

40.1.4 The design and operation of wastewater irrigation systems is very site specific. This document is intended to provide regulations and general guidelines for design and operation of slow rate land treatment systems in Delaware. However, hydrogeologic and soil conditions vary widely throughout the State and site assessment and monitoring requirements may vary not only from region to region but even from site to site within the same region.

50.0 Sources of Information

The Division of Water Resources recommends the following additional sources of information for the planning, design and operation of slow rate land treatment systems

50.1 Organizations

50.1.1 American Society of Agricultural Engineers, 2950 Niles Road, St. Joseph, Michigan 49085.

50.1.2 American Society of Agronomy, 667 S. Segoe Road, Madison, Wisconsin 53711.

50.1.3 Delaware Agricultural Extension Service, College of Agriculture, University of Delaware, Newark, Delaware 19703.

50.1.4 The Irrigation Association, 13975 Connecticut Avenue, Silver Spring, Maryland 20906.

50.1.5 United States Department of Agriculture (USDA), Soil Conservation Service, Treadway Towers, Dover, Delaware 19901.

50.2 Technical References

50.2.1 Brady, N.C. 1974. The Nature and Properties of Soils, Eighth Edition. (ISBN 0-02-313350-3) MacMillan: New York, New York.

50.2.2 Cole, D., C. Henry, and W. Nutter. 1986. Forest Alternative for Land Treatment of Municipal and Industrial Wastes. University of Washington Press, Seattle, 592 pp.

50.2.3 The Irrigation Association. 1983. Irrigation, Fifth Edition. Silver Spring, Maryland.
50.2.4 Metcalf and Eddy, Inc. 1979. Wastewater Engineering: Treatment, Disposal and Reuse. (ISBN 0-07-041667-X) McGraw-Hill: New York, New York.
50.2.5 Overcash, M.R. and P. Pal. 1979. Design of Land Treatment Systems for Industrial Wastes - Theory and Practice. Ann Arbor Science: Ann Arbor, Michigan.
50.2.6 Reed, S.C. and R.W. Crites. 1984. Handbook of Land Treatment Systems for Industrial and Municipal Wastes. (ISBN 0-8155-0991-X) Noves Publications: Park Bridge, New Jersey.
50.2.7 Rich, L.G. 1980. Low Maintenance, Mechanically Simple Wastewater Treatment Systems. (ISBN 0-07-052252-9) McGraw-Hill: New York, New York.
50.2.8 Smedema, L.K. and D.W. Rycroft. 1983. Land Drainage: Planning and Design of Agricultural Drainage Systems. (ISBN 0-8014-1629-9) Cornell University Press: Ithaca, New York.
50.2.9 United States Department of Agriculture. National Engineering Handbook, Sections 15 and 16. Soil Conservation Service. Washington, D.C.
50.2.10 United States Environmental Protection Agency. 1981. Process Design Manual: Land Treatment of Municipal Wastewater. (EPA 625/1-81-013) Center for Environmental Research Information. Cincinnati, Ohio.
50.2.11 United States Environmental Protection Agency. 1983. Design Manual: Municipal Wastewater Stabilization Ponds. (EPA-625/1-83-015) Center for Environmental Research Information. Cincinnati, Ohio.
50.2.12 Water Pollution Control Federation, American Society of Civil Engineers. 1977. WPCF Manual of Practice No. 8: Wastewater Treatment Plant Design. Washington, D.C.

51.0 Definitions.

The following terms have the meanings indicated.

"Agricultural land" means land cultivated for the production of crops or used for raising livestock.

"Agricultural wastes" means wastes normally associated with the production and processing of food and fiber on farms, feedlots, ranches, ranges, and forests which may include animal manure, crop residues, and dead animals; also agricultural chemicals, fertilizers and pesticides which may find their way into surface and subsurface water.

"Crops for direct human consumption" means crops that are consumed by humans without processing to minimize pathogens before distribution to the consumer.

"Department" means the Department of Natural Resources and Environmental Control.

"Disposal" means the discharge, deposit, injection, dumping, spilling, leaking, or placing of wastewater, other liquid waste, or any constituent of it on or in the land, the air or any waters, including ground water, and includes any method of utilization that involves reuse of the nutrients at greater than agronomic rates.

"Food chain crops" means tobacco, crops grown for human consumption, and crops grown to feed animals whose products are consumed by humans.

"Free liquids" means liquids which readily separate from the solid portion of a waste under the following tests:

(a) EPA Plate Test. Place a 1 to 5 kilogram (2.2 to 11.0 lbs.)sample of waste on a level or slightly sloping plate of glass or other similarly flat and smooth solid material for at least 5 minutes. If a liquid phase separation is observed, the waste contains free liquids.

(b) EPA Gravity Test. The test protocol calls for a 100 ml representative sample of the waste from a container to be placed in a 400 micron conical paint filter for 5 minutes. The filter specified is a standard paint filter which is commonly available at hardware and paint stores. The filter is to be supported by a funnel on a ring stand with a beaker or cylinder below the funnel to capture any free liquid that passes through the filter. If any amount of free liquid passes through the filter, the waste is considered to hold free liquids.

"Household waste" means any waste derived from households (including single and multiple residences, hotels and motels, bunkhouses, ranger stations, crew quarters, campgrounds, and day-use recreation areas), not including sewage or septage.

"Impermeable" means having a hydraulic conductivity equal to or less than 1×10^{-7} cm/sec as determined by field and laboratory permeability tests made according to standard test methods which may be correlated with soil densification as determined by compaction tests.

"Land application" means the placement of liquid waste or treated liquid waste within 2 feet below the surface of land used to support vegetative growth.

"Land treatment" means a technology for the intimate mixing or dispersion of wastes into the upper zone of the plant-soil system with the objective of microbial stabilization, immobilization, selective dispersion, or crop recovery leading to an environmentally acceptable assimilation of the waste.

"Liquid waste" means any waste which is not a solid waste as defined for the purposes of these regulations.

"Person" means an individual, trust, firm, joint stock company, federal agency, corporation (including a government corporation), partnership, association, state, municipality, commission, political subdivision of a state, or any interstate body**.**

"Septage" means the liquid and solid contents of a septic tank.

"Sewage" means water-carried human or animal wastes from septic tanks, water closets, residences, buildings, industrial establishments, or other places, together with such groundwater infiltration, subsurface water, admixture of industrial wastes or other wastes as may be present.

"Sewage sludge" means sludges which derive in whole or in part from sewage.

"Sludge" means the accumulated semi-liquid suspension, settled solids, or dried residue of these solids that is deposited from (a) liquid waste in a municipal or industrial wastewater treatment plant, (b) surface or groundwaters treated in a water treatment plant, whether or not these solids have undergone treatment. Septage is included herein as sludge.

"Solid waste" means any garbage, refuse, rubbish, and other discarded materials resulting from industrial, commercial, mining, agricultural operations and from community activities which does not contain free liquids. Containers holding free liquids shall be considered solid waste when the container is designed to hold free liquids for use other than storage (e.g. radiators, batteries, transformers) or the waste is household waste which is not sewage or septage.

"Spray irrigation" means the loading rate for land treatment of wastewater which shall not exceed either the needs of the crop grown on the particular soil plus the other assimilative mechanisms (e.g. immobilization with organic material, volatilization, and leachate in compliance with drinking water standards), or the hydraulic capacity of the soil. The Department may require a lower loading rate if the design criteria for pathogens, metals or organics contained in these Regulations and generally accepted technical standards for land treatment technology (e.g. U.S. EPA Process Design Manual or Overcash, M.R. and P. Pal 1979 Design of Land Treatment Systems for Industrial Wastes - Theory and Practice cannot be achieved at a rate consistent with agricultural utilization.

"Storage" means the interim containment of liquid waste or treated liquid waste before disposal or utilization.

"Surface impoundment" means a natural topographic depression, and/or man-made excavation, and/or diked area formed primarily of earthen materials (although it may be lined with man-made materials) or remains unlined, and which is designed to hold an accumulation of liquid wastes or wastes containing free liquids. Examples of surface impoundments are holding, storage, settling, and elevation pits, ponds, and lagoons. Design requirements for storage are given in Section 900 of the Sludge and Sludge Products Regulations.

"Treatment" means a process which alters, modifies, or changes the biological, physical, or chemical characteristics of sludge or liquid waste.

"Treatment works" means any device and system used in the storage, treatment, recycling and reclamation of municipal sewage, or industrial wastes of a liquid nature, or necessary to recycle or reuse water at the most economical cost over the estimated life of the works, including intercepting sewers, outfall sewers, sewage collection systems, pumping, power and other equipment, and their appurtenances, extensions, improvements, remodeling, additions and alterations thereof; elements essential to provide a reliable recycled supply such as standby treatment units and clear well facilities and improvements to exclude or minimize inflow and infiltration.

"Wastewater treatment plant" means a facility designed and constructed to receive, treat, or store waterborne or liquid wastes.

52.0 Procedures for State Review and Approval

52.1 (Subsection 201) Proposal for Land Treatment

52.1.1 Title 7, Chapter 60 of the Delaware Code (the Environmental Protection Act) and these regulations govern procedures necessary to gain Department approval of slow rate land treatment systems. The steps outlined in Table 201-1 are in accordance with the Act and regulations. These steps are explained in the following sections. (Section 300 of these regulations contains a detailed discussion of required design considerations for slow rate systems.) Projects funded under the Federal Construction Grant Program (Title II of the Federal Clean Water Act) must meet all Federal funding requirements in addition to the steps listed in Table 201-1. Whenever the preparation of reports or other documents required by these

regulations involves the practice of engineering, geology or other recognized profession under Delaware law, sufficient evidence of appropriate certification or registration in accordance with Title 24 of the **Delaware Code** must be submitted by the preparer.

52.2 Letter of Intent

52.2.1 The facility owner, his engineer or agent must submit to the Department a letter of intent to develop a wastewater irrigation system. It must indicate the projected design flow and wastewater characteristics for this system and proposed source(s) of project funding. In addition, owners of private domestic wastewater irrigation systems are required to execute a trust indenture with a local government body or other trustee approved by the Division. This trust indenture guarantees operation and maintenance of the facility in the event of operational or financial default by the owner.

52.3 Site Selection and Evaluation Report

52.3.1 Upon receipt of the letter of intent, the Department will inform the facility owner of the need for a "Site Selection and Evaluation Report". Potential land treatment sites must be identified and evaluated by the facility owner, and a preliminary soil survey conducted at the selected site(s).

52.3.2 Table 201-2 outlines information generally needed in the Site Selection and Evaluation Report. For Federal Construction Grant Projects, this information is included in the Facilities Plan Report. Additional information may be requested as needed.

52.4 Site Inspection and Concurrence

52.4.1 The Site Selection and Evaluation Report is submitted by the owner for Department review along with a request for general site concurrence. Upon receipt of the report, a Department representative will inspect the selected site(s). A site concurrence or denial letter will be written based on a engineering and geologic evaluation of site conditions. It should be noted that site concurrence is preliminary and pertains only to general wastewater treatment and application to the land. The letter will indicate what requirements are necessary to proceed with the project. Site concurrences for slow rate land treatment are valid for two years. If detailed design has not begun within this period, the Department may choose to reevaluate the project.

53.0 Design Development Report

53.1 After a site has been selected by the owner and accepted by the Department as suitable for slow rate land treatment, a "Design Development Report" must be submitted by the owner or his agent. This report shall include, but is not limited to, the information outlined in Tables 202-1 and 202-2. The report required by this section shall be prepared by qualified persons in soil science and land treatment.

53.2 The Design Development Report is submitted for Department review, and once accepted, becomes the basis of design for the project. In any event, the applicant must demonstrate that the proposed Land Treatment System will meet the regulatory objectives set forth in 300 of the Policies and Procedures for Land Treatment of Wastes and will not cause violations of State and Federal drinking water standards on an average annual basis or State Water Quality Standards for streams.

54.0 Permitting of Slow Rate Land Treatment Systems

54.1 The Department permits all slow rate land treatment systems. This permit incorporates a Department approved Plan of Operation and Management prepared for the facility by the owner or owner's engineer. No permit may be granted unless the county or municipality having jurisdiction has first approved the activity by zoning procedures provided by law.

54.2 Public Notice, Draft and Final Land Treatment System (LTS) Permits

54.3 Upon Department acceptance of the Design Development Report, the owner of the proposed facility must submit an application for a Department Land Treatment System (LTS) Permit. Upon receipt of the completed application for a permit, the Department will advertise receipt of the application and conduct any hearings in accordance with 7 **Del.C.**, Ch. 60. The cost of the advertisement is to be borne by the applicant. If no hearings are held and if all requirements of these regulations.

55.0 Table 201-1 Steps for Delaware Department of Natural Resources and Environmental Control (DNREC) Review and Approval of Slow Rate Land Treatment Systems

55.1 Letter of Intent submitted to Department by owner or owner's representative.

55.2 Department response. Identifies need for:

55.2.1 Site Selection and Evaluation Report

55.2.2 Site Inspection

55.2.3 Design Development Report

55.2.4 Permit Application and Public Notice

55.2.5 Plans and Specifications

55.2.6 Plan of Operation and Management
55.2.7 Trust Indenture for privately owned facilities
55.3 Site Selection and Evaluation Report:
55.3.1 Submitted for Department review
55.3.2 Department conducts site inspection
55.3.3 Site concurrence or denial issued by Division
55.4 Design Development Report:
55.4.1 Submitted for Department review
55.4.2 Accepted by Department as the basis for facility design
55.5 Application for permit to apply treated wastewater to land:
55.5.1 Permit application requested from owner
55.5.2 Permit application completed and submitted to Department
55.5.3 Application reviewed and checked against design development report
55.6 Public Notice:
55.6.1 Public Notice drafted by Department
55.6.2 Public Notice advertised by Department; billing sent to owner
55.6.3 Public comment period
55.6.4 Public Notice requirements completed (hearing held if necessary)
55.6.5 Trust Indenture executed for privately owned facilities
55.7 Land Treatment System (LTS) Permit drafted by Division.
55.7.1 Industrial pretreatment requirements included if necessary
55.7.2 Draft permit and monitoring requirements sent to owner for comment
55.7.3 Draft permit modified if necessary
55.8 Plans and Specifications:
55.8.1 Submitted by owner for Department review with permit application
55.8.2 Checked against accepted Design Development Report
55.8.3 Approved by Department for construction and incorporated into final LTS permit
55.9 Plan of Operation and Management:*
55.9.1 Submitted by owner for Department review
55.9.2 Approved by Department
55.9.3 Incorporated into final LTS Permit
55.10 Final Land Treatment System (LTS) Permit issued.
55.10.1 Permit signed
55.10.2 Sent to facility owner
55.10.3 Facility construction begins
55.11 Certification of Construction Completion:
55.11.1 Submitted to Department by design engineer
55.11.2 Department conducts facility inspection to verify compliance with approved plans and specifications
55.12 Authorization to commence operation at design flow.
55.13 *While the steps shown in 55.9 are the preferred approach, in any case the Final Operation and Management Plan must be approved by the Department prior to issuance of an Authorization to commence operation at design flow (Item 55.12)

56.0 Table 201-2 Site Selection And Evaluation Report Information

56.1 Site Description:
56.1.1 Location map
56.1.2 Topographic map (7.5 minute quadrangle, scale 1:24000)
56.1.3 Soil survey map
56.1.4 Geologic and hydrologic conditions
56.1.5 Known cultural or historic resources (cemeteries, archaeologic sites, etc.)
56.2 Site Soil Characteristics:
56.2.1 USDA Soil Conservation Service soil series classifications
56.2.2 Narrative description for same including:
56.2.2.1Texture
56.2.2.2Permeability
56.2.2.3Slope
56.2.2.4Drainage

56.2.2.5 Depth to seasonal high water table

56.2.2.6 Depth to impervious strata

56.2.2.7 Erodibility

56.3 100 year flood elevation for site (if applicable).

56.4 Existing vegetative cover.

56.5 Existing land use.

56.6 Present land owner.

56.7 A detailed soil investigation report is required to be submitted with the Design Development Report (reference Sections 55.0 and 56.0 [Tables 202-1 and 202-2])have been fulfilled, a draft LTS Permit will be prepared for the slow rate land treatment system. The final permit will be issued upon submission and approval by the Department of the Plan of Operation and Management for the facility prior to start-up and operation. Upon granting written approval for operation, the Department shall give notice of such approval to any person who has submitted a written request for such notice.

56.8 Standard Permit Conditions. The following conditions shall apply to and will be included in all permits.

56.8.1 Compliance Required.The permittee shall comply with all conditions of the permit.

56.8.2 Renewal Responsibilities.If the permittee intends to continue operation of the permitted facility after the expiration of an existing permit, the permittee shall apply for a new permit in accordance with these regulations no later than 180 days prior to expiration.

56.8.3 Operation of Facilities.The permittee shall at all times properly maintain and operate all structures, systems, and equipment for treatment, control and monitoring, which are installed or used by the permittee to achieve compliance with the permit or these regulations.

56.8.4 Provide Information.The permittee shall furnish to the Department within a reasonable time, any information including copies of records, which may be requested by the Department to determine whether cause exists for modifying, revoking, reissuing, or terminating the permit, or to determine compliance with the permit or these regulations.

56.8.5 Entry and Access.The permittee shall allow the Department, consistent with 7 **Del.C**., Chapter 60, to:

56.8.5.1 Enter the permitted facility.

56.8.5.2 Inspect any records that must be kept under the conditions of the permit.

55.8.5.3 Inspect any facility, equipment, practice, or operation permitted or required by the permit.

55.8.5.4 Sample or monitor for the purpose of assuring permit compliance, any substance or any parameter at the facility.

56.8.6 Reporting.The permittee shall report to the Department under the circumstances and in the manner specified in this section:

56.8.6.1 In writing thirty (30) days before any planned physical alteration or addition to the permitted facility or activity if that alteration or addition would result in any significant change in information that was submitted during the permit application process.

56.8.6.2 In writing thirty (30) days before any anticipated change which would result in noncompliance with any permit condition or these regulations.

56.8.6.3 Orally within twenty-four (24) hours from the time the permittee became aware of any noncompliance which may endanger the public health or the environment at telephone numbers provided in the permit by the Department.

56.8.6.4 In writing as soon as possible but within five (5) days of the date the permittee knows or should know of any noncompliance unless extended by the Department. This report shall contain:

56.8.6.4.1 A description of the noncompliance and its cause;
The period of noncompliance including to the extent possible, times and dates and, if the noncompliance has not been corrected, the anticipated time it is expected to continue; and

56.8.6.4.2 Steps taken or planned to reduce or eliminate reoccurrence of the noncompliance.

56.8.6.5 In writing as soon as possible after the permittee becomes aware of relevant facts not submitted or incorrect information submitted, in a permit application or any report to the Department. Those facts or the correct information shall be included as a part of this report.

56.9 Minimize Impacts. The permittee shall take all necessary actions to eliminate and correct any adverse impact on the public health or the environment resulting from permit noncompliance.

56.10 Reopener. In the event that the regulations governing land disposal of wastes via spray irrigation are revised by the Department, this permit may be reopened and modified accordingly after notice and opportunity for a public hearing.

Specific Permit Conditions. A permit issued pursuant to these rules may include but not be limited to such information and conditions as the following:

56.11 Basis for Specific Permit Conditions.Conditions necessary for the protection of the environment and the public health may differ from facility to facility because of varying environmental conditions and wastewater compositions.The Department may establish, on a case-by-case basis, specific permit conditions. Specific conditions shall be established in consideration of characteristics specific to a facility and inherent hazards of those characteristics.Such characteristics include, but are not limited to:

56.11.1 Chemical, biological, physical, and volumetric characteristics of the wastewater;

56.11.2 Geological and climatic nature of the facility site;

56.11.3 Size of the site and its proximity to population centers and to ground and surface water;

56.11.4 Legal considerations relative to land use and water rights;
Techniques used in wastewater distribution and the disposition of that vegetation exposed to wastewaters;

56.11.5 Abilities of the soils and vegetative covers to treat the wastewater without undue hazard to the environment or to the public health; and

56.11.6 The need for monitoring and recordkeeping to determine if the facility is being operated in conformance with its design and if its design is adequate to protect the environment and the public health.

56.12 Duration of the Permit.The permit shall be effective for a fixed term of not more than five (5) years.

56.13 Limitations to Operation.Conditions of the permit may specify or limit:

56.13.1 Wastewater composition;

56.13.2 Method, manner, and frequency of wastewater treatment;

56.13.3 Wastewater pretreatment requirements;

56.13.4 Physical, chemical, and biological characteristics of a land application facility; and

56.13.5 Any other condition the Department finds necessary to protect public health or environment.

56.14 Compliance Schedules The Department may establish a compliance schedule for existing facilities as part of the permit conditions including:

56.14.1 Specific steps or actions to be taken by the permittee to achieve compliance with applicable requirements or final permit conditions;

56.14.2 Dates by which those steps or actions are to be taken; and

56.14.3 In any case where the period of time for compliance exceeds one (1) year the schedule may also establish interim requirements and the dates for their achievements.

56.15 Monitoring Requirements.Any facility may be subject to monitoring requirements including, but not limited to:

56.15.1 The installation, use, and maintenance of monitoring equipment;

56.15.2 Monitoring or sampling methodology, frequency, and locations;

56.15.3 Monitored substances or parameters;

56.15.4 Testing and analytical procedures; and

56.15.5 Reporting requirements including both frequency and form

56.16 Permit Modification

56.16.1 Minor Modifications.Minor modifications are those which if granted would not result in any increased impact or risk to the environment or to the public health. Such modifications shall be made by the Department. Minor modifications are normally limited to:

56.16.1.1The correction of typographical errors.

56.16.1.2Transfer of ownership or operational control.

56.16.1.3A change in monitoring or reporting frequency.

56.17 Major Modifications. All modifications not considered minor shall be considered major modifications. The procedure for making major modifications shall be the same as that used for a new permit under these regulations.

56.18 Permit Transferable. Permits shall be transferable to a new owner or operator provided that the permittee notifies the Department by requesting a minor modification of the permit before the date of transfer and that such transfer is consistent with any trust indenture required by these rules.

58.19 Appeals of final permits shall be governed by 7 **Del.C.,** 6008 and 6009.

58.20 Permit Revocation

58.20.1 Conditions for Revocation.The Department may revoke a permit if the permittee violates any permit condition or these regulations.

58.20.2 Notice of Revocation.Except in cases of emergency, the Department shall issue a written notice of intent to revoke to the permittee prior to final revocation. Revocation shall become final within twenty (20) days of

receipt of the notice by the permittee, unless within that time the permittee requests an administrative hearing in writing.

58.20.3 Notice of Hearing.The Department shall notify the permittee in writing of any revocation hearing at least twenty (20) days prior to the date set for such hearing. The hearing shall be conducted in accordance with 7 **Del.C.**, Chapter 60.

58.20.4 Emergency Action. If the Department finds the public health, safety or welfare requires emergency action, the Department shall incorporate findings in support of such action in a written notice of emergency revocation issued to the permittee. Emergency revocation shall be effective upon receipt by the permittee. Thereafter, if requested by the permittee in writing, the Department shall provide the permittee a revocation hearing and prior notice thereof.

Such hearings shall be conducted in accordance with 7 **Del.C.**, Chapter 60.

58.21 Plan of Operation and Management

An outline for the scope of the Plan of Operation and Management required for the Department Land Treatment System Permit is presented in Subsection 701. The Plan is submitted by the owner or owner's engineer. Once accepted by the Department, this Plan becomes the operating and management manual for the facility.

58.22 Land Treatment Systems with Underdrains

Land treatment systems incorporating drainage improvements in the system design that result in a point discharge to surface waters fall under Federal and State point source discharge rules and regulations. These systems will be issued a National Pollutant Discharge Elimination System (NPDES) Permit in place of a Delaware LTS Permit. The NPDES Permit will include a special condition requiring submission and approval of a Plan of Operation and Management as required for the Delaware LTS Permit. All procedures for State review and approval outlined in this chapter remain in effect for underdrained land treatment systems.

59.0 Engineering Plans and Specifications

59.1 Review

59.1.1 In order to obtain Department acceptance of the Design Development Report and issuance of a final Land Treatment System (LTS) Permit (reference Section 14.0), the owner must submit detailed construction plans and specifications. These should be completed in accordance with the rules and current policies of the Department. The plans and specifications will be reviewed for consistency with the Design Development Report and accepted engineering standards. Upon satisfactory review of the plans and specifications, a letter authorizing construction will be written. This approval is valid for two years. If construction has not begun within this period, the project will require reevaluation. Approval of privately owned, domestic wastewater irrigation systems is contingent upon execution of the trust indenture referenced in subsection 12.1.

59.2 Final Inspection

59.2.1 Upon project completion, the design engineer or owner must certify, in writing and through submission of "as-builts", to the Department that the project was constructed in accordance with the approved plans and specifications. Upon receipt of this certification, a Department representative will inspect the completed facility. When the facility is verified as being complete and operational, a letter authorizing operation under the facility's LTS Permit will be issued. Upon granting written approval for operation, the Department shall give notice of such approval to any person who has submitted a written request for such notice.

60.0 Table 202-1 Design Development Report Information

60.1

60.1.1 Site Description:
60.1.2 Location map
60.1.3 Climate
60.1.4 Geology (including subsurface hydrology)
60.1.5 Topography
60.1.6 Access
60.1.7 Wells within 2500 L.F. of facility
60.1.8 Groundwater quality background data

60.2 Scaled drawing with 2-foot elevation contours showing the preliminary site layout including:

60.2.1 Preapplication treatment facility
60.2.2 Storage pond(s)
60.2.3 Spray fields

60.2.4 Buffer zones
60.2.5 Soil investigation locations
60.2.6 Access roads and utilities
60.2.7 Watercourses
60.2.8 Monitor well locations
60.2.9 Drainage structures
60.2.10 Flood elevations
60.2.11 Residences and habitable structures within or contiguous to the site

60.3 Design wastewater characteristics, influent to preapplication treatment facility and treated effluent to spray fields (specific industrial-type wastewaters and some vegetation management schemes may require different or additional characterization):
60.3.1 Average and peak daily flows
60.3.2 Biochemical Oxygen Demand (for preapplication facility management)
60.3.3 Chemical Oxygen Demand (for land treatment system management)*
60.3.4 Total Organic Carbon
60.3.5 Total Suspended Solids
60.3.6 Ammonia, Total Kjeldahl and Nitrate and Nitrite Nitrogen
60.3.7 Total Phosphorus
60.3.8 Chloride
60.3.9 Sodium Adsorption Ratio (when appropriate)
60.3.10 Electrical Conductivity
60.3.11 Metals
60.3.12 Priority Pollutants**
60.3.13 pH

60.4 Detailed Soil Investigation Report (reference Table 202-2).
60.5 Water Balance/determination of design wastewater loading(s).
60.6 Nitrogen Balance/selection of cover crop and management scheme.
60.7 Phosphorus and other constituent loading rates60.8Determination of land limiting constituent (LLC).
60.9 Determination of wetted field area(s) and required storage volume.
60.10 Process design for preapplication treatment facility.
60.10.1 Schematic of pump stations and unit processes
60.10.2 Basin volumes, loading rates, hydraulic detention times, storage capacities, etc.
60.10.3 Capacity of pumps, blowers and other mechanical equipment
60.11 Groundwater and Effluent Monitoring Plan
60.12 Proposed trust indenture for Department approval (for private domestic wastewater irrigation systems)
60.13 *Chemical Oxygen Demand or Total Organic Carbon may be substituted for industrial wastewaters where appropriate.
60.14 **Priority pollutant analysis is required for all industrial wastewaters and municipal wastewater systems that receive industrial process wastes. The analyses required depend on the particular process wastewater being discharged and will be determined on a case-by-case basis. However, in all cases the presence of industrial process wastewaters must be identified. A current listing of the 126 priority pollutants can be found by referencing 40 CFR Part 423, Appendix A, 1987.
60.15 All design calculations must be submitted. Details and an example of the determination of needed land area and site life are given in the Guidance Section for Slow Rate Land Treatment and in Subsection 703, Example Calculations.

THIS TABLE IS NOT AN EXHAUSTIVE LISTING OF ALL REQUIREMENTS FOR OBTAINING A SPRAY IRRIGATION PERMIT. PLEASE REVIEW ALL PARTS OF THESE REGULATIONS PRIOR TO SUBMISSION OF A DDR.

61.0 Table 202-2 Detailed Soil Investigation Report Information

61.1
61.1.1 Site description:
61.1.2 Location map
61.1.3 Topographic map
61.1.4 Soil Survey map
61.1.5 Site soil investigations

61.2 Soil series descriptions (each soil series present).
61.2.1 Texture
61.2.2 Permeability
61.2.3 Slope
61.2.4 Drainage
61.2.5 Depth to seasonal high water table
61.2.6 Depth to bedrock
61.2.7 Erodibility
61.3 Soil characteristics (each soil series present):
61.3.1 Soil investigations:
61.3.1.1 Soil horizons
61.3.1.2 Depth to groundwater
61.3.1.3 Depth to impermeable strata
61.3.2 Unified Soil Classification
61.3.3 Saturated hydraulic conductivity (restrictive horizons)
61.3.4 Soil chemistry:
61.3.4.1 pH
61.3.4.2 Cation exchange capacity
61.3.4.3 Percent base saturation
61.3.4.4 Phosphorus adsorption
61.3.4.5 Nutrients (N,P,K)
61.3.4.6 Characterization of metals and minerals
61.3.5 Engineering properties of soils proposed for pond construction
61.4 Identification of subsurface conditions adversely affecting vertical or lateral drainage of the land treatment site.
61.5 Delineation of soils and areas suitable and not suitable for wastewater irrigation.
61.6 Determination of design percolation.

62.0 Required Design Considerations

62.1 Suitability of Sites for Wastewater Irrigation
62.1.1 Location
62.1.1.1 There are two, often contradictory, requirements for slow rate land treatment sites: proximity to the wastewater source and a large tract of suitable land. Additional considerations are a moderate degree of isolation, ease of access, availability of utilities and protection from flooding. Wastewater irrigation systems can be developed on agricultural land and forests. The Department will also consider wastewater irrigation of golf courses, cemeteries, green areas and parks. Special preapplication treatment requirements may apply to such systems (see subsection 64.7.2.2 and 64.7.2.3).

62.2 Topography
62.2.1 Due to equipment limitations and erosion potential, maximum slopes for wastewater spray fields are generally limited to 7 percent for row crops, 15 percent for forage crops and 30 percent for forests. Sloping sites are preferred over flat sites because lateral subsurface drainage occurs which makes ponding and extended saturation of the soil less likely. Depressions must be carefully evaluated in the design.

62.3 Soils
62.3.1 In general, soils with a USDA Soil Conservation Service permeability classification of moderately slow (.02 to 0.6 inches/hour) or more are suitable for wastewater irrigation. However, groundwater and drainage conditions must also be suitable. Soils which are poorly drained, have high groundwater tables or restrictive subsurface soil layers are generally not suitable for slow rate treatment without drainage improvements.

62.4 Hydrogeology
62.4.1 Hydrogeologic characteristics of the site shall be investigated by a Professional Geologist registered in the State of Delaware and submitted as part of the design report. This information can be obtained from published literature or from on-site field investigations. The hydrogeologic report shall contain a description of the geologic and hydrogeologic characteristics of the site including:
62.4.1.1 Stratigraphy;
62.4.1.2 Lithology of the water table aquifer;

62.4.1.3 Hydrologic properties of the water table aquifer, including horizontal and vertical hydraulic conductivity, groundwater flow gradient, water table elevations, and a determination of the depth to seasonal high groundwater table including an estimate of seasonal variations;

62.4.1.4 Elevation interval and lithology of the uppermost, laterally extensive confining unit;

62.4.1.5 Lithology, elevation interval and hydrologic properties of the uppermost confined aquifer;

62.4.1.6 Identification of any facilities, such as nearby high capacity irrigation wells, that do or may potentially influence groundwater flow characteristics;

62.4.1.7 An assessment of the effects on groundwater flow at the land treatment site, if any, that may be caused by nearby activities;

62.4.1.8 Identification of any activities adjacent to the land treatment site which do or may potentially contaminate groundwater at the land treatment site, and a description of such activities and associated potential contaminants.

63.0 Soil Investigations

63.1 General

63.1.1 Each design development report shall include a detailed soils investigation report which contains details on the field investigations conducted by a person who is registered as a Professional Soil Scientist with the American Registry of Certified Professionals in Agronomy, Crops and Soils (ARCPACS) depicting soils conditions on the site. Soil investigations for land treatment differ greatly from investigations for foundations, road and other civil engineering works. As a result, different investigative and testing methods are required. The land treatment soil investigation must characterize the permeability and chemical properties of the surface 5 to 10 feet of the soil profile. It must verify Soil Conservation Service soil mapping. It must also determine the elevation of the seasonal high groundwater, establish the groundwater flow direction and gradient, and identify any subsurface conditions which may limit the vertical or lateral drainage of the land treatment site. The number of soil samples necessary to supply all of this information will be dependent on the nature of the particular site. As a minimum however, the Department requires that at least one sample be taken for every 5 to 10 acres of each soil series to confirm the Soil Conservation Service mapping and to provide a sufficient number of undisturbed soil samples. The specific information required for design is outlined in Table 202-2.

63.2 Saturated Hydraulic Conductivity Testing

63.2.1 Saturated vertical hydraulic conductivity testing is required for the most limiting horizon (i.e., horizon with lowest saturated conductivity) of each major soil series present. The most limiting soil horizon shall be determined from soil survey information and on-site observations. A minimum of three (3) tests for each major soil series shall be performed. These test results will be compared with the values published by SCS. If the values are not comparable, additional testing is recommended. Testing for saturated horizontal hydraulic conductivity may be necessary when subsurface drainage systems are planned or when lateral subsurface drainage is the predominant drainage mechanism for the land treatment site. Less intensive conductivity testing may be conducted when hydraulic loading is much less than site capacity.

63.2.2 Acceptable methods for saturated hydraulic conductivity testing are listed in Table 302-1. Field testing is preferred over laboratory testing methods. The Department will accept laboratory approaches only when field testing is not possible. Percolation tests as performed for septic tank drain fields are not acceptable.

63.2.3 Use of the hydraulic conductivity values to determine design percolation rates is discussed in Section 3.0.

63.3 Soil Chemical Testing.

63.3.1 The pH, cation exchange capacity, phosphorus adsorption and percent base saturation, of each soil series must be determined from samples taken from the A and B horizons. These chemical tests determine the retention of wastewater constituents in the soil and the suitability of the soil for different cover crops. A minimum of three (3) samples for each major soil series shall be taken. Testing for soil nutrients (nitrogen, phosphorus and potassium) and agronomic trace elements shall be included if appropriate for the vegetative management scheme.

63.3.2 Soil chemical testing should be in accordance with Methods of Soil Analysis published by the American Society of Agronomy, Madison, Wisconsin. Other methods, properly documented, may be accepted upon approval by the Department.

64.0 Table 302-1 Hydraulic Conductivity Test Methods

64.1 Saturated Vertical Hydraulic Conductivity[a]

64.1.1 Laboratory Tests[b]:

Constant Head Method	ASTM D 2434-68
(coarse grained soils)	AASTHOT 215-70
	Bowles (1978), pp 97-104
	Kezdi (1980), pp 96-102
Falling Head Method	Bowles (1978),pp 105-110
(cohesive soils)	Kezdi (1980), pp 102-108

64.1.2 Field Tests:

Cylinder Infiltrometer	Boersma (1965)
	U.S. EPA (1981),pp 3-17 to 19
Double Tube Method	Bower (1966)
	U.S. EPA (1981), pp 3-24 to 3-27
Air-Entry Permeameter	Bower (1966)
Method	Reed and Crites (1984), pp 176-180 Topp and Binns (1976) U.S. EPA (1981), pp 3-24 to 3-27

64.2 Saturated Horizontal Hyraulic Conductivity[d] S

64.2.1 Field Tests:

Auger Hole Method[c]	Reed and Crites (1984), pp 165 to 168
	U.S. EPA (1984), pp 3-31 to 35
Slug Test	Bouwer and Rice (1976)

64.3 [a]Other methods, properly documented, may be accepted by the Department. However, "standard" percolation tests as performed for septic tank drain fields are not acceptable. Basin flooding tests are appropriate only to design of rapid infiltration systems.

64.4 [b]These tests require undisturbed" field samples properly prepared to insure saturation. Reconstructed field samples are not acceptable. A description of the field sampling technique should accompany the laboratory testing results.

64.5 [c]Methods recommended by the Department.

64.6 [d]Testing for saturated horizontal hydraulic conductivity is required at land treatment sites where drainage improvements are planned and where lateral, as opposed to vertical subsurface drainage, is the predominant drainage pathway.

64.7 Preapplication Treatment Requirements

64.7.1 General

64.7.1.1 Wastewater irrigation systems have a demonstrated ability to treat high strength organic wastes to low levels. However, such systems require management with particular attention paid to organic loading rates and aeration of the soil profile between wastewater applications.

64.7.1.1.1 The Department requires that all wastewaters containing domestic wastes receive biological treatment prior to irrigation. This is necessary to:

64.7.1.1.2 Protect the health of persons contacting the irrigated wastewater, and

64.7.1.1.3 Reduce the potential for odors in storage and irrigation.

64.7.1.1.4 Most industrial wastes will require some pretreatment but some may be suitable for direct land treatment by irrigation. The Department will evaluate such systems on a case-by-case basis.

All industrial system Design Development Reports must contain copies of work place chemical lists. This information will aid the Department and the applicant in evaluating potential problems with a land treatment system. The principal criteria to be considered by the Department to not require pretreatment will be a demonstration that odors and nuisance conditions and adverse impacts to groundwater or soil such as clogging and runoff, will not occur.

64.7.2 Wastewater Reclamation Standards for domestic and municipal wastewater for BOD, TSS, and Disinfection, Based on Site Access Control.

64.7.2.1 The primary water quality objective for any reclaimed wastewater spray irrigation project is to prevent the spread of waterborne diseases while also preventing environmental degradation of the site and surrounding areas. Protection of public health can be achieved either by limiting public access to the site or by reducing the concentration of pathogenic bacteria and enteric viruses in the reclaimed wastewater. In cases where public access cannot be restricted, such as landscaped areas, golf courses, parks, and roadway medians, levels of wastewater pretreatment need to be increased in order to assure comparable public health safeguards exist. Epidemiological studies performed at domestic wastewater spray irrigation reclamation sites have shown that reclaimed wastewater treated to advanced levels with reduction of entritic viruses below detectable levels pose no ascertainable risks to public health. Based on these findings, the Department has established the following pretreatment requirements based on the level of site access control to be provided.

64.7.2.1.1 Restricted Public Access Sites (See subsection 73.2)

64.7.2.1.1.1 Restricted public access sites are sites where access to the site by the public is controlled and only accessible to authorized operators and farm personnel. All wastewater must be treated to a 5-day biochemical oxygen demand of 50 mg/L at average design flow and 75 mg/L under peak loads. Total suspended solids are limited to 50 mg/L for mechanical systems and 90 mg/L for ponds. Disinfection is required to yield a discharge not to exceed 200 colonies/100 mL fecal coliform at all times. Disinfection requirements may be waived when wastewater is irrigated in remote or restricted use sites such as forests.

64.7.2.2 Limited Public Access Sites

64.7.2.2.1 Limited public access sites are landscaped areas where public access is limited to specific periods of time and buffer zones pursuant to subsection 311 can be maintained to property boundaries and surface waters. Spray irrigation activities shall be limited to those periods of time when the public is effectively excluded from accessing the site. All wastewater irrigated on limited access sites must not exceed a 5-day biochemical oxygen demand of 30 mg/L. Total suspended solids are limited to 30 mg/L. Disinfection to reduce fecal coliform bacteria to 200 colonies/100 mL is required.

64.7.2.3 Unlimited Public Access Sites

64.7.2.3.1 Unlimited public access sites are those landscaped areas such as golf courses, residential lawns, cemeteries, parks, and highway medians which may not have adequate buffer zones and which are accessible to the public at all times. An example is the typical residential golf course community where private homes abut the fairways and greens, and the public cannot effectively be excluded from accessing the site during spray irrigation.All wastewaters used for irrigation of unlimited access sites must be pretreated to advanced limits with high- level disinfection. The advanced treatment system shall include the following processes: oxidation,clarification, coagulation, flocculation, filtration, and disinfection.The wastewater shall not contain more than ten (10(c) mg/L total suspended solids, and turbidity shall not exceed five (5(c) TU. 5-day biochemical oxygen demand shall not exceed ten (10(c) mg/L, and the wastewater must be disinfected to reduce fecal coliforms to a level below 20 colonies/100 mL.

64.7.3 Nitrogen

64.7.3.1 Maximum nitrogen removal occurs when nitrogen is land applied in the ammonia or organic form. Nitrate is not retained by the soil and leaches to the groundwater, especially during periods of dormant plant growth. Therefore, the preapplication treatment system should not produce a nitrified effluent.

64.7.3.2 The Department recommends that aerated or facultative wastewater stabilization ponds be used for preapplication treatment where possible. These systems generally produce a low-nitrate effluent well suited for wastewater irrigation. When mechanical plants are employed for preapplication treatment, they should be designed and operated to limit nitrification.

64.7.3.3 The Design Development Report shall indicate the expected range of nitrogen removal in the preapplication treatment system. Predictive equations for nitrogen removal in facultative wastewater stabilization ponds have been developed by Pano and Middlebrooks (1982), and Reed (1985).

64.7.4 Pretreatment Systems and Storage Ponds

64.7.4.1 Pretreatment may consist of mechanical or pond-type systems. All systems must have provisions for storage either as a separate facility or incorporated into the pretreatment system if the efficiency of treatment is not compromised. Pretreatment ponds may be aerated, facultative or a combined aerated/facultative system. The storage pond and the irrigation pump station must be designed such that pumping does not affect the design hydraulic detention time. The Department recommends the United States Environmental Protection Agency's October 1983 Design Manual: Municipal Wastewater Stabilization Ponds as a reference for design of preapplication treatment ponds.

64.7.4.2 Ponds used for preapplication treatment and storage must have impermeable liners. Facultative pond cells should have an appropriate length to width ratio consistent with current practice to minimize short circuiting with a depth between 3 and 5 feet. Sizing of completely and partially mixed aerated ponds should be based on first-order removal rate kinetic equations and the expected annual temperature variation. Adequate freeboard is required for all ponds to contain excess rainfall and wastewater flows.

64.7.4.3 Treatment facilities for wastewater to be used on unlimited access sites shall include continuous on-line monitoring for turbidity before application of the disinfectant. Continuous on-line monitoring of residual disinfection concentrations, shall be provided at the compliance monitoring point for limited and unlimited access sites. The permittee shall develop and submit for the Department's review and approval, an operating protocol designed to insure that the high-level disinfection criteria will be met before the wastewater is released to the storage impoundment system or to the wastewater reuse system. Automatic diversion of wastewater that fails to meet the operating criteria shall be established in the operating protocol. Such diversions shall be to a reject wastewater storage system. Increased reject wastewater storage capacity shall be provided if needed.

64.7.4.4 Reclaimed wastewater that fails to meet the criteria established in the operating protocol shall not be discharged into the storage impoundment system or to the reuse system. Such substandard wastewater (reject wastewater) shall be either stored in a separate off-line system for subsequent additional treatment, or shall be discharged to another permitted reuse system requiring lower levels of pretreatment, or to a permitted effluent disposal system.

65.0 Soil and Cover Crop Compatibility

Inorganic constituents of effluent from preapplication treatment must be compared with Table 303-1 to insure compatibility with land treatment site soils and cover crops. IN NO CASE SHALL THE CUMULATIVE METAL LOADINGS EXCEED THE LEVELS SET FORTH IN TABLE 2 OF THE GUIDANCE. THE APPLICANT SHALL UTILIZE TABLE 2 IN CONJUNCTION WITH TABLE 303-1 TO CALCULATE THE SITE LIVES FOR THE CONSTITUENT METALS(r)

66.0 Protection of Irrigation Equipment

Prior to pumping to the spray field distribution system, consideration must be given to removal of materials which might clog distribution pipes or spray nozzles. Screening to remove solids greater than one-third (1/3(c) the diameter of the smallest sprinkler nozzle is recommended by some sprinkler manufacturers. If screens are necessary, screenings should be captured and removed for disposal (method of disposal must be described in detail in DDR).

67.0 Determination of Design Percolation Rates

67.1 General

67.1.1 An important step in the design of a slow rate land treatment system is development of a "design percolation rate" from results of the site hydraulic conductivity evaluations. This value is used in water balance calculations to determine design wastewater loading(s(c) and thus spray field area requirements. The percolation rate is a function of soil permeability and site drainage.

67.2 Design Values

67.2.1 The restrictive saturated hydraulic conductivity of each soil series must be identified. Any subsurface conditions which limit the vertical or lateral drainage of the soil profile must also be identified. Examples of such conditions are shallow impermeable strata, high water table and extremely anisotropic soil permeability. Values of saturated vertical hydraulic conductivity from soil testing are used to develop the design percolation rate.

68.0 Table 303-1 Assessment Criteria For Inorganic Constituents in WasteWater Applied to Land (U.S. EPA, 1976 and 1981)

68.1

Potential Problem and Constituent	No Problem	Increasing Problem	Severe
pH (std. units)	5.5 - 8.4		<5.0 <9.0
Sodium Adsorption Ratio[a]	< 5.0	5.0-9.0	> 9.0
Electrical Conductivity[b] (mmho/cm @ 25°C)	< 2-4	4-8	8->12
Bicarbonate (meq/L) (mg/L as CaCO3)	1.5 < 150	1.5-8.5 150-850	>8.54 > 850
Chloride (meq/L) (mg/L)	< 3.0 < 100	> 3.0 > 100	> 10 > 350
Fluoride (mg/L)	< 1.8		
Ammonia (mg/L as N)	> 5.0	5.0 - 30	> 30
Sodium (meq/L) (mg/L)	<3.0 <70	>3.0 >70	9.0 210
Trace Metals (mg/L):			
Aluinum	<10		
Arsenic	<0.2		
Beryllium	<0.2		
Boron	<0.5	0.5-2.0	>2.0
Cadmium	<0.02		
Chromium	<0.2		
Cobalt	<0.1		
Copper	<0.4		
Iron	<10		
Lead	<10		
Lithium	<2.5		
Manganese	<0.4		
Molybdenum	<0.02		
Nickel	<0.4		
Selenium	<0.04		
Zinc	<4.0		

[a]Sodium Adsorption Ratio - $\frac{Na+^{1}}{SQR\ [(Ca+^{2}+ Mg+^{2})/2\ ]}$

Where, $Na+^{1}$ Ca+2 and $Mg+^{2}$ in the wastewater are expressed in milliequivalents per liter (meq/L). SQR represents 'square root of'.

[b]Severity of problem related to salt tolerance of the crop.

68.2 Values of saturated vertical hydraulic conductivity must be modified by an appropriate safety factor to determine design percolation. The safety factor reflects the influence of several elements including: the fact that long periods of saturation are undesirable, the uncertainty of test values, the drainage characteristics of the land treatment site, the variation of permeability within and between different soil series, the rooting habits of the vegetation, soil reaeration factors, and potential long- term changes in soil permeability due to wastewater application.

68.3 The Department requires that the design percolation rate at land treatment sites with seasonal high groundwater at depths greater than 5 feet (after consideration of mounding due to wastewater irrigation(c) be

no more than 10 percent of the mean saturated hydraulic conductivity of the most limiting layer within the first five feet from the surface. Sites with seasonal high groundwater less than 5 feet deep shall be evaluated as to need for the drainage improvements before they are utilized for slow rate land treatment. The design percolation at such sites is a function of the design of the drainage system and the hydraulic conductivity of the most limiting layer above the drain depth.

68.4 The percentage reduction in mean hydraulic conductivity to specify the design percolation rate should be reduced for variable or poorly defined soil conditions. The percentage to be used is a judgement made by the designer after consideration of all site physical, climate, and vegetation management factors. Refer to the EPA Process Design Manual (EPA 1981) for additional discussion of design percolation rate selection.

69.0 Determination of Design Wastewater Loading(s)

69.1 General. The design wastewater loading is a function of:

69.1.1 Precipitation

69.1.2 Evapotranspiration

69.1.3 Design percolation rate

69.1.4 Nitrogen loading and other constituent loading limitations

69.1.5 Groundwater and drainage conditions

69.1.6 Average and peak design wastewater flows and seasonal fluctuations

69.1.7 Therefore, developing the design wastewater loading is an iterative process.An initial value is selected from water balance calculations and used to determine wetted field area.

69.1.8 This loading is then compared to nitrogen and other constituent loading limitations (reference Subsection 308). If the initial value exceeds these limitations, the design wastewater loading is reduced and the process is repeated. This iterative process is illustrated in Subsection 700.

69.1.9 The Department limits design wastewater loadings to a maximum of 2.5 inches/week and instantaneous wastewater application rates to 0.25 inches/hour. Requests for higher loadings will be evaluated on a case- by-case basis. The design wastewater loading may be fixed at a constant rate or may vary monthly but it must account for site specific wastewater flow, climatic, drainage and vegetation management limitations.

69.2 Water Balance

69.2.1 Maximum allowable monthly wastewater loadings are determined from the following water balance equation:

$$D(allowed) = (Evap + Perc) - Precip \qquad \text{eq. 307.2.}$$

Where,

D(allowed) = Maximum allowable hydraulic wastewater loading (in/month).

Evap = Potential evapotranspiration (in/month)

Perc = Design percolation rate (in/month):

Precip = Design precipitation (in/month).

69.2.2 Example water balance calculations are presented in Section 700. From these, critical water balance months, i.e(r) months with the smallest allowable hydraulic wastewater loading, are identified.

69.3 Potential Evapotranspiration

69.3.1 Reliable field data for evapotranspiration are difficult to obtain. Therefore, values for average monthly potential evapotranspiration generated from vegetative, soil and climatological data are used in water balance calculations. A list of evapotranspiration references is presented in Subsection 603. For row crops, the Department recommends use of the modified Penman Method calibrated for local conditions. For forage and forested systems, or when data for other methods are not available, the Thornthwaite equation is preferred. The Thornthwaite equation and values for all US Weather Service long-term stations are presented in the Appendices.

69.3.2 The method used to estimate average monthly potential evapotranspiration for water balance calculations must be referenced in the Design Development Report.

69.4 Five-Year Return Monthly Precipitation

69.4.1 The Department requires the use of five-year return, monthly precipitation values in water balance calculations. Five-year return values are defined as the 80th percentile value in a 30-year ranked listing of historical monthly precipitation data. This corresponds to:

Precip(avg) + (0.85 x std. dev. eq. 307.4

Where,

Precip(avg) = 1/2 Average monthly precipitation from 30 or more years historic record

std. dev. = Standard deviation for same.

69.4.1 Factoring design precipitation into the water balance equation for winter months must consider conditions such as form of precipitation, soil freezing, etc. Wastewater not irrigated must be stored.

69.4.2 Records of both monthly precipitation and temperature are available for all of Delaware from the National Climatological Center of the National Oceanic and Atmospheric Administration in Asheville, North Carolina. The source of precipitation data used for design must be referenced in the Design Development Report. Mean and design precipitation values for each of the US Weather Service long-term stations in Delaware are presented in Table 702-3.

70.0 Nitrogen Balance/Cover Crop Selection and Management

70.1 General

70.1.1 Nitrate concentration in percolate from wastewater irrigation systems must not exceed the state drinking water standard of 10 mg/L. Percolate nitrate concentration is a function of nitrogen loading, cover crop, management of vegetation and hydraulic loading. The design wastewater loading determined from water balance calculations must be checked against nitrogen loading limitations. If for the selected cover crop and management scheme, the proposed wastewater loading results in estimated percolate nitrate concentrations exceeding 10 mg/L, either the loading must be reduced or a cover crop with a higher nitrogen uptake must be selected.

70.2 Nitrogen Balance

70.2.1 Percolate nitrate concentrations are estimated from a monthly nitrogen balance based on the average design wastewater loading, proposed cover crop, and cover crop management scheme.Example nitrogen balance calculations are presented in Section 7.0.

70.2.2 In nitrogen balance calculations, all nitrogen not lost to denitrification, ammonia volatilization or plant uptake is assumed to leach into the groundwater as nitrate. For row and forage crop systems, assumed losses to denitrification should not exceed 15 percent of the total nitrogen applied. In forest systems, assumed denitrification losses should not exceed 25 percent. (Forest denitrification losses may be greater because more carbon is generally available in forests and the hydraulic loading rate can often be greater.(c) Assumed losses to ammonia volatization should not exceed 5 percent of the total ammonia applied. Some industrial wastes with high pH may experience higher rates of ammonia volatilization. Soil storage of nitrogen should be assumed to be zero. The Department recommends Tables 4-11 and 4-12 of the United States Environmental Protection Agency's October 1981 Process Design Manual: Land Treatment of Municipal Wastewater" for guidance in selecting cover crops and their nutrient uptake rates. For forests, the most recent estimates of nitrogen uptake are presented in Cole, Henry, and Nutter (1986), Forest Alternative for Land Treatment of Municipal and Industrial Wastes. In all cases, the source of the plant nitrogen uptake rate used for design must be referenced in the Design Development Report.

70.3 Cover Crop Selection and Management

70.3.1 Row crops may be irrigated with wastewater containing domestic waste only when not intended for direct human consumption. Forage crops irrigated with domestic wastewater must be harvested before feeding to livestock. Unmanaged, volunteer vegetation (i.e. weeds) is not an acceptable spray field cover. Disturbed areas in forest systems must be initially grassed and replanted or covered with a thick mulch for succession to forest vegetation.

70.3.2 Spray field cover crops require management and periodic harvesting to maintain optimum growth conditions assumed in design. Forage crops must be harvested and removed at least several times annually. Pine forest systems should be harvested at 20 to 25 year intervals. Hardwood forest systems

should be harvested at 40 to 60 years. It is recommended that whole tree harvesting be considered to maximize nutrient removal. However, due to soil exposure and compaction as a result of the harvesting activities, wastewater loadings must be reduced until the hydraulic capacity of the site is restored. Spray field area to allow for harvesting and the regeneration cycle should be considered in design.

70.3.3 Many wastewaters are usually deficient in some of the essential fertilizer elements needed for vigorous agronomic cover crop growth. High growth rate forage crops may require supplemental fertilizer addition to maintain nutrient uptake rates assumed in design. Industrial wastewaters considered for irrigation should be carefully evaluated for their plant nutrient values.

71.0 Phosphorus and Other Constituent Loading Rates

71.1 Annual loading rates and site life limitations must be determined for phosphorus and other constituents present in the wastewater, since there is a potential that any one of these constituents may limit the site life of the facility.

71.2 Phosphorus present in the wastewater is removed primarily through adsorption and precipitation reactions in the soil profile and through plant uptake. The soil profile can be considered to have a finite phosphorus adsorption capacity associated with each layer. However, there is the potential that the adsorption capacity of the entire soil profile may eventually reach saturation and soluble phosphorus will appear in the percolate. As a result of this, phosphorus may become the land limiting constituent (LLC) over time. Conditions which may indicate that phosphorus has become the LLC include: 1) A rise in phosphorus concentrations as indicated by groundwater monitoring well test results over three consecutive sampling periods, or 2) Phosphorus adsorption test results indicate that the phosphorus adsorption capacity of the site has decreased to a level at which the adsorption capacity of the site is no longer sufficient to assimilate excess phosphorus not taken up by the vegetation. Once phosphorus has become the LLC the phosphorus application rate must be reduced to crop uptake levels. Under such conditions, high phosphorus utilization vegetation may be grown to increase the phosphorus assimilative capacity.

71.3 The site assimilative capacity for heavy metals must be determined on a constituent by constituent basis to determine the site life for a facility. The number of years wastewater may be applied to a site shall be based on the allowable cumulative metal loading rates (values) established in Table 2 of the Guidance. Spray irrigation activities shall be terminated when any one of the cumulative metal limits is reached.

72.0 Storage Volume

72.1 Municipal systems may normally require 45 to 60 days storage to provide maximum flexibility in system operation, while industrial systems generally need less storage. For those facilities where it is practical to halt the generation of wastewaters minimal storage volumes can be designed. At a minimum, the Department requires at least 15 days storage unless other measures for controlling flow are demonstrated in the system design. The Department may reduce storage requirements upon a showing that unusual waste characteristics or operating conditions warrant such a reduction without adverse impact to the environment.

72.2 A separate off-line system for storage of reject wastewater shall be provided at all limited and unlimited access sites, unless another permitted reuse system or effluent disposal system is capable of receiving the reject wastewater. Reject wastewater storage shall have sufficient capacity to ensure the retention of wastewater of unacceptable quality. At a minimum, this capacity shall be the volume equal to two (2) days flow at the average daily design flowrate of the pretreatment facility. Provisions for recirculating this reject wastewater to other parts of the pretreatment facility for further treatment shall be incorporated into the design of the facility.

The total storage volume required for wastewater irrigation systems consists of three (3) separate storage components such that:

Total Storage = Operational Storage

+

Wet Weather and Emergency Storage

+

Water Balance Storage eq. 310.1

72.3 These separate storage components are described in the Sections that follow.

72.3.1 Operational Storage

72.3.1.1 Operational storage is a design parameter. For example, many wastewater irrigation systems are designed to apply wastewater 5 days per week and store weekend flows. Facilities which harvest

cover crops on a frequent basis may stop irrigation to allow drying of the spray fields. Wastewater storage volume is required during these periods. Operational storage requirements are based on system management evaluations by the designer.

72.3.2 Inclement Weather and Emergency Storage

72.3.2.1 Inclement weather and emergency storage provides for periods of excess rainfall or snowfall, saturated and frozen soil conditions and equipment failure when wastewater cannot be applied. The Department has minimum requirements for inclement weather and emergency storage. These are necessary to insure reliability of the slow rate land treatment system.

72.3.2.2 The volume provided for inclement weather and emergency storage is determined as follows:

$$\frac{\text{Delta P} \times (30.4 \text{ days/month})}{D_{(\text{allowed}),\ \text{crit}}} \qquad \text{eq. 310.2}$$

Where,

Delta P = 30 year variation from 5-year return monthly design precipitation, reference Table 309-1 (in)

$D_{(\text{allowed}),\ \text{crit}}$ = Maximum allowable hydraulic loading in most critical water balance month, reference eq. 307.2 (in/month).

72.3.2.2.1 Table 310-1 DELTA P VALUES FOR DELAWARE NATIONAL WEATHER SERVICE CLIMATIC DIVISIONS[1]

Delaware Climatic Division	Delta P (inches)
Northern	2.9
Southern	2.1

72.3.2.2.1 [1]30 year variation from 5-year return monthly precipitation. Derived from National Oceanic and Atmospheric Administration historical rainfall data for Delaware.

72.3.3 Water Balance Storage

Water balance storage is a function of wastewater flow, wetted field area and the wastewater loading rate. Therefore, before the water balance storage volume can be determined, the actual rather than design wastewater loading rate (WLR), in in/wk, must be calculated. In order to calculate the WLR, the areas necessary to eliminate the operational and the wet weather and emergency storage volumes as well as the area necessary to treat a normal week's flow at the design loading rate must be calculated. Once the WLR has been calculated, the required monthly water balance storage is determined from water balance calculations and the following equation:

72.3.3.1WBS = D(potential) - D(allowed)eq. 310.3

Where,

WBS = Required water balance storage (in/month)

D (potential) = Potential wastewater loading (in/month); assumes all influent wastewater is applied to the spray fields

D(allowed) = Maximum allowable hydraulic wastewater loading (in/month); reference eq. 307.2

Example calculations of this type are presented in Section 700.

73.0 Determination of Wetted Field Area

73.1 The wetted field area is subdivided into individual spray fields. Effluent should be applied once or twice per week per field. This allows for aeration and drying of the soil profile. It must be demonstrated by the applicant that a zone of aeration suitable for the rooting zone of the vegetation will be reestablished between wastewater applications. The minimum zone of aeration is often selected as 2 feet but must be based on the vegetation grown.

73.2 The wetted field area is sized to adequately treat four volumes of water; the storage volumes discussed in Subsection 71.0 and seven days of the design average daily flow. In equation form, this relationship is represented as:

A(wetted) = A(ADF) + A(OP) + A(WW/E) + A(WB) eq. 311

Where,

A(wetted) = required wetted field area (acres)

A(ADF) = area (acres) necessary to treat seven days' average daily flows

A(OP) = area (acres) necessary to treat the operational storage (see subsect. 71.1)

A(WW/E) = area (acres(c) necessary to treat the inclement weather/emergency storage (see subsect. 71.2), acres

A(WB) = area (acres) necessary to treat the water balance storage (see subsect. 71.3)

73.3 The Department requires that sufficient area be provided so that the stored wastewater can be irrigated within a reasonable period of time such that system operation and future storage needs are not compromised.The necessary areas for treating the storage volumes are determined using the WLR corresponding to [D(allowed) crit].

73.3.1 Area for Average Daily Flow, A(ADF)

73.3.1.1The area necessary for distributing the average daily flow is calculated using the following formula:

A(ADF) = 7 days/wk x ADF, gal/day x (1 cf/7.48 gal) x (1 acre/43,560 sf) x 12 in/ft x 1/WLR, in/wk eq. 311.1

73.3.2 Area for Operational Storage, A(OP)

73.3.2.1Spray field area necessary for treating operational storage associated with a plan of operation which calls for spraying less than seven days per week is already provided in A(ADF). Thus, A(OP) should be calculated only for the other elements of operational storage. As mentioned above, the area is based on the critical month WLR and on eliminating the storage volume within a reasonable period of time.

A(OP) = (gal/wk x 7/90) x (1 cf/7.48 gal) x (1 acre/43,560 sf) x 12 in/ft x 1/WLR, in/wkeq. 311.2

73.3.3 Area for Wet Weather and Emergency Storage, A(WW/E)

73.3.3.1The wet weather and emergency storage volume is also to be eliminated within a 90 day period. Therefore, the equation for calculating A(WW/E) is the same as 72.2 with the wet weather and emergency storage volume substituted for the operational storage volume.

A(WW/E) = (gal/wk x 7/90) x (1 cf/7.48 gal) x (1 acre/43,560 sf) x 12 in/ft x 1/WLR, in/wkeq. 311.3

73.3.4 Area for Water Balance Storage, A(WB)

73.3.5 The equation to calculate the area necessary to eliminate the water balance storage within a 90 day period would be similar to 72.2 with the water balance storage volume substituted for the operational storage volume:

A(WB) = (gal/wk x 7/90) x (1 cf/7.48 gal) x (1 acre/43,560 sf) x 12 in/ft x 1/WLR, in/wkeq. 311.4

Example calculations of the wetted field area requirements are contained in Appendix B.

74.0 Buffer Zones, Public Access and Protection of Water Supply Wells

74.1 Buffer Zones

74.1.1 Buffer zones are required to protect the public from aerosol sprays. These zones should be maintained in forest, shrubs or other screening vegetation. Rights-of-way can be used as part of the buffer area. However, these rights-of-way must be exclusive with no possibility of development, and for highways, must be measured from the outer edge of the shoulder or edge of the highway if no shoulder.

74.1.2 The following minimum buffer zones around the irrigation site must be provided for restricted public access sites:

74.1.2.1A 150-foot buffer must be maintained between the edge of the wetted field area and all property boundaries and the shoulder of internal and external public roads.

74.1.2.2Internal roads that are closed to public use do not require buffer zones. However, wastewater irrigation on these roads is prohibited. Trails for access to irrigation equipment may be irrigated if runoff turnouts are provided to prevent runoff from the site.

74.1.2.3A 100-foot buffer is required between the wetted edge of spray fields and the edge of any perennial lake or stream. A 50-foot buffer is required between spray fields and the edge of any channelized, intermittent watercourse. If wastewater irrigation causes an intermittent watercourse to become perennial, the 100-foot buffer requirement will apply.

74.1.2.4Wetlands buffers will be determined on a case-by-case basis.

74.1.3 Lesser distances may be allowed if the designer can demonstrate that aerosols will be contained within the site and/or no threat to public health or the environment exists. The buffer zone requirements may be

increased when deemed necessary by the Department. Buffer zones for sites open to public access will be determined on a case-by-case basis, depending upon treatment levels and proposed use.

74.1.4 Buffer zones for unlimited public access sites such as golf courses, and cemeteries are not normally required but may be required in certain circumstances.

74.1.5 Buffer zones around pretreatment facilities should be designed for aerosol containment, noise abatement and nuisance control. These factors should be addressed in the facilities plan.

74.2 Public Access

74.2.1 Public access to the spray fields at restricted access sites shall be discouraged by posting signs and maintaining well vegetated buffer zones. Fencing of spray fields is not required. However, suitable barriers and access road gates shall be provided along property lines adjacent to residential and other developed areas. Fencing is required at preapplication treatment facilities, pump stations and holding ponds.

74.3 Protection of Water Supply Wells

74.3.1 The potential effect of wastewater irrigation on water supply aquifers is site specific and difficult to predict. Abandoned wells within the treatment site must be identified as well as all domestic wells within 1000 linear feet and irrigation, commercial, industrial, and public wells within 2500 linear feet (L.F.) of the land treatment site.[1] There must be a satisfactory demonstration (through an evaluation of the depth of the water supply aquifer, its gradient, the condition of the aquitard(s), the condition of existing water supply wells, and their capacity(c) that the LTS system will not have any adverse effect on those wells. Shallow and poorly constructed wells within the land treatment system will require abandonment and sealing.

75.0 Surface Drainage and Runoff Control

75.1 Drainage of storm runoff shall be considered in design. Spray fields must be protected against flooding, ponding and erosion. Runoff shall be channelized through or around the wastewater irrigation site. However, the collection and channelization of irrigated wastewater must be avoided. Direct application of wastewater to drainage ditches and seasonal watercourses is prohibited.

75.2 A properly designed and operated slow rate land treatment system will not produce direct runoff; i.e., all water applied will infiltrate into the soil profile. Thus, irrigation on frozen soils must not be practiced. Sites that experience direct runoff as a result of wastewater irrigation will be required to reduce hydraulic loading rates. Tailwater return systems may be required as a remedial action. Indirect runoff as a result of interflow, changes in slope, and shallow restrictive soil layers can be expected at some slow rate land treatment sites. Indirect runoff is acceptable when it is dispersed over a wide area. However, monitoring of streams affected by such indirect runoff shall be addressed in the Plan for Operations and Management.

76.0 Subsurface Drainage

76.1 General

76.1.1 Sites with a seasonal high water table less than 5 feet in depth, including groundwater mounding as a result of wastewater irrigation, may require drainage improvements to assure a desired zone of aeration for optimum wastewater treatment and plant growth. A minimum 2-foot depth for this zone shall be maintained at all times.

76.1.2 The Department recommends Section 16 of the USDA Soil Conservation Service National Engineering Handbook" and the 1983 publication Land Drainage" by Smedema and Rycroft as references for the design of drainage systems. In addition, the Soil Conservation Service in Dover, Delaware has available the DRAINMOD" computer program (Skaggs,)

76.1.3 [1]Name and address for domestic wells, all available information for all other wells. Well types are as defined in State of Delaware Regulations Governing the Construction of Water Wells. Information may be obtained (for a fee(c)) from Delaware Water User Data System (DWUDS) through the Department.

76.1.4 1980; Skaggs and Nassehzadeh-Tabrizi,1982). This is a comprehensive drainage design model for agricultural and wastewater irrigation systems.

76.2 Effluent Limits and Monitoring

76.2.1 Discharges from drainage systems for wastewater irrigation facilities fall under point source discharge rules and regulations that require a National Pollutant Discharge Elimination System (NPDES) Permit. The required quality of the discharge from the drainage system is dependent upon the receiving stream and will be determined on a case-by-case basis. Water quality monitoring of the drainage system discharges will be in accordance with NPDES permit requirements.

77.0 Distribution Systems and Construction

77.1 General

77.1.1 The Department recommends Section 15 of the USDA Soil Conservation Service National Engineering Handbook" and the 1983 publication Irrigation by the Irrigation Association as references for the design of slow rate wastewater distribution systems. Also recommended are material and installation standards of the American Society of Agricultural Engineers. Note that these publications were written for the design of supplemental irrigation systems. herefore not all material contained in these publications will be appropriate for systems intended to treat wastewater through spray irrigation.

77.1.2 Spray field pressure variation due to friction loss and static head for solid set, uniformly spaced systems should not exceed plus or minus 10 percent of the design spray nozzle pressure. If this criterion cannot be met, sprinkler head spacing and spray nozzle diameters should be adjusted or flow control valves be used to insure a uniform application depth. The use of pressure reducing or throttling valves to balance the distribution system should be avoided.

77.1.3 The use of secondary mist nozzles on impact sprinklers is not recommended. These nozzles tend to cause more frequent sprinkler freeze-up in winter.

77.2 Access, Flow Measurement, and Controls

77.2.1 The layout of spray fields and spray field roads should provide easy access for inspection and maintenance of the distribution system. Spray field access roads must be designed for all-weather use. Steep grades must be avoided. Irrigation on access roads is prohibited.

77.2.2 A flow recorder, in conjunction with chart recorder and totalizer, is required on the discharge of each irrigation pump station to measure the total volume of wastewater applied to the spray fields. If an automated system is chosen, it must include use of chart recorders to monitor system operation. Influent flow monitoring devices may be required for domestic facilities in order to evaluate treatment facility performance.

77.2.3 A low pressure detection system to automatically shut down irrigation pumps in the event of force main, submain or lateral blowout is required. A high pressure shut-off at the irrigation pump station should also be provided.

77.3 Freeze Protection

77.3.1 The Department requires that above ground piping systems drain when depressurized. Pipe drains shall discharge either to the spray fields or to the storage pond(s) and must not produce a runoff.

77.4 Construction Disturbance, System Start-up and Testing

77.4.1 Construction activities associated with distribution systems can greatly alter the infiltration rate of spray field soils. Construction disturbance within spray fields must be minimized.Excessive compaction of surface soils by construction equipment must be avoided.Regrading of pipeline trenches must match original contours.Subsidence of trench backfill must be repaired, as this promotes channelization of runoff and erosion.

77.4.2 In forested systems, it is necessary to grub only the pipe centerline. Excessive clearing and grubbing should be avoided. Clearing for above ground piping systems should involve only vegetation that will interfere with operation of the system. All areas disturbed by construction must be revegetated immediately. Sloped areas may require protection from erosion.

77.4.3 “The Manual for Erosion and Sediment Control in Delaware" published by the Division of Soil and Water Conservation should be used as a guide for erosion and sediment control during construction of slow rate land treatment systems.

77.4.4 Pressure testing of the irrigation force mains and laterals shall be conducted during installation to avoid damage to spray fields from reexcavation and repair. Extensive flushing is usually necessary to clear distribution system pipes of construction debris which will clog sprinkler nozzles. Care should be exercised to prevent erosion or flooding of the spray fields during pipeline flushing. Every effort should be made to keep trash and debris out of the distribution systems. Sprinklers and drain valves shall be checked for proper operation prior to installation.

77.4.5 Bare soil resulting from construction can tolerate only short periods of wastewater application before producing runoff. Irrigation of bare soil compacts the soil surface, reduces the infiltration rate, promotes erosion, and hinders the establishment of vegetation. In addition, the treatment capacity of bare soil is poor. Wastewater irrigation on bare soil is not allowed beyond what is necessary to establish a vegetative cover. Wastewater application at the design rate can begin only when a uniform vegetative cover has been established. Specifications for spray field construction must include a revegetation performance standard and this standard must be enforced.

77.4.6 The Department recommends that spray fields be constructed early in the project so a vegetative cover can be reestablished on disturbed areas before wastewater irrigation begins. Potable, ground or surface water may be used for distribution system testing and irrigation to establish vegetation. At least one

growing season may be necessary before newly constructed spray fields can accept the design wastewater loading. This start-up period must be considered in the design and operation of slow rate land treatment systems.

78.0 Criteria for Site Management

79.0 Operation and Management of Slow Rate Land Treatment Systems

As discussed in Section 204, the Department Land Treatment System (LTS) Permit incorporates a Plan of Operation and Management submitted by the owner or owner's engineer. This plan covers operation of both the spray fields and preapplication treatment facility. It provides a management scheme consistent with the basis of design outlined in the Design Development Report. Once accepted by the Department, the Plan of Operation and Management becomes the operating and monitoring guidebook for the slow rate land treatment system. A suggested outline for the scope of the Plan of Operation and Management is presented in the following Subsection 90.0.

80.0 Monitoring Requirements

80.1 General

80.1.1 There are at least two objectives for a monitoring program at a land application site. The first is to satisfy the permit requirements set by the Department. The second objective is to provide the data necessary to optimize the system's operation. The data to meet the second objective may or may not be the same as that required by the permit. The facility's Plan of Operation and Management shall address the data needs for optimum plant operation.

80.1.2 The sampling and analysis methods used for wastewater and groundwater must be in accordance with the most recent issue of Standard Methods for Examination of Water and Wastewater" published jointly by the American Public Health Association, the American Water Works Association and the Water Pollution Control Federation, and Methods for Chemical Analysis of Water and Wastes" published by the United States Environmental Protection Agency. Soil chemical testing must be in accordance with the Methods of Soil Analysis" published by the American Society of Agronomy. Other methods, properly documented by the applicant, may be utilized upon approval by the Department.

80.2 Preapplication Treatment Facility and Storage Pond(s)

80.2.1 Influent to the preapplication treatment system and treated effluent applied to the spray fields must be monitored. Parameters which may require monitoring under the system's permit include: influent flow, volume of water applied to the spray fields, BOD (influent and effluent), suspended solids (influent and effluent), fecal coliform bacteria, pH (influent and effluent), COD, TOC, ammonia nitrogen, nitrate nitrogen, total Kjeldahl nitrogen, total phosphorus, chloride, Na, K, Ca, Mg, metals, and priority pollutants. The parameters included in the permit monitoring requirements and the sampling frequency for those parameters will be determined on a case by case basis and will be dependent on site conditions. The designer shall propose a monitoring program based on preapplication facility and land treatment system management; emphasis shall be placed on those constituents identified as land limiting.

80.3 Groundwater

80.3.1 A system is required for monitoring the quality of groundwaters influenced by the slow rate land treatment system. These regulations require the operation of systems that will function according to their performance criteria without causing the State's groundwater resources to violate State or Federal Drinking Water Standards on an average annual basis.

80.3.2 The placement and screened interval of monitoring wells shall be determined based upon site specific hydrogeology.Minimum monitoring well requirements are as follows:

80.3.3 One well upgradient or otherwise outside the influence of the land treatment site for background monitoring.

80.3.4 One well within the wetted field area of each drainage basin intersected by the land treatment site.

80.3.5 Two wells downgradient of the wetted field area in each drainage basin intersected by the land treatment site.

80.3.6 One well upgradient and one well downgradient of the pond treatment and storage facilities in each drainage basin intersected by the land treatment site.

80.3.7 Monitoring wells must be constructed in accordance with the Department's "Guidelines for the Construction of Monitoring Wells". Protective casings or other barriers must be located around all monitor wells to protect them from damage by farm equipment or other vehicles. In addition, all monitor wells must be labeled as indicated in the design plans.

80.3.8 The Division's Water Supply Branch must be consulted for the design and construction of groundwater monitoring wells at slow rate land treatment sites. Permits are required for the installation of these wells.

80.3.9 Sampling of the groundwater under the LTS permit must be performed according to the Department's "Manual for Groundwater Sampling" or other Department-approved procedure and may require measurement of one or more of the following parameters: depth to groundwater, pH, COD, TOC, nitrate nitrogen, total phosphorus, electrical conductivity, chloride, fecal coliform bacteria, metals and priority pollutants. The parameters included in the permit monitoring requirements and the sampling frequency for those parameters will be determined on a case by case basis and will be dependent on site conditions. The permittee will be required to submit groundwater quality and water table elevation data on a periodic basis. The Department also encourages the installation and monitoring of soil water lysimeters within the wetted field area. These are useful as trend monitoring devices to identify problems before the groundwater system is affected.

80.4 Surface Water and Drainage Systems

80.4.1 When a perennial stream traverses or lies at the boundary of a slow rate land treatment site, water quality monitoring of this stream may be required. The parameters and frequency of monitoring will be specified as a special condition in the facility's LTS Permit. Sampling upstream and downstream of the wetted field area as well as flow measurement may be required.

80.4.2 As discussed in Subsection 75.0, land treatment systems incorporating drainage improvements that result in a point discharge to surface waters must obtain a National Pollutant Discharge Elimination System (NPDES) Permit. In addition to requiring a Plan of Operation and Management, the NPDES Permit will include effluent limits, monitoring parameters, and sampling frequencies for the drainage system. The intent of this monitoring is to insure complete renovation of the irrigated wastewater before discharge.

80.5 Soil

80.5.1 Representative soil samples from each major soil series within the wetted field area must be taken and analyzed according to the schedule in Table 402-1. Soil pH is an indicator of changes in soil chemistry. If soil pH remains constant, analysis of cation exchange capacity and percent base saturation is not required. If the soil pH changes by one unit, analysis of these parameters shall be required.

80.5.2 Wastewater irrigation systems receiving industrial process wastes may be required to monitor metals and priority pollutants in site soils and possibly vegetation. The parameters and frequencies will be determined on a case-by-case basis.

80.6 Rainfall and Climatic Data

80.6.1 Monitoring of daily rainfall and temperature at the land application site may be required depending on the criticalness of these factors to system management. Antecedent rainfall and soil moisture conditions can be correlated to provide an operating scheme for the wastewater irrigation system. Monitoring of wind speed and direction may also be required.

80.7 Table 402-1 MONITORING REQUIREMENTS, SOIL[a]

Parameter	Sampling Frequency
pH	Once per yea
Cation Exchange Capacity	If pH changesd
Percent Base Saturation	If pH changesd
Phosphorus Adsorption[b]	Once every 4 years
Metals and Priority Pollutants	Once per year

80.7.1 [a]Composite soil samples representing each soil series within spray fields. Soil samples should be taken at 15 to 30 inches depth. A minimum of one composite sample for every 10 to 20 acres of each soil series is required.

80.7.2 [b]At sites receiving high phosphorus loadings where percolate is likely to flow to a sensitive surface water, sampling frequencies will be determined on a case-by-case basis.

80.7.3 [c]For facilities receiving significant quantities of metals or priority pollutants, this analyses is required. For other facilities, frequency to be set on a case-by-case basis.

80.7.4 [d]More than one standard unit from pH of soil prior to the application of wastes.

81.0 Fees

82.0 Fee Schedule

The Department may establish a schedule of annual and/or one- time fees with respect to spray irrigation wastewater treatment facility construction and operation. This fee schedule may be revised from time-to-time after notice and opportunity for hearing.

83.0 Fee Payment

83.1 One-time fees shall be submitted to the Department at the time of application. Annual fees shall be submitted to the Department upon receipt of notice from the Department, or in accordance with the following fee payment schedule:

Fee Amount	Payment Schedule
Less than $1,000	Upon Receipt of notice from the Department
Between $1,000 and $10,000	Four equal quarterly payments
Over $10,000	Twelve equal monthly payments

83.2 The Department shall impose late charges at the rate of 1 percent per month, compounded, for any fee not received within 30 days of the due date.

83.3 Failure to pay fees shall constitute grounds for denial of subsequent applications for Permits, and revocation of previously issued permits involving spray-irrigated wastewater from the applicant.

84.0 Severability

If any part of these regulations, or the application of any part thereof, is held invalid or unconstitutional, the application of such part to other persons or circumstances and the remainder of these regulations shall not be affected and shall be deemed valid and effective.

85.0 References Cited in Text

85.1 Brady, N.C. 1974. The Nature and Properties of Soils, Eighth Edition. MacMillan: New York, New York.

85.2 Cole, D., C. Henry, and W. Nutter 1986. Forest Alternative for Treatment of Municipal and Industrial Wastes. University of Washington Press, Seattle. pp 520.

85.3 The Irrigation Association. 1983. Irrigation, Fifth Edition. Silver Spring, Maryland.

85.4 Metcalf and Eddy, Inc. 1979. Wastewater Engineering: Treatment Disposal and Reuse. McGraw-Hill: New York, New York.

85.5 Pano, A. and E.J. Middlebrooks. 1982. "Ammonia Nitrogen Removal in Facultative Wastewater Stabilization Ponds."Journal Water Pollution Control Federation. Vol. 54, No. 4. pp 344-351.

85.6 Reed, S.C. 1985. "Nitrogen Removal in Wastewater Stabilization Ponds." Journal Water Pollution Control Federation. Vol. 57, No. 1. pp 39-45.

85.7 Reed, S.C. and R.W. Crites. 1984. Handbook of Land Treatment Systems for Industrial and Municipal Wastes. Noyes Publications: Park Ridge, New Jersey.

85.8 Rich, L.G. 1980. Low Maintenance, Mechanically Simple Wastewater Treatment Systems. McGraw-Hill: New York, New York.

85.9 Skaggs, R.W. 1980. "Combination Surface-Subsurface Drainage Systems for Humid Regions." Journal of the Irrigation and Drainage Division. American Society of Civil Engineers. Irrigation and Drainage Division. Vol. 106, No. IR4. pp 265-283.

85.10 Skaggs, R.W. and A. Nassehzadeh-Rabrizi. 1982. "Drainage Systems for Land Treatment of Wastewater." Journal of the Irrigation and Drainage Division. American Society of Civil Engineers. Irrigation and Drainage Division. Vol. 108, No. IR3. pp 196-211.

85.11 Smedema, L.K. and D.W. Rycroft. 1983. Land Drainage: Planning and Design of Agricultural Drainage Systems. Cornell University Press: Ithaca, New York.

85.12 United States Department of Agriculture. National Engineering Handbook. Section 15: Irrigation. Soil Conservation Service. Washington, D.C.

85.13 United States Department of Agriculture. National Engineering Handbook, Section 16: Drainage of Agricultural Land. Soil Conservation Service. Washington, D.C.

85.14 United States Environmental Protection Agency. 1976. Land Treatment of Municipal Wastewater Effluents: Design Factors, Parts I and II. Technology Transfer Program. Cincinnati, Ohio.
85.15 United States Environmental Protection Agency. 1981. Process Design Manual: Land Treatment of Municipal Wastewater. (EPD 625/1-81-013) Center for Environmental Research Information. Cincinnati, Ohio.
85.16 United States Environmental Protection Agency. 1983. Design Manual: Municipal Wastewater Stabilization Ponds. (EPA 625/1-83-015) Center for Environmental Research Information. Cincinnati, Ohio.
85.17 Water Pollution Control Federation, American Society of Civil Engineers. 1977. WPCF Manual of Practice No. 8: Wastewater Treatment Plant Design. Washington, D.C.

86.0 Test Methods Cited in Text

86.1 American Association of State and Highway Transportation Officials.T 215-70 or latest revision.
86.2 American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1985. Standard Methods for the Examination of Water and Wastewater, 16th Edition. Washington, D.C.
86.3 American Society for Testing and Materials. D 2434-68 or latest revision: D 3385-75 or latest revision.
86.4 American Society of Agronomy. 1965. Methods of Soil Analysis, Part 1: Physical and Mineralogical Properties, Including Statistics of Measurement and Sampling. C.A. Black, editor. (ASA Monograph No. 9) Madison, Wisconsin.
86.5 American Society of Agronomy. 1982. Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties, Second Edition. A.L. Page, editor. (ASA Monograph No. 9) Madison, Wisconsin.
86.6 Boersma, L. 1965. "Field Measurement of Hydraulic Conductivity Above a Water Table." in American Society of Agronomy. Methods of Soil Analysis , Part 1. C.A. Black, editor. (ASA Monograph No. 9) Madison, Wisconsin. pp 234-252.
86.7 Bouwer, H. 1966. "Rapid Field Measurement of Air Entry Value and Hydraulic Conductivity of Soil as Significant Parameters in Flow System Analysis." Water Resources Research. Vol. 2. pp 729-738.
86.8 Bouwer, H. and R.C. Rice. 1967. "Modified Tube Diameters for the Double-Tube Apparatus". Proceedings Soil Science Society of America. Vol. 31. pp 437-439.
86.9 Bouwer, H. and R.C. Rice. 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells." Water Resources Research. Vol. 12. pp 423-428.
86.10 Bowles, J.E. 1978. Engineering Properties of Soils and Their Measurement. McGraw-Hill: New York, New York.
86.11 Kezdi, A. 1980. Handbook of Soil Mechanics, Volume 2: Soil Testing. Elsevier Scientific Publishing Company: New York, New York.
86.12 Reed, S.C. and R.W. Crites. 1984. Handbook of Land Treatment Systems for Industrial and Municipal Wastes. Noves Publications: Park Ridge, New Jersey.
86.13 Topp, G.C. and M.R. Binns. "Field Measurements of Hydraulic Conductivity with a Modified Air-Entry Permeameter." Canadian Journal of Soil Science . Vol. 56. pp 139-147.
86.14 United States Environmental Protection Agency.1979. Methods for Chemical Analysis of Water and Wastes. (EPA 600/4-79-020) Environmental Monitoring and Support Laboratory. Cincinnati, Ohio.
86.15 United States Environmental Protection Agency. 1981. Process Design Manual: Land Treatment of Municipal Wastewater. (EPD 625/1-81-013) Center for Environmental Research Information. Cincinnati, Ohio.

87.0 Evapotranspiration References

87.1 The Irrigation Association. 1983. Irrigation, Fifth Edition. Silver Springs, Maryland. Chapter V.
87.2 Veimeyer, F.J. 1964. "Evapotranspiration." in Chow, V.T. Handbook of Applied Hydrology. McGraw-Hill: New York, New York. Section 11.
87.3 United States Department of Agriculture. 1967. Irrigation Water Requirements. (Technical Release No. 21) Soil Conservation Service. Washington, D.C. (revised 1970).
87.4 Wright, J.L. 1982. "New Evapotranspiration Crop Coefficients". Journal of the Irrigation and Drainage Division. American Society of Civil Engineers. Irrigation and Drainage Division. Vol. 108, No. IR2. pp 57-74.
87.5 Wright, J.L. and M.E. Jensen. 1978. "Development and Evaluation of Evapotranspiration Models for Irrigation Scheduling".Transactions of the American Society of Agricultural Engineers. Vol. 21, No. 1. pp 88-96.
87.6 Subsection 604. Performance, Material and Installation Standards
87.7 American Society of Agricultural Engineers. Minimum Standards for Aluminum Irrigation Tubing. (ASAE S263.2) St. Joseph, Michigan.
87.8 American Society of Agricultural Engineers. Minimum Requirements for the Design, Installation and Performance of Sprinkler Irrigation Equipment. (ASAE EP264.2) St. Joseph, Michigan.
87.9 American Society of Agricultural Engineers. Procedure for Sprinkler Testing and Performance Reporting. (ASAE S298T) St. Joseph, Michigan.

87.10 American Society of Agricultural Engineers. Wiring and Equipment for Electrically Driven or Controlled Irrigation Machines. (ASAE S362.2) St. Joseph, Michigan.
87.11 American Society of Agricultural Engineers. Design, Installation and Performance of Underground Thermoplastic Irrigation Pipelines. (ASAE S376.1) St. Joseph, Michigan.
87.12 American Society of Agricultural Engineers. Specifications for Irrigation Hose and Couplings Used With Self-Propelled Hose-Drag Agricultural Irrigation Systems. (ASAE S394). St. Joseph, Michigan.
87.13 American Society of Agricultural Engineers. Safety for Self-Propelled, Hose-Drag Agricultural Irrigation Systems. (ASAE S395) St. Joseph, Michigan.
87.14 American Society of Agricultural Engineers. Electrical Service and Equipment for Irrigation. (ASAE S397T) St. Joseph, Michigan.

88.0 Additional References

88.1 Bohn, H.L., McNeal, B.L. and G.A. O'Connor. 1979. Soil Chemistry. John Wiley and Sons: New York, New York.
88.2 Bouwer, H. 1969. "Planning and Interpreting Soil Permeability Measurements." Journal of the Irrigation and Drainage Division. American Society of Civil Engineers. Irrigation and Drainage Division. Vol. 28, No. IR3. pp 391-402.
88.3 Chopp, K.M., Clapp, C.E. and E.L. Schmidt. 1982. "Ammonia-Oxidizing Bacteria Populations and Activities in Soils Irrigated with Municipal Waste Water Effluent." Journal of Environmental Quality. Vol. 11, No. 2. pp 221-226.
88.4 Chow, V.T. 1964. Handbook of Applied Hydrology. McGraw-Hill: New York, New York.
88.5 Freeze, R.A. and J.A. Cherry. 1979. Groundwater. Prentice-Hall: Englewood Cliffs, New Jersey.
88.6 Galegar, W.C., Harlin, C.C. and C.G. Enfield. 1980. "Drainage Requirements for Land Application Wastewater Treatment." Transactions of the American Society of Agricultural Engineers. Vol. 23. pp 343-350.
88.7 Hook, J.E. and L.T. Kardos. 1978. "Nitrate Leaching During Long-Term Spray Irrigation for Treatment of Secondary Sewage Effluent on Woodland Sites." Journal of Environmental Quality. Vol. 7, No. 1. pp 30-34.
88.8 Johnson, D.W., Breuer, D.W. and D.W. Cole. 1979. "The Influence of Anion Mobility on Ionic Retention in Waste Water-irrigated Soils." Journal of Environmental Quality. Vol. 8, No. 2. pp 246-250.
88.9 Kays, W.B. 1977. Construction of Linings for Reservoirs, Tanks and Pollution Control Facilities. John Wiley and Sons: New York, New York.
88.10 Kleinbaum, D.G. and L.L. Kupper. 1978. Applied Regression Analysis and Other Multivariable Methods. Duxbury Press: Belmont, California.
88.11 Miller, D.W. (editor) 1980. Waste Disposal Effects on Ground Water. Premier Press: Berkeley, California.
88.12 Olson, G.W. 1981. Soils and the Environment: A Guide to Soil Surveys and Their Application. Dowden and Culver: New York, New York.
88.13 Overcash, M.R. and P. Pal. 1979. Design of Land Treatment Systems for Industrial Wastes - Theory and Practice. Ann Arbor Science: Ann Arbor, Michigan.
88.14 Palazzo, A.J. and T.F. Jenkins. 1979. "Land Application of Waste Water: Effect on Soil and Plant Potassium." Journal of Environmental Quality. Vol. 8, No. 3. pp 309-312.
88.15 Sanks, R.L. and T. Asano. 1976. Land Treatment and Disposal of Municipal and Industrial Wastewater. Ann Arbor Science: Ann Arbor, Michigan.
88.16 Sopper, W.E. and S.N. Kerr (editors). 1979. Utilization of Municipal Sewage Effluent and Sludge on Forest and Disturbed Land. Pennsylvania State University Press: State College, Pennsylvania.
88.17 United States Department of Agriculture. National Engineering Handbook, Section 8 Engineering Geology. Soil Conservation Service Washington,DC
88.18 United States Environmental Protection Agency. 1976. Land Treatment of Municipal Wastewater Effluents: Case Histories. Technology Transfer Program. Cincinnati, Ohio.
88.19 United States Environmental Protection Agency. 1978. Wastewater Stabilization Pond Linings. (MCD-54) Office of Water Program Operations. Washington, D.C.
88.20 United States Environmental Protection Agency. 1979. A History of Land Application as a Treatment Alternative. (MCD-40) Office of Water Program Operations. Washington, D.C.
88.21 United States Environmental Protection Agency. 1979. Cost of Land Treatment Systems. (MCD-10) Office of Water Program Operations. Washington, D.C.
88.22 United States Environmental Protection Agency. 1979. Handbook of Analytical Quality Control in Water and Wastewater Laboratories. (EPA 600/4-79-019) Environmental Monitoring and Support Laboratory. Cincinnati, Ohio.

88.23 United States Environmental Protection Agency. 1980. Wastewater Aerosols and Disease. (EPA 600/9-80-028) Office of Research and Development. Cincinnati, Ohio.

88.24 United States Environmental Protection Agency. 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act." (40 CFR Part 136) Federal Register. Vol. 49, No. 209. October 26, 1984.

89.0 Appendices

90.0 Plan of Operation and Management for Slow Rate Land Treatment Systems

The plan shall include but not be limited to the following:

90.1 Introduction

90.1.1 System Description:

90.1.1.1A narrative description and process design summary for the land treatment facility including the design wastewater flow, design wastewater characteristics, preapplication treatment system and spray fields.

90.1.1.2A map of the land treatment facility showing the preapplication treatment system, storage pond(s), spray fields, buffer zones, roads, streams, drainage system discharges, monitoring wells, etc.

90.1.1.3A map of interceptor sewers, force mains and major pump stations tributary to the land treatment facility. Indicate their size and capacity.

90.1.1.4A schematic and plan of the preapplication treatment system and storage pond(s) identifying all pumps, valves and process control points.

90.1.1.5A schematic and plan of the irrigation distribution system identifying all pumps, valves, gauges, sprinklers, etc.

90.1.1.6Discussion of the design life of the facility and factors that may shorten its useful life,including procedures or precautions which will compensate for these limitations.

90.1.1.7A copy of facility's National Pollutant Discharge Elimination System (NPDES) Permit, if applicable.

90.2 Management and Staffing

90.2.1 Outline of management's responsibilities and duties.

90.2.2 Outline of staffing requirements and duties:

90.2.2.1Describe the various job titles, number of positions, qualifications, experience, training, etc.

90.2.2.2Define the work hours, duties and responsibilities of each staff member.

90.3 Facility Operation and Management

90.3.1 Preapplication Treatment System:

90.3.1.1Describe how the system is to be operated.

90.3.1.2Discuss process control.

90.3.1.3Discuss maintenance schedules and procedures.

90.3.2 Irrigation System Management:

90.3.3 Wastewater Application. Discuss how the following will be monitored and controlled. Include rate and loading limits.

90.3.3.1Wastewater loading rate (inches/week)

90.3.3.2Wastewater application rate (inches/hour)

90.3.3.3Spray field application cycles

90.3.3.4Organics, metals, nitrogen, and phosphorus loading (lbs/acre per month, etc)

90.3.4 Discuss how the system is to be operated and maintained.

90.3.4.1Storage pond(s)

90.3.4.2Irrigation pump station(s)

90.3.4.3Spray field force main(s) and laterals

90.3.5 Discuss start-up and shut-down procedures.

90.3.6 Discuss system maintenance.

90.3.4.1Equipment inspection schedules

90.3.4.2Equipment maintenance schedules

90.3.7 Discuss operating procedures for adverse conditions.

90.3.7.1Wet weather

90.3.7.2Freezing weather

90.3.7.3Saturated Soil

90.3.8 Excessive winds

90.3.8.1Electrical and mechanical malfunctions

90.3.9 Provide troubleshooting procedures for common or expected problems.

90.3.10 Discuss the operation and maintenance of back-up, stand-by and support equipment.

90.3.11 Vegetation Management:

90.3.11.1Discuss how the selected cover crop is to be established, monitored and maintained; how the irrigation schedule will be altered during harvest and regeneration.

90.3.12 Discuss cover crop cultivation procedures, harvesting schedules and uses.

90.3.13 Discuss buffer zone vegetative cover and its maintenance.

90.3.14 Drainage System (if applicable):

90.3.14.1Discuss operation and maintenance of surface drainage and runoff control structures.

90.3.14.2Discuss operation and maintenance of subsurface drainage systems.

90.3.15 Emergency and Contingency Planning

90.4 Monitoring Program (reference section 80.0)

90.4.1 Discuss sampling procedures, frequency, location and parameters for:

90.4.1.1Preapplication treatment system.

90.4.1.2Irrigation System:

90.4.1.2.1 Storage pond(s)

90.4.1.2.2 Groundwater monitoring wells

90.4.1.2.3 Drainage system discharges (if applicable)

90.4.1.2.4 Surface Water (if applicable)

90.4.2 Discuss soil sampling and testing:

90.4.3 Discuss ambient conditions monitoring:

90.4.3.1Rainfall.

90.4.3.2Wind speed

90.4.3.3Soil moisture

90.4.4 Discuss the interpretation of monitoring results and facility operation:

90.4.4.1Preapplication treatment system.

90.4.4.2Spray fields.

90.4.4.3Groundwater.

90.4.4.4Soils

90.5 Records and Reports

90.5.1 Discuss maintenance records:

90.5.1.1Preventive.

90.5.1.2Corrective.

90.5.2 Monitoring reports and/or records (appropriate items to be included are determined by nature of the wastewater, pretreatment, site conditions and management):

90.5.2.1Preapplication treatment system and storage pond(s).

90.5.2.1.1 Influent flow

90.5.2.1.2 Influent and effluent wastewater characteristics

90.5.2.2Irrigation System.

90.5.2.2.1 Wastewater volume applied to spray fields

90.5.2.2.2 Spray field scheduling

90.5.2.2.3 Loading rates

90.5.2.3Annual Record of Groundwater Depth.

90.5.2.4Drainage system discharge parameters (if applicable).

90.5.2.5Surface water parameters (if applicable).

90.5.2.6Soils data.

90.5.2.7Rainfall and climatic data.

91.0 Water Balance Data

91.1 General

91.1.1 Presented in the following sections are the Thornthwaite potential evapotranspiration calculation procedures and monthly mean temperatures, potential evapotranspiration, precipitation and 5-year return period precipitation for each of the long-term U.S. Weather Service stations in Delaware.

91.2 Thornthwaite Potential Evapotranspiration

91.2.1 The Thornthwaite Potential Evapotranspiration (P.E.T.) is defined as "the amount of water which will be lost from a surface completely covered with vegetation if there is sufficient water in the soil at all times for use of the vegetation." The Thornthwaite method is an empirical equation developed from correlations of mean monthly air temperature with evapotranspiration from water balance studies in valleys of the east-central United States where soil moisture conditions do not limit evapotranspiration. (The Irrigation Association, 1983, pp 112 to 114).

91.3 Calculational Procedures

91.3.1 The potential evapotranspiration is given by Thornthwaite as:

91.3.1.1 P.E.T. = 1.6 L (10 x Ta)/I)m in cm per month eq. 702-1

where I = 12 3i = 12 3(Ta/5)1.514 1 1

91.3.1.2and where

L = a daylength and month-length factor given in Table 702-1

Ta = the actual Celsius mean air temperature for the month

Ta = the climatological normal temperature in degrees

Celsius for each of the twelve months, and

m = a cubic function of the denominator of the term inside the bracket (the heat index I).

m = 6.75x10-7I3 - 7.71x10-5I2 + 1.79x102I + 0.449

91.3.1.3The climatological normal mean is the 30-year mean updated every 10 years. Convert U.S. Weather Station temperatures in degrees Farenheit to degrees Celcius by the following:

oC = (oF - 32) x 5/9

92.0 Table 702-1 Monthly Average Daylight Hours in Units of 12 Hours(L), As a Function of Latitude for Thornthwaite Potential Evapotranspiration

Duration on 15th Day of Month

Month	39° N Latitude*
January	0.81
February	0.8
March	0.99
April	1.10
May	1.19
June	1.24
July	1.22
August	1.15
September	1.04
October	.93
November	.84
December	.79

*Values for 39° N latitude may be used for all latitudes in Delaware

93.0 Table 702-2 Climatological Normal Temperatures (Ta) and Thornthwaite Potential Evapotranspiration for the U.S. Weather Service Stations in Delaware (The table in the original Word document is unreadable, therefore, the content is not duplicated here.)

94.0 Table 702-3 Climatological Normal Precipitation (P) and 5-Year Return Period Monthly Precipitation Data (P5)for the Long-Term U.S. Waether Service Stations in Delaware (The table in the original Word document is unreadable, therefore, the content is not duplicated here.)

94.1

94.2

94.3 Potential Evapotranspiration Data for Delaware

94.3.1 Presented in Table 702-2 are the monthly normal climatological temperature and calculated potential evapotranspiration data for each of the long-term U.S. Weather Service stations in Delaware.

94.3.2 The potential evapotranspiration data were calculated using the normal climatological temperature in eq. 702.1 for both Ta and Ta. Thus, the potential evapotranspiration data presented in Table 702-2 represent long-term means. If the potential evapotranspiration for a specific year is desired, the actual monthly temperatures are used as Ta in eq. 702-1 and the normal climatological temperatures from Table 702-2 are used as Ta.

94.4 Design Precipitation

94.4.1 Presented in Table 702-3 are the monthly climatological normal precipitation and 5-year return period monthly precipitation data for all the long-term U.S. Weather Service stations in Delaware.

95.0 Example Calculations

95.1 Municipal Wastewater

95.1.1 Introduction and Assumptions

95.1.2 Design of slow rate land treatment systems is a process of balancing site limitations against construction and operating costs.

The following example calculations are for a hypothetical one (1) MGD facility in the Central area of Delaware. The example illustrates the basic computations required and the relationship between variables.

95.1.3 The following assumptions were made. They must not be used for real world systems without verification.

95.1.4 A small municipal system with little industrial input and an average design flow of one (1) MGD without significant seasonal fluctuation.

95.1.5 The land treatment site is moderately well drained with seasonal high groundwater after consideration of mounding due to irrigation more than 5 feet below the surface. The most limiting layer in the soil profile occurs at a depth of 2 to 4 feet. Testing for saturated vertical hydraulic conductivity indicates an average permeability for this layer 0.2 inches/hour.

95.1.6 The annual average precipitation is 44.3 inches. Evapotranspiration occurs at the potential evapotranspiration as computed by the Thornthwaite equation.

95.1.7 Nitrogen concentrations in effluent from the preapplication treatment system are as follows:
Total Nitrogen as N 20 mg/L
Ammonia Nitrogen as N15 mg/L

95.1.8 Nitrogen is applied to the site through rainfall and fixation at a rate of 5 lbs/acre-year.

95.1.9 Maximum loss to ammonia volatilization is 5 percent of the total ammonia applied. Maximum loss to denitrification for pine forest is 20 percent of the total nitrogen applied. Maximum loss to denitrification for alfalfa is 15 percent of the total nitrogen applied.

95.1.10 Net uptake and removal of nitrogen in pine forest with understory growth is 75 lbs/acre-year. Nitrogen uptake and removal for Alfalfa is 300 lbs/acre-year.

95.1.11 Delta P from Table 309-1 is assumed to be 2.1 inches.

95.2 Design Percolation

95.2.1 As stated above, the average permeability of the most limiting soil layer is 0.2 inches/hour. As this limiting layer occurs at a depth less than 5 feet, 10 percent of this value will be used for design (reference Subsection 306.2). The design percolation rate becomes:

95.2.1.1 0.10 x (0.2 in/hr) x (24 hr/day) = 0.48 in/day.

95.3 Water Balance

95.3.1 Water balance calculations for the hypothetical one MGD wastewater irrigation system are presented in Table 703-1. This table makes use of eq. 307.2 to determine maximum allowable monthly hydraulic wastewater loadings.

95.3.2 Thornthwaite potential evapotranspiration and 5-year return monthly precipitation values for Dover are used in Table 703-1. The table indicates that for the assumed site conditions, the month with the lowest wastewater application [D(allowed)] is February with a maximum allowable wastewater loading of 9.3 inches, corresponding to 2.2 inches/week. Therefore, an annual design wastewater loading greater than 2.2 inches/week will require water balance storage in February. Conversely, no water balance storage will be required for a design wastewater loading less than 2.2 inches/week (reference Subsection 71.3. Wastewater loadings equal to D(allowed) for each specific month could be applied for each respective month without requiring water balance storage.

96.0 Table 703-1 Water Balance Calculations

Month	**Evap[a]**	**Perc[b]**	**Precip[c]**	**D(allowed)**	**D(allowed)**
	(in)	**(in)**	**(in)**	**(in/month)**	**(in/week)[d]**
1	2	3	4	5=(2+3-4)	6=(5/4.3)
January	0.1	14.9	4.6	10.4	2.4
February	0.1	13.4	4.3	9.3	2.2
March	0.7	14.9	5.3	10.3	2.4
April	1.9	14.4	4.9	11.4	2.7
May	3.4	14.9	5.2	13.1	3.0
June	4.9	14.4	5.2	14.1	3.3
July	5.6	14.9	7.0	13.5	3.1
August	5.1	14.9	7.4	12.6	2.9
September	4.2	14.4	6.8	11.8	2.7
October	2.0	14.9	5.0	11.9	2.8
November	0.9	14.4	4.9	10.4	2.4
December	0.2	14.9	5.2	9.9	2.3
Total 29					

96.1 [a]Thornthwaite average monthly potential evapotranspiration.

96.2 [b]Based on the number of days per month, a saturated vertical hydraulic conductivity (0.2 in/hr), and a design percolation factor of 10 percent.

96.3 [c]Five-year return, monthly precipitation.

96.4 [d]The maximum allowable monthly hydraulic wastewater loading divided by an average 4.3 weeks/month.

97.0 Table 703-2 Nitrogen Balance, Pine Forest and Alfalfa

	Pine Forest	Alfalfa
Average Daily Flow, ADF (mgd)	1.0	1.0
Average Design Wastewater Loading (in/week)	1.50	2.50
ADF Wetter Area (acres)	172	103
Nitrogen Input from Wastewater (lbs/acre-year)	354	591
Nitrogen Input from Rainfall and Fixation Rainfall and Fixation	5	5
Total Nitrogen Input (lbs/acre-year)	359	596
Ammonia Volatilization,@ 5% of ammonia applied (lbs/acre-year)	13	22
Denitrification, @ 20% of total nitrogen applied (lbs/acre-year)	71	119
Net Plant Uptake and Storage (lbs/acre-year)	75	300
Nitrogen Leached by Percolate (l)	202	159
Precipitation (in/year)	44	44
Wastewater Applied (in/year)	78	130
Potential Evapotranspiration (in/year)	29	29
Percolate (in/year)	93	145
Estimated Percolate	9.6	4.8
Total Nitrogen (mg/L		

Note that ammonia volatilization is based only on applied ammonia, not total nitrogen as the other components of the nitrogen balance.

97.1 Nitrogen Balance

97.1.1 The nitrogen balance is used to evaluate the range of wastewater loadings possible under different cover crop and management schemes.Table 703-2 presents nitrogen balances for cover crop alternatives of pine forest and alfalfa grass.

97.1.2 To meet a percolate total nitrogen limit of 10 mg/L, Table 703-2 indicates a pine forest cover crop will require a design wastewater loading of approximately 1.5 inches/week or less and alfalfa grass will allow a design wastewater loading greater than the suggested maximum of 2.5 inches/week. The final cover crop selected is an economic decision balancing wetted area and storage requirements against operating cost and maximum allowable wastewater loading.

97.2 Operating Scheme

97.2.1 The operating scheme for the hypothetical one MGD facility is as follows:

97.2.1.1 The average initial design wastewater loading will be 2.5 inches/week. The actual loading rate will be somewhat less than 2.5 inches/week during normal operation because the additional acreage needed for treating the operational storage, water balance storage and wet weather/emergency storage will be used to treat the normal daily flows. This will be done in order to maintain the cover crop regardless of whether there is any water in storage.

97.2.1.2 The cover crop will be alfalfa. The alfalfa will be harvested and sold.

97.2.1.3Normal operation will be five (5) days per week. The flow from the other two days will be stored. sSince the system will normally be operated five days per week, the wastewater volume applied each day is:

97.2.1.3.1 (7 days/week) / (5 days/week)] x 1 MGD = 1.4 MGD

97.3 Storage Volume Requirements

97.3.1 As discussed in Subsection 309, the required storage volume consists of three (3) separate storage components.

97.3.1.1Operational Storage

97.3.1.2The operating scheme selected for design calls for irrigation five days per week with storage of two days' flow. The required operational storage is:

97.3.1.2.1 (7 days - 5 days) x 1 MGD = 2 Mgal

97.3.1.3For this example it is assumed that harvesting of the grass will not occur during the wet weather months. Therefore, no additional storage will be needed for fields out of service due to harvesting since the wet weather storage volume will be available. Wet weather harvest and long harvest and vegetation establishment periods will require additional irrigation area or storage volume.

97.3.2 Inclement Weather and Emergency Storage

97.3.2.1Minimum requirements for inclement weather and emergency storage are discussed in Subsection 71.2

97.3.2.2For the hypothetical facility, Delta P from Table 309-1 is assumed to be 2.1 inches. The maximum allowable hydraulic wastewater loading in the most critical water balance month (February) from Table 703-1 is 9.3 inches/month. By eq. 309.2:

97.3.2.2.1 [(2.1 in) x (30.4 days/month)] / 9.3 in/month = 6.9 days

97.3.2.3The designer must consider this value as a minimum storage requirement and balance other site and management factors for determination of inclement weather and emergency storage needs. For the purpose of this example, 12 days is selected as the minimum requirement. Therefore, the storage is:

97.3.2.3.1 12 days x 1 MGD = 12 Mgal

97.3.3 Water Balance Storage

97.3.3.1As discussed in Subsection 71.3, the water balance storage is a function of hydraulic loading which is a function of the total wetted field area. Therefore, before the water balance storage can be determined the wetted field area must be defined.

97.4 Wetted Field Area Determination

97.4.1 The area required for the spray site is the total of four separate components.

97.4.2 A(wetted) = A(ADF) + A(WBS) + A(OP) + A(WW/E)

97.4.3 Substituting the appropriate loading rates and the appropriate volumes into equations 310.1 and 310.3 results in the following wetted area requirements:

97.4.3.1A(ADF) = 103.0 acres

97.4.3.2A(WW/E) = 15.6 acres

97.4.4 Since the only operational storage is associated with spraying less than 7 days per week:

97.4.4.1A(OP) = 0.0 acres

97.4.5 With these areas determined the next step is to define the necessary water balance storage and the wetted area associated with that storage.

97.4.6 The wastewater loading rate (WLR) is:

97.4.6.1WLR = 7 x 10^6 gal/wk x (1 cf/7.48 gal) x 12 in/ft x (1 acre/43,560 sf) x 1/118.6 acres = 2.17 in/wk

97.4.7 Table 703-3 combines eq. 307.2 and 309.3 to determine the required water balance storage (WBS) for the loading rate of 2.17 in/wk. Storage for the most critical month (February) is 0 as well as for all other months and no additional land is required for reduction of water balance storage.

97.4.8 The total area necessary for this land treatment system is:

97.4.8.1A(ADF) 103 acres

97.4.8.2 A(OS) 0

97.4.8.3 A(WW/E) 16

97.4.8.4A(WBS) 0

97.4.8.5-A(TOTAL) 119 acres

97.4.9 Spraying 1.4 Mgal each day for five days per week, the wetted field area will be divided into 23.8 acre sections. For normal flows each field will be loaded at a rate of:

97.4.9.1(1.4 x 10^6 gal/day) x (1 cf/7.48 gal) x (12 in/ft) x

97.4.9.2(1 acre/43,560 sf) x (1/23.8 acres) = 2.17 in/wk

97.4.10 The average wastewater irrigation period will be:

97.4.10.1(2.17 in/week) / [(1 day/week) x (0.25 in/hr)] = 8.7 hr/day

98.0 Table 703-3 Water Balance Storage

Month	D(potential[a] (in)	D(allowed)[b] (in)	WBS[c] (in)	Sum (WBS) (in)
January	9.6	10.4	0.0	0
February	8.7	9.3	0.0	0
March	9.6	10.3	0.0	0
April	9.3	11.4	0.0	0
May	9.6	13.1	0.0	0
June	9.3	14.1	0.0	0
July	9.6	13.5	0.0	0
August	9.6	12.6	0.0	0
September	9.3	11.8	0.0	0
October	9.6	11.9	0.0	0
November	9.3	10.4	0.0	0
December	9.6	10.9	0.0	0

98.1 [a]Based on the number of days per month and the design wastewater loading of 2.17 in/week, assumes all influent wastewater is applied to spray fields.

98.2 [b]Values from Table 703-1.

98.3 [c]WBS = Water balance storage, reference eq. 307.4.

99.0 Table 703-4 Irrigation Schedule

Month	Design[a] Precip (in/week)	D(allowed)[b] (in/week)	Maximum[c] Irrigation Period (hr/week)
January	1.1	2.4	9.6
February	1.0	2.2	8.8
March	1.2	2.4	9.6
April	1.1	2.5	10.0
May	1.2	2.5	10.0
June	1.2	2.5	10.0
July	1.6	2.5	10.0
August	1.7	2.5	10.0
September	1.6	2.5	10.0
Ocotober	1.6	2.5	10.0
Novmember	1.1	2.4	9.6
December	1.2	2.3	9.2

99.1 Weekly fraction of five-year return, monthly precipitation used in design. This rainfall depth is accounted for in D(allowed).

99.2 Maximum allowable hydraulic wastewater loading, each spray field. If rainfall during the week (7 days) prior to irrigation is less than the design precipitation, spray fields may be loaded up to D(allowed) in order to dispose of water diverted to storage. If rainfall during the week preceding irrigation exceeds the design precipitation, D(allowed) must be proportionally reduced and water diverted to storage.

99.3 Based on D(allowed) and the application rate of 0.25 in/hr. This is the maximum number of hours each spray field may be operated per week when rainfall during the week (7 days) prior to irrigation is less than the design precipitation. When rainfall exceed the design precipitation, both D(allowed) and the irrigation period must be modified.

99.4 The maximum wastewater irrigation period will be:

99.4.1 (2.50 in/week) / [(1 day/week) x (0.25 in/hr)] = 10.0 hr/day

99.5 Irrigation Schedule

99.5.1 The simplest method for operating a wastewater irrigation system is to control the irrigation period by time clock. Maximum irrigation periods correspond to the maximum allowable hydraulic wastewater loading for each month. This insures the correct volumes of wastewater are applied and stored.

99.6 Table 703-4 is an example irrigation schedule for the hypothetical one (1) MGD facility. The table is based on Tables 703-1 and 703-3 and is intended as a general guide for operation. Daily application periods are adjusted according to antecedent rainfall and soil moisture conditions. Wastewater is not applied during periods of heavy rain or saturated soil. Conversely, dry weather allows long irrigation periods and disposal of wastewater diverted to storage.

99.7 Industrial Wastewater

99.7.1 Introduction and Assumptions

99.7.1.1 Industrial wastewaters can be quite variable and may require a different design approach than municipal wastewaters to determine design and operational parameters. Although many industrial wastewaters will have nitrogen and/or hydraulic loading as their limiting constituents, other constituents may have to be considered in the design.

99.7.1.2 The following example illustrates an industrial wastewater in which metals are the limiting constituents. The same site assumptions as used for the municipal wastewater example will be used for this example as well. The following additional assumptions are made:

99.7.1.2.1 Flow averages 20,000 gallons per week.

99.7.1.3 The wastewater consists of industrial process waste, no domestic wastes from the plant are included.

99.7.1.4 Solids content of the waste is low (less than municipal) and does not require screening prior to land application.

99.7.1.5 The hydraulic loading calculations completed for the municipal wastewater example apply to this example as well.

99.7.1.6 The waste characterization is as follows:

	mg/L
Calcium	3.1
Magnesium	.64
Sodium	12.0
Cadmium	.008
Copper	3.5
Nickel	.014
Lead	.048
Zinc	.069
Total Nitrogen	32.7
Total Phosphorus	8.4
pH	7.0 (standard units)

99.8 Site Assimilative Capacities

99.8.1 Calculation of assimilative capacities for nitrogen, phosphorus, hydraulic loading, and metals were conducted and it was determined that metals were the potential design or land limiting constituents. In accordance with the cumulative metal loadings listed in Table 2 of the Guidance section, the cumulative loadings for the site with a cation exchange capacity of 5 meq/100 g soil or less are as follows:

99.8.1.1 lb/ac

Lead	500
Zinc	250
Copper	125
Nickel	125
Cadmium	4.4

99.8.1.2Furthermore, cadmium loadings cannot exceed 0.44 lb/ac/yr (0.5 kg/ha/yr) for food chain crops.

99.8.2 The site available for wastewater application is 9 acres and it is decided to use the entire area to provide flexibility in operation. Based on calculations using the above cumulative metal loadings, the site life for each of the metals is:

99.8.2.1

Site Life	Years
Lead	1070
Zinc	2640
Copper	36
Nickel	125
Cadmium	105

99.8.2.2The cadmium loading would be 0.04 lb/ac/yr, less than the permissible loading of 0.44 lb/ac/yr.

99.8.2.3Nitrogen loading is 42.4 lbs/ac/yr and the hydraulic loading is approximately 0.5 in/wk.

99.8.3 Because the sodium concentration appears high in comparison with calcium and magnesium the sodium adsorption ratio (SAR) of the waste should be calculated. Refer to the Guidance section for a discussion of SAR and the procedure for calculation. Based on the waste characteristics, the SAR is 1.6. This value is less than the critical value of 12 for the type soils described for this example and therefore does not limit the wastewater application.

99.8.4 Since wastewater loadings are low for this example waste and site, calculations of storage requirements as outlined in the municipal wastewater example are not necessary. However, determinations of storage requirements for winter and wet weather and emergency conditions should be determined to provide flexibility in operations and not lead to severe curtailment of plant operations. Considering these factors and examination of the weather records, a decision to provide one-weeks storage was made with consideration that plant operations will be reduced if there is a longer period during which the waste cannot be land applied. Additional storage would be necessary if storage or curtailment of plant operations cannot be accepted by the applicant.

PART III Land and Treatment of Sludges and Sludge

Amended October 15, 1999

B. Regulations

100.0 Authority and Scope

101.0 Authority

101.1 **Delaware Code**, Chapter 60; and Sections 405(d) and (e) of the Clean Water Act, as amended by Pub. L. 95-217, Sec. 54 (d), 91 Stat. 1591 (33 U.S.C. 1345 9 d) and (e); and Pub. L. 100-4, Title IV, Sec. 406 (a), (b), 101 Stat., 71, 72 (33 U.S.C. 1251 et seq.) code of Federal Regulations, Part 503 - Standards for the Use of Disposal of Sewage Sludge.

102.0 Scope

102.1 This regulation establishes standards which consist of general requirements, pollution limits, management practices and operational standards for the final use or disposal of sludge generated in the treatment of wastewater at a wastewater treatment or wastewater pretreatment facility. Standards are included in this part for sewage sludge applied to land, sold or given away in bag or bulk or used for research purposes.

102.2 The regulation also provides standards for all persons engaged in the collection, handling, generation, preparation, storage, and transportation of sludge, treated sludge or any product containing these materials in the State of Delaware.

102.3 These regulations supersede the Delaware Solid Waste Disposal Regulations of the Department of Natural Resources and Environmental Control, dated December 1994 regarding sludge or any material containing sludge.

102.4 This regulation in its entirety is effective immediately upon promulgation.

103.0 Definitions.

The following terms have the meanings indicated.

"**Aerobic digestion"** is the biochemical decomposition of organic matter in sewage sludge into primarily carbon dioxide and water by microorganisms in the presence of air.

"Anaerobic digestion" is the biochemical decomposition of organic matter in sewage sludge into methane gas and carbon dioxide by microorganisms in the absence of air.

"Agricultural land" is land on which a food crop, a feed crop, or a fiber crop is grown. This includes range land and land used as pasture.

"Agricultural utilization" means the application rate of wastes or sludge or sludge products which shall not exceed the nutrient needs of the crop grown on the particular soil plus the other assimilative pathways in soils (e.g. immobilization with organic material, volatilization, and leachate in compliance with drinking water standards).

"Agricultural wastes" means wastes normally associated with the production and processing of food and fiber on farms, feedlots, ranches, ranges, and forests which may include animal manure, crop residues, and dead animals; also agricultural chemicals, fertilizers and pesticides which may find their way into surface and subsurface water.

"**Agronomic rate"** is the whole sludge application rate (dry weight basis) designed:

1 To provide the amount of nitrogen needed by the food crop, feed crop, fiber crop, cover crop, or vegetation grown on the land; and

2 To minimize the amount of nitrogen in the sewage sludge that passes below the root zone of the crop or vegetation grown on the land to the ground water.

"**Annual pollutant loading rate"** is the maximum amount of a pollutant that can be applied to a unit area of land during a 365 day period.

"Annual whole sludge application rate" is the maximum amount of sewage sludge (dry weight basis) that can be applied to a unit area of land during a 365 day period.

"Applier" is a person who is responsible for applying stabilized sewage sludge to a parcel of land.

"Aquifer" is a geologic formation, grouping of geologic formations, or a portion of a geologic formation capable of yielding ground water to wells or springs.

"Base flood" is a flood that has a one percent chance of occurring in any given year.

"Bulk sewage sludge" is Exceptional Quality sludge that is not sold or given away in a bag or other container for application to the land.

"Collection" means any action involved in the gathering or subsequent placement or sludge, treated sludge, or any other product containing these materials, into a vehicle, container or any other vessel for transportation to some other location.

"Cover" is soil or other material used to cover sewage sludge placed on an active sewage sludge unit.

"Cover crop" is a small grain crop, such as oats, wheat, or barley, grown to prevent nitrogen leaching during the winter months.

"Crops for direct human consumption" means crops that are consumed by humans without processing.

"Cumulative pollutant loading rate" is the maximum amount of an inorganic pollutant that can be applied to an area of land.

"Density of microorganisms" is the number of microorganisms per unit mass of total solids (dry weight) in the sewage sludge.

"Department" means the Department of Natural Resources and Environmental Control.

"Disposal" means the discharge, deposit, injection, dumping, spilling, leaking, or placing of sludge, any material containing sludge, or any constituent of it on or in the land, the air or any waters, including ground water, and includes any method of sludge utilization that involves reuse of nutrients in the sludge at greater than agronomic rates (this excludes land reclamation).

"Distribute" means to barter, sell, offer for sale, consign, furnish, provide, or otherwise supply a material as part of a commercial enterprise or a giveaway program.

"Domestic septage" is either liquid or solid material removed from a septic tank, cesspool, portable toilet, Type III marine sanitation device, or similar treatment works that receives only domestic sewage. Domestic septage does not include liquid or solid material removed from a septic tank, cesspool, holding tank, or similar treatment works that receives either commercial wastewater or industrial wastewater and does not include grease removed from a grease trap at a restaurant.

"Domestic sewage" is water and wastewater from humans or household operations that is discharged to or otherwise enters a treatment works.

"Dry weight basis" means calculated on the basis of having been dried at 105 degrees Celsius until reaching a constant mass (i.e., essentially 100 percent solids content).

"Exceptional Quality Sludge ("EQ Sludge")" sludge that has been stabilized (as per Subsection 603) by a Further Reduction Pathogens, meets one of the Vector Attraction Reduction Requirements specified in Subsection 604(88.1-8) and contains lower metal concentrations than the allowable Pollutant Concentration specified Table 402-3.

"Feed crops" are crops produced primarily for consumption by animals**.**

"Fiber crops" are crops such as flax, cotton, and hemp.
"Food chain crops" means tobacco, crops grown for human consumption, and crops grown to feed animals whose products are consumed by humans.
"Food crops" are crops consumed by humans. These include, but are not limited to, fruits, vegetables, and tobacco.
"Forest" is a tract of land thick with trees and underbrush.
"Forestry" means the science of the ecosystems, management and production of a forest or forest system.
"Free liquids" means liquids which readily separate from the solid portion of a waste under the EPA Gravity Test. The test protocol calls for a 100 ml representative sample of the waste from a container to be placed in a 400 micron conical paint filter for 5 minutes. The filter specified is a standard paint filter which is commonly available at hardware and paint stores. The filter is to be supported by a funnel on a ring stand with a beaker or cylinder below the funnel to capture any free liquid that passes through the filter. If any amount of free liquid passes through the filter, the waste is considered to hold free liquids.
"Grease trap waste" means the combined liquid and solid fractions of material accumulated in a tank or other device designed for the removal of grease, fat and oil from wastewater (for the purpose of these regulations petroleum products are excluded).
"Grit (and screenings)" are the heavy materials such as sand, gravel, cinders and egg shells collected in the preliminary treatment of sewage. Screenings are the materials separated from wastewater during preliminary treatment made up of floatable debris such as wood, plastic and cloth.
"Ground water" is water below the land surface in the saturated zone.
"Handling" means any way in which sludge, treated sludge, or any other product containing these materials is dealt with, other than collection, burning, storage, treatment, land application, disposal, or transportation. It includes distribution of treated sludge.
"Holding tank waste" means wastewater from any home or business that is held temporarily in a container where no on-site treatment is performed. The wastewater is hauled off site for treatment.
"Impermeable" means having a hydraulic conductivity equal to or less than 1 x 10-7 cm/sec as determined by field and laboratory permeability tests made according to standard test methods which may be correlated with soil densification as determined by compaction tests.
"Industrial wastewater" is wastewater generated in a commercial or industrial process.
"Label" means the display of all written, printed, or graphic material on the immediate container, or information accompanying the material.
"Land application" means the placement of sludge, treated sludge, or any other product containing these materials on or within 2 feet below the surface of land used to support vegetative growth.
"Land disposal of sludge" means application of sludge at rates higher than acceptable for agricultural utilization.
"Land with a high potential for public exposure" is land that the public uses frequently. This includes, but is not limited to, a public contact site and a reclamation site located in a populated area (e.g., a construction site located in a city).
"Land with a low potential for public exposure" is land that the public uses infrequently. This includes, but is not limited to, agricultural land, forest, and a reclamation site located in an unpopulated area (e.g., a strip mine located in a rural area).
"Land reclamation" means the application of sludge at a rate not greater than necessary to support and maintain immediate revegetation. Application may be in multiple cycles prior to establishment of vegetation, but must be accomplished within a single short-term operational period.
"Land treatment" means a technology for the intimate mixing or dispersion of wastes into the upper zone of the plant-soil system with the objective of microbial stabilization, immobilization, selective dispersion, or crop recovery leading to an environmentally acceptable assimilation of the waste.
"Landfill" means a natural topographic depression, man-made excavation or diked area formed primarily of earthen materials, which has been lined with man-made materials or remains unlined and which is designed to hold an accumulation of solid wastes.
"Liquid waste" means any waste which is not a solid waste as defined for the purposes of these regulations.
"Other container" is either an open or closed receptacle. This includes, but is not limited to, a bucket, box, carton, truck or trailer.
"Pasture" is land on which animals feed directly on forage crops such as legumes, grasses, grain stubble, or stover.
"Pathogenic organisms" are disease-causing organisms. These include, but are not limited to, certain bacteria, protozoa, viruses, and viable helminth ova.

"Permitting authority" is either EPA or a State with an EPA-approved sludge management program.
"Person" means an individual, trust, firm, joint stock company, federal agency, corporation (including a government corporation), partnership, association, state, municipality, commission, political subdivision of a state, or any interstate body.
"PFRP" means process to further reduce pathogens.
"pH" means the logarithm of the reciprocal of the hydrogen ion concentration.
"Pollutant" is an organic substance, an inorganic substance, a combination of organic and inorganic substances, or a pathogenic organisms that, after discharge and upon exposure, ingestion, inhalation, or assimilation into an organism, either directly from the environment or indirectly by ingestion through the food chain, could, on the basis of information available to the Administration of EPA, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations in either organisms or offspring of the organisms.
"Pollutant limit" is a numerical value that describes the amount of a pollutant allowed per unit amount of sewage sludge (e.g., milligrams per kilogram of total solids); the amount of a pollutant that can be applied to a unit area of land (e.g., kilograms per hectare); or the volume of a material that can be applied to a unit area of land (e.g., gallons per acre)**.**
"Preparer" is a person who prepares sewage sludge or is either the person who generates sewage sludge during the treatment of domestic sewage in a treatment works or the person who derives a material from sewage sludge.
"PSRP" means process to significantly reduce pathogens.
"Public contact site" is land with a high potential for contact by the public. This includes, but is not limited to, public parks, ball fields, cemeteries, plant nurseries, turf farms, and golf courses.
"Range land" is open land with indigenous vegetation.
"Reclamation site" is drastically disturbed land that is reclaimed using sewage sludge. This includes, but is not limited to, strip mines and construction sites.
"Runoff" is rainwater, leachate, or other liquid that drains overland on any part of a land surface and runs off of the land surface**.**
"Sewage" means water-carried human or animal wastes from septic tanks, water closets, residences, buildings, industrial establishments, or other places, together with such groundwater infiltration, subsurface water, admixture of industrial wastes or other wastes as may be present.
"Sewage sludge" means sludges which derives in whole or in part from sewage.
"Silviculture" means any forest management activity, including but not to, the harvest of timber, construction of roads and trails for the purpose of forest management, and preparation of property for reforestation.
"Sludge compost" means a treated sludge produced by subjecting a mixture of sludge and a bulking agent, such as wood chips, to aerobic decomposition in a manner that destroys primary pathogenic and malodorous components.
"Sludge" means the accumulated semi-liquid suspension, settled solids, or dried residue of these solids that is deposited from (a) liquid waste in a municipal or industrial wastewater treatment plant, (b) domestic septage is included herein as sludge (see section 200, (22))**.**
"Sludge generator":

Means a person who owns or operates a facility that receives or processes wastewater and produces or otherwise generates sludge.

Does not include the owner or operator of a septic tank, chemical toilet, privy, or holding tank used for the collection of sewage.

"Sludge utilization" means the preparation , transportation, storage, land application, or marketing and distribution of sludge.
"Sludge utilizer" means: any person who collects, stores, applies to land, or markets or distributes sludge.
"Solid waste" means any garbage, refuse, rubbish, and other discarded materials resulting from industrial, commercial, mining, agricultural operations and from community activities which does not contain free liquids. Containers holding free liquids shall be considered solid waste when the container is designed to hold free liquids for use other than storage (e.g. radiators, batteries, transformers) or the waste is household waste.
"Specific oxygen uptake rate (SOUR)" is the mass of oxygen consumed per unit time per unit mass of total solids (dry weight basis) in the sewage sludge.
"Spray irrigation" means the loading rate for land treatment of wastewater which shall not exceed either the needs of the crop grown on the particular soil plus the other assimilative mechanisms (immobilization with organic material, volatilization, and leachate in compliance with drinking water standards), or the hydraulic capacity of the soil. The Department may require a lower loading rate if the design criteria for pathogens,

metals or organics contained in these Regulations and generally accepted technical standards for land treatment technology (e.g. U.S. EPA Process Design Manual or Overcash, M.R. and P. Pal 1979 Design of Land Treatment Systems for Industrial Wastes - Theory and Practice cannot be achieved at a rate consistent with agricultural utilization.

"Storage" means the interim containment (for a period not to exceed two years) of sludge, treated sludge, or any other product containing these materials after removal from a wastewater treatment plant and before disposal or utilization.

"Surface impoundment" means a natural topographic depression, or diked area formed primarily of earthen materials may be lined with man-made materials or remains unlined, and which is designed to hold an accumulation of liquid wastes or wastes containing free liquids**.**

"Total solids" are the materials in sewage sludge that remain as residue when the sewage sludge is dried at 103 to 105 degrees Celsius**.**

"Transportation" means the off-site movement of sludge, treated sludge, or any other product containing these materials by air, rail, highway, pipeline, or water.

Treat or treatment of sewage sludge" is the preparation of sewage sludge for final use or disposal. This includes, but is not limited to, thickening, stabilization, and dewatering of sewage sludge.

"Treatment" means a process which alters, modifies, or changes the biological, physical, or chemical characteristics of sludge or liquid waste.

"Treatment works" means any device and system used in the storage, treatment, recycling and reclamation of municipal sewage, or industrial wastes of a liquid nature, or necessary to recycle or reuse water at the most economical cost over the estimated life of the works, including intercepting sewers, outfall sewers, sewage collection systems, pumping, power and other equipment, and their appurtenances, extensions, improvements, remodeling, additions and alterations thereof; elements essential to provide a reliable recycled supply such as standby treatment units and clear well facilities and improvements to exclude or minimize inflow and infiltration.

"TWDS" means Treatment Works Treating Domestic Sewage.

"Unstabilized solids" are organic materials in sewage sludge that have not been treated in either an aerobic or anaerobic treatment process.

"Vector attraction" is the characteristic of sewage sludge that attracts rodents, flies, mosquitos, or other organisms capable of transporting infectious agents.

"Volatile solids" is the amount of the total solids in sewage sludge lost when the sewage sludge is combusted at 550 degrees Celsius in the presence of excess air.

"Wastewater treatment plant" means a facility designed and constructed to receive, treat, or store waterborne wastes**.**

"Wetlands" means those areas that are inundated or saturated by surface water or ground water at a frequency and duration to support, and that 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.

104.0 Permits.

105.0 Permits Required.

105.1 Unless excepted under the provisions of Subsection 105.2, a person may not engage in the generation, collection, storage, preparation, land application, marketing and distribution, disposal or transportation of sludge, treated sludge, or any product containing these materials in the State without first obtaining a permit from the Department. No permit may be granted unless the county or municipality having jurisdiction has first approved the activity by zoning procedures provided by law. No person shall use sludge, treated sludge or any product containing these materials for the purpose of agricultural use, land reclamation, research, distribution or land disposal if the sludge was generated outside of the State of Delaware without obtaining a permit from the Department. No permit shall be issued for agricultural use, land reclamation, research, distribution or land disposal of sludge, treated sludge or any product containing sludge generated outside the State of Delaware that does not meet the standards for Exceptional Quality as outlined in these regulations. No sludge or sludge product generated in the State shall be transported, marketed, distributed, prepared or land applied in any other state or jurisdiction without notification of the permitting authority of that state or jurisdiction.

105.2 *Exception*. Permits issued under this regulation are not required for a wastewater treatment plant, if the pertinent activities involve the construction and operation of the plant in accordance with plans approved by the Department. This exception does not include removal of sludge from the plant.

106.0 Exclusions.

106.1 A permit from the Department is not required under these regulations for the following activities. The exclusion under these regulations do not exclude requirements from other Federal, State, County or local regulations as they may apply:

106.1.1 Cofiring of sewage sludge with other waste in an incinerator, unless the other waste is used as auxiliary fuel for the firing of the sludge.

106.1.2 Hazardous wastewater sludge determined to be hazardous by this regulation or any other Federal, State, County or local regulation as they may apply.

106.1.3 Sewage sludge with high PCB concentrations as determined by this regulation or any other Federal, State, County or local regulations as they may apply.

106.1.4 Incinerator ash for use or disposal from the firing of sewage sludge in a sewage sludge incinerator.

106.1.5 Grit and screenings generated or collected in a wastewater treatment process.

106.1.6 Aquatic plants or managed wetlands plants used and harvested as part of a wastewater treatment process and that are not complexed with the sludge at the time of harvest.

106.1.7 Drinking water treatment residuals from non-sewage sources.

106.1.8 Commercial septage, industrial septage, a mixture of domestic septage and commercial septage or a mixture of domestic septage and industrial septage.

106.1.9 Grease trap waste.

107.0 Application for a Permit

107.1 Initial applications for permits, permit renewals or permit modifications under the provisions of these regulations shall be submitted to the department on an application form specified by the Department.

107.2 An application consists of the initial application form specified by the Department combined with a Project Development Report (PDR) containing any supplementary information and analysis necessary to enable the Department to review the proposed project to determine if it is consistent with Delaware law and regulation.

107.3 An application shall demonstrate how the applicant plans to comply with the applicable requirements of these regulations, as well as any additional operating requirements set forth in these regulations that are specifically applicable to the particular type of operation that is proposed.

107.4 A separate permit application shall be submitted for each sludge utilization site. Adjacent properties owned by separate individuals shall be considered as separate sites. Noncontiguous but proximate parcels owned by one person may, at the discretion of the Department, be considered as a single utilization site.

107.5 Depending on the sludge utilization method chosen, additional specific submission requirements may apply. These requirements are given in Section 136 of the regulation.

108.0 Public Notice, Application for Sludge Utilization Permit.

108.1 Upon Department acceptance of the Project Development Report, the applicant must apply for a Department Sludge Utilization permit. Upon receipt of a completed application for this permit, the Department will advertise receipt of the application and conduct any hearings in accordance with 7 **Del.C.** Ch. 60. The cost of the advertisement is to be borne by the applicant.

108.2 The final permit will require submission by the applicant and approval by the Department of any revisions required by the Department for the Plan of Operation and Management or Plans and Specifications report for the facility prior to start-up and operation.

109.0 Standard Permit Conditions.

109.1 The following conditions shall apply to and be included in all permits.

109.1.1 Compliance Required. The permittee shall comply with all conditions of the permit.

109.1.2 Renewal Responsibilities. If the permittee intends to continue operation of the permitted facility after the expiration of an existing permit, the permittee shall apply for a new permit in accordance with these regulations.

109.1.3 Operation of Facilities. The permittee shall at all times properly maintain and operate all structures, systems, and equipment for treatment, control and monitoring, which are installed or used by the permittee to achieve compliance with the permit or these regulations.

109.1.4 Provide Information. The permittee shall furnish to the Department within a reasonable time, any information including copies of records, which may be requested by the Director to determine whether cause exists for modifying, revoking, reissuing, or terminating the permit, or to determine compliance with the permit or these regulations.

109.1.5 Entry and Access. The permittee shall allow the Department, consistent with 7 **Del.C.**, Chapter 60, to:

109.1.5.1Enter the permitted facility.

109.1.5.2 Inspect any records that must be kept under these regulations or conditions of the permit.

109.1.5.2.1 Inspect any facility, equipment, practice, or operation permitted or required by the permit.

109.1.5.2.2 Sample or monitor for the purpose of assuring permit compliance, any substance or any parameter at the facility.

109.1.3 Reporting. The permittee shall report to the Department under the circumstances and in the manner specified in this section:

109.1.3.1 In writing thirty (30) days before any planned physical alteration or addition to the permitted facility or activity if that alteration or addition would result in any significant change in information that was submitted during the permit application process.

109.1.3.2 In writing thirty (30) days before any anticipated change which would result in noncompliance with any permit condition or these regulations.

109.1.3.3 Orally within twenty-four (24) hours from the time the permittee became aware of any noncompliance which may endanger the public health or the environment at telephone numbers provided in the permit by the Department.

109.1.3.4 In writing as soon as possible but within five (5) days of the date the permittee knows or should know of any noncompliance unless extended by the Department. This report shall contain:

109.1.3.4.1 A description of the noncompliance and its cause;

109.1.3.4.2 The period of noncompliance including to the extent possible, times and dates and, if the noncompliance has not been corrected, the anticipated time it is expected to continue; and

109.1.3.4.3 Steps taken or planned to reduce or eliminate reoccurrence of the noncompliance.

109.1.3.5 In writing as soon as possible after the permittee becomes aware of relevant facts not submitted or incorrect information submitted, in a permit application or any report to the Director. Those facts or the correct information shall be included as a part of this report.

109.2 Minimize Impacts.The permittee shall take all necessary actions to eliminate and correct any adverse impact on the public health or the environment resulting from permit noncompliance.

109.3 Reopener. In the event that the regulations governing the land treatment of sludges and sludge products are revised by the Department, this permit may be reopened and modified accordingly after notice and opportunity for a public hearing.

110.0 Specific Permit Conditions.

110.1 Basis for Specific Permit Conditions. Conditions necessary for the protection of the environment and the public health may differ from facility to facility because of varying environmental conditions and waste compositions. The Department may establish additional permit conditions. Specific conditions shall be established in consideration of characteristics specific to a facility and inherent hazards of those characteristics. Such characteristics include, but are not limited to:

110.1.1 Chemical, biological, physical, and volumetric characteristics of the sludge;

110.1.2 Geological and climatic nature of the facility site;

110.1.3 Size of the site and its proximity to population centers and to ground and surface water;

110.1.4 Legal considerations relative to land use and water rights;

110.1.5 Techniques used in sludge distribution and the disposition of that vegetation exposed to sludge;

110.1.6 Abilities of the soils and vegetative covers to treat the sludge without undue hazard to the environment or to the public health; and

110.1.7 The need for monitoring and record keeping to determine if the facility is being operated in conformance with its design and if its design is adequate to protect the environment and the public health.

110.2 Duration of Permit. The permit shall be effective for a fixed term of not more than five (5) years.

110.3 Limitations to Operation. Conditions of the permit may specify or limit:

110.3.1 Sludge composition;

110.3.2 Method, manner, and frequency of sludge treatment;

110.3.3 Sludge pretreatment requirements;

110.3.4 Physical, chemical, and biological characteristics of a land application facility; and

110.3.5 Any other condition the Department finds necessary to protect public health or environment.

110.4 Compliance Schedules.The Department may establish a compliance schedule for existing facilities as part of the permit conditions including:

110.4.1 Specific steps or actions to be taken by the permittee to achieve compliance with applicable requirements or final permit conditions;

110.4.2 Dates by which those steps or actions are to be taken; and

110.4.3 In any case where the period of time for compliance exceeds one (1) year the schedule may also establish interim requirements and the dates for their achievement.

110.5 Monitoring Requirements.Any facility may be subject to monitoring requirements including, but not limited to:

110.5.1 The installation, use, and maintenance of monitoring equipment;

110.5.2 Monitoring or sampling methodology, frequency, and locations;

110.5.3 Monitored substances or parameters;

110.5.4 Testing and analytical procedures; and

110.5.5 Reporting requirements including both frequency and form.

111.0 Permit Modification.

111.1 Minor Modifications. Minor modifications are those which if granted would not result in any increased hazard to the environment or to the public health. Such modifications shall be made by the Director. Minor modifications are normally limited to:

111.1.1 The correction of typographical errors.

111.1.2 Transfer of ownership or operational control.

111.1.3 A change in monitoring or reporting frequency.

111.2 Major Modifications. All modifications not considered minor shall be considered major modifications. The procedure for making major modifications shall be the same as that used for a new permit under these regulations.

112.0 Permit Transferable.

Permits shall be transferable to a new owner or operator provided that the permittee notifies the Department by requesting a minor modification of the permit before the date of transfer and provided that the transferee shows evidence of a legal right to use the site and is otherwise in compliance with all applicable provisions of these regulations.

113.0 Appeal of Final Permits.

Appeals of final permit shall be governed by 7 **Del.C.** §§6008 and 6009.

114.0 Permit Revocation.

114.1 Conditions for Revocation.The Department may revoke a permit if the permittee violates any permit condition or these regulations or fails to pay applicable Department fees.

114.2 Notice of Revocation. Except in cases of emergency, the Department shall issue a written notice of intent to revoke to the permittee prior to final revocation. Revocation shall become final within twenty (20) days of receipt of the notice by the permittee, unless within that time the permittee requests an administrative hearing in writing.

114.3 Notice of Hearing.The Department shall notify the permittee in writing of any revocation hearing at least twenty (20) days prior to the date set for such hearing. The hearing shall be conducted in accordance with 7 **Del.C.** Chapter 60.

114.4 Emergency Action. If the Department finds the public health, safety or welfare requires emergency action, the Department shall incorporate findings in support of such action in a written notice of emergency revocation issued to the permittee. Emergency revocation shall be effective upon receipt by the permittee. Thereafter, if requested by the permittee in writing, the Department shall provide the permittee a revocation hearing and prior notice thereof. Such hearings shall be conducted in accordance with 7 **Del.C.** Chapter 60.

115.0 Procedures for State Review and Approval

115.1 Proposal for a Sludge Utilization Permit.

115.1.1 Any person who intends to utilize sludge or sludge products must submit a letter of intent to the Department. The letter shall indicate the projected location, size, and anticipated utilization method. The steps in subsection 118.0 provide the prospective permit applicant with an overview of the entire Department process. Whenever the preparation of reports or other documents required by these regulations involves the practice of engineering, geology or other recognized profession under Delaware law, sufficient evidence of appropriate certification or registration in accordance with Title 24 of the Delaware Code must be submitted by the preparer.The guidance document included with these regulations should be used to tailor the design criteria for the specific waste, process, use, or site under consideration.

116.0 Table 402-1 Range of Organic Priority Pollutants Typical of Municipal Sludge in the U.S.

Volatile Compounds (Purgeable)	Parts Per Million Concentration (Dry Weight Basis)	
Benzene	0.29	-7.3
Carbon tetrachloride	0.9	-22
Chlorobenzene	0.23	-5.8
Chloroform	0.17	-4.2
1,2-Dichloroethane	5	-125
Methylene Chloride	1.7	-43
Tetrachloroethylene	0.69	-17
Toluene	340	-8,600
Trichloroethylene	1.8	-46
Vinyl chloride	7.1	-180
ACID COMPOUNDS (ACID EXTRACTABLE)		
Pentachlorophenol	2.1	-52
Phenol	39	-96
2,4,6-Trichlorophenol	0.46	-12
BASE/NEUTRAL COMPOUNDS (BASE/NEUTRAL EXTRACTABLE)		
Benzo (a)anthracene	1.8	-46
Benzo(a)pryene	51	-1300
bis(2-Ethylhexyl)phthalate	32	-790
Chrysene	1.7	-42
3,3-Dichlorobenzidine	0.33	-8.2
Hexachlorobenzene	0.25	-6.2
Hexachlorobutadiene	0.9	-22
n-Nitrosodimethylamine	0.008	-0.2
Phenanthrene	1.2	-30
Pyrene	1.4	-34
PESTICIDES AND PCB'S		
Aldrin	0.03	-0.75
Gamma-BHC(Lindane)	0.004	-0.01
Chlordane	0.6	-15
2,4-D		-23
4,4-DDT	0.056	-1.4
4,4-DDE	0.0012	
4,4-DDD	0.042	-1
Dieldrin	0.004	-0.1
Endrin	ND	
Heptachlor	0.004	-0.1
Malathion	0.13	-3.2
PCB's	6	-50*
Tpxaphene	1.6	-39

116.1 Range encompasses 50% of data for organic compounds found in several U.S. analytical studies (adopted from Fricke, C., C. Clarkson, E. Lomnitz, and T. O'Farrell, 1985. Comparing priority pollutants in municipal sludges, Biocycle, Jan/Feb: 35-37).
Note:*Sludges containing more than 10 ppm of PCB's must be incorporated into the soil upon application, and sludges containing more than 50 ppm of PCBs are subject to TOSCA requirements.

116.2 Table 402.2 Ceiling Concentrations Table 402.3 Pollutant Concentrations

TABLE 402.2 CEILING CONCENTRATIONS		TABLE 402.3 POLLUTANT CONCENTRATIONS	
Pollutant	**Ceiling concentration (milligrams per kilogram))[1]**	**Pollutant**	**average concentration (milligrams per kilogram)[1]**
Arsenic	75	Arsenic	41
Cadmium	85	Cadmium	39
Chromium	3000	Chromium	1200
Copper	4300	Copper	1500
Lead	840	Lead	300
Mercury	57	Mercury	17
Molybdenum	75	Molybdenum	17
Nickel	420	Nickel	420
Selenium	100	Selenium	36
Zinc	7500	Zinc	2800

[1]Dry weight basis [1]Dry weight basis

TABLE 402.4 CUMULATIVE POLLUTANT LOADING RATES		TABLE 402.5 ANNUAL POLLUTANT LOADING RATE	
Pollutant	**Cumulative Polluatnt Loading Rate (kilograms per hectare)**	**Pollutant**	**Annual Pollutant Loading Rate (kilograms per heactare per 365 day period)**
Arsenic	41	Arsenic	2.0
Cadmium	39	Cadmium	1.9
Chromium	3000	Chromium	150
Copper	1500	Copper	75
Lead	300	Lead	15
Mercury	17	Mercury	0.85
Molybdenum	18	Molybdenum	0.95
Nickel	420	Nickel	21
Selenium	100	Selenium	5.0
Zinc	2800	Zinc	140

117.0 Project Development Report:

117.1 General Requirements.

117.1.1 A Project Development Report must be prepared. After this report is submitted for Department review, and accepted, it becomes the basis for the permit application. In any event, the applicant must demonstrate that the proposed facility, site or use will meet the regulatory objectives set forth in in these regulations

and will not cause violations of State or Federal drinking water standards on an average annual basis or State water quality standards for streams.

117.1.2 Upon receipt of a Project Development Report, the Department will schedule a public information meeting to inform interested citizens of the proposed utilization project. The Department may consider local zoning or other locally required meetings as sufficient for satisfying this requirement. After the Department has fixed the date, place and time for a public information meeting, the Department shall notify by certified mail owners and occupants of land contiguous to the site of the proposed facility or site and of the scheduled meeting. A copy of the Project Development Report will be available for review and discussion at the public meeting. The applicant for the permit shall also be present at the public meeting to present information on the proposed project.

117.1.3 The Department will accept and consider all comments, concerns and suggestions received during the public meeting. If the concerns raised at the public meeting cannot be reasonably addressed, a permit will not be issued for the proposed project.

117.2 Project Development Reports for all proposed facilities, land application sites and sludge uses must provide a chemical analysis of the sludge to be produced or utilized which includes the following:

117.2.1 Results of three chemical analyses of the sludge from each treatment facility or other source of sludge. The Department will waive this requirement for domestic septage that is land applied in accordance with the State's Septage Management Plan. Chemical analyses include:

117.2.1.1 Moisture content.

117.2.1.2 Percent total nitrogen (moist and dried).

117.2.1.3 Percent organic nitrogen (moist and dried).

117.2.1.4 Ammonia and nitrate concentration (moist and dried).

117.2.1.5 pH.

117.2.1.6 Percent volatile solids.

117.2.1.7 PCB's.

117.2.1.8 The following, as reported on a dry weight basis: cyanide, sodium, calcium, magnesium, phosphorous, potassium, cadmium, zinc, copper, nickel, lead, chromium, mercury, arsenic, molybdenum and selenium.

117.2.1.9 Such other components or constituents which may be required by the Department, including but not limited to TOC, COD, FOG, and boron.

117.2.2 Sludges are to be analyzed as a composite sample for the priority pollutants. If the organics are higher than the typical municipal sludge range in the U.S. (see Table 402-1) then the Department shall require the applicant to submit a detailed sludge analysis for those elevated organic constituents to assess their fate in a soil matrix.

117.2.3 Sludges are to be analyzed as a composite sample using the Toxicity Characteristic Leaching Procedure (TCLP). Any sludge that fails the TCLP test shall be deemed to be hazardous and will then be subject to regulations under Subtitle C of the Resource Conservation and Recovery Act (RCRA).

117.2.4 For septage, a specific plan for obtaining representative samples may be required.

117.2.5 No sludge or sludge product which exceeds the Ceiling Concentrations in Table 402.2 will be permitted for land application in the State. Sludge or sludge products which exceed the Pollutant Concentrations in Table 402.3 will not be permitted for marketing and distribution in the State. Application rates for any sludge may not exceed the values in Tables 402.4 and Table 402.5.

117.2.6 The analyses shall be conducted on composite samples of the waste to be applied, and shall be reported in a tabular form that lists the range of the three samples. Each of the composite samples shall be taken at intervals of more than 30 days unless otherwise approved by the Department in writing. Sampling and analytical procedures shall be approved by the Department and be consistent with Section 1000 of these Regulations.

118.0 Project Development Reports: Specific Requirements for Facilities.

A permit is required for the construction and operation of any sludge handling, storage, processing or treatment operation. Such facilities include, but are not limited to: composting, alkaline stabilization or heat drying facilities, storage lagoons or tanks, and disposal sites. Information required for the Project Development Report includes:

118.1 Maps and related information.

118.1.1 A topographic map or maps on a scale not less than a USGS 7.5 minute series or equivalent, including any necessary narrative descriptions, which show the following:

118.1.1.1All boundaries and names of present owners of record of land and including easements, rights of way, and other property interests, for the proposed permit area and contiguous area; and a description of all title, deed, or usage restrictions affecting the proposed permit area.

118.1.1.2Latitude and longitude of site

118.1.1.3The boundaries of any land where sludge or sludge product will be stored at various times over the estimated total life of the proposed operation.

118.1.1.4The location and name of any domestic wells within 1000 feet and irrigation, commercial, industrial and public wells within 2500 feet of the outer edge of the buffer zone as defined in 137.4. Information may be obtained (for a fee) through the Department from the Delaware Water User Data System (DWUDS).

118.1.1.5Other information that the Department deems relevant or necessary.

118.1.2 A soil map which shows the locations and types, and engineering properties of soils found within the proposed permit area and which includes a report on the field investigations conducted by a registered Engineer or Professional Soil Scientist depicting soils conditions on the site. This element should be prepared and submitted to the Department early in the process so that unsuitable sites/areas can be eliminated from further analysis.

118.2 Ground water information. The Project Development Report shall contain a description of the ground water hydrology of the proposed site and adjacent area.

118.2.1 The following information shall be prepared by a Geologist, Hydrologist or a Professional Engineer qualified in hydrology and licensed to practice in the State of Delaware.

118.2.1.1A map of the site and surrounding area showing all potential contamination sources (such as large on-site systems, feedlots, bulk storage facilities, etc.). Surface water bodies within 1,000 feet of the site boundary of the proposed sludge application area shall also be located.

118.2.1.2Description of the geology of the area, including the lithology and thickness of the outcropping and subcropping or underlying formations. Any unique or important geomorphological features which could influence ground water flow directions should also be indicated.

118.2.1.3The following hydrogeological information should be provided to the Department:

118.2.1.3.1 The thickness, saturated thickness, and depth to water (DTW) of the water table aquifer. The depth to water measurement should indicate the level of the local seasonal high water table.

118.2.1.3.2 The DTW of the seasonal high water table formed by a perched water table when these water table types exist.

118.2.1.3.3 The thickness, lithology, and name of the geological formation which forms the first aquitard of aquiclude beneath the water table aquifer.

118.2.1.3.4 The name of the first confined aquifer beneath the ground surface including the name(s) of the formation(s) composing this aquifer.

118.2.1.3.5 A description of the ground water flow patterns under the proposed site. A hydraulic head contour map with ground water flow lines should be included in the description. When the direction of the ground water flow cannot be determined with any degree of confidence, observation wells (piezometers) in numbers sufficient enough to determine ground water flow direction will be required.

118.2.1.3.6 Reference must be provided for all the geological and hydrogeological information which was researched.

118.3 Surface water information.

118.3.1 Each Project Development Report shall contain a description of the surface waters in the proposed site and adjacent area, including the name of the watershed which will receive any water discharges, the location of all surface water bodies such as streams, lakes, ponds, and descriptions of major surface drainage systems within the proposed permit area and adjacent areas.

118.3.2 Each Project Development report shall also include a plan to manage runoff and control erosion during the lifetime of the facility. These plans will use best management practices for nonpoint source pollution control such as developed by the USDA Natural Resources Conservation Service (NRCS).

118.4 Detailed Construction Specifications - Each Project Development Report shall include drawings of proposed site layout, plan and elevation view of structures, equipment layout, facility access, and construction site erosion and sediment controls, stamped by an engineer registered in the state of Delaware.

118.5 Plan of Operation and Management - Each plan shall contain a narrative description of the following:

118.5.1 Explaining the type of operation to be conducted at the proposed facility.

118.5.2 Detailing the operation and processing steps of the proposed facility; the expected life of the operation; and the origin, dry weight and volume of sludge that are proposed to be utilized during the operation.

118.5.3 The equipment to be used at the facility for handling, storage, processing and treatment (including mixing, air control, bagging and monitoring the sludge or sludge products), or site preparation and land disposal of sludge.

118.5.4 The closure plan and future use of the site if the facility ceases operation.

118.5.5 A control plan to prevent health hazards or nuisances.

118.5.6 For disposal sites, a crop nitrogen balance, the proposed application rate per acre and management scheme, crops to be grown; phosphorus and other constituent loading rates; determination of land limiting constituent; acreage needed and required storage volume, if any; and the dates (or climatic conditions) when the applicant proposes to apply sludge.

118.5.7 Material Safety Data Sheets

118.6 Endangered Species Assessment - No facility may be constructed or operated in a manner likely to adversely affect a threatened or endangered species listed under section 4 of the Endangered Species Act or its designated critical habitat. An endangered or threatened species and impact report is required.

118.7 Additional requirements for land disposal sites

118.7.1 Each Project Development Report shall contain a description of:

118.7.1.1 Soils within the proposed permit area, including a description of the depth, matrix, color, texture, structure, pH, consistency, degree of mottling and, if present mottled colors and coarse fragment content for each horizon of soil from the surface to a depth of at least five (5) feet or bedrock, whichever is shallower.

118.7.1.2 Any subsurface conditions adversely affecting lateral or vertical drainage of the land.

118.7.1.3 A delineation of soil areas at the site which are not suitable for land application of sludge.

118.7.1.4 The applicant shall base the description on a sufficient number of pits, hand augerings, or excavations to allow an accurate characterization of the soils within the proposed permit area. As a minimum, however, the Department requires that at least one sample be taken for every 5 to 10 acres of each soil series to confirm NRCS.

118.7.2 All classifications and interpretations of soil materials required by this section shall be based on criteria specified in the United States Department of Agriculture Handbooks 436 (Soil Taxonomy) and 18 (Soil Survey Manual).

118.7.3 The Project Development Report shall include a minimum of three chemical analyses for each major soil series at the proposed facility. Soil chemistry testing must be in accordance with the Methods of Soil Analysis published by the American Society of Agronomy, or otherwise shall be consistent with Department guidance and the requirements of Section 1000. Results are to be expressed on a dry soil basis. The constituents to be tested are pH, cation exchange capacity, percent organic matter, plant nutrient status, total cadmium, total copper, total lead, total nickel, total zinc, total arsenic, total selenium and total molybdenum.

118.7.4 For sites where sludge was previously applied within 5 years to the proposed permit area, the application shall also describe background concentrations for all constituents identified above for similar soils where sludge has not been applied.

118.7.5 The information required by this section shall be prepared by qualified persons in soil science or land treatment.

118.8 Additional requirements for sludge storage facilities are identified in section 900.

119.0 Project Development Reports: Specific Requirements for Land Application Sites.

Sludge or sludge products which meet the minimum quality criteria of Subsection 117.0 and Section 600, but do not meet Exceptional Quality criteria for marketing and distribution, may only be applied to sites permitted for land application. Land application to permitted sites may be for agricultural, silvicultural, reclamation or research purposes. The following information is required in the Project Development Report for each land application site:

119.1 Maps and related information.

119.1.1 Each Project Development Report shall contain a topographic map or maps on a scale not less than a USGS 7.5 minute series or equivalent, including any necessary narrative descriptions, which show the following:

119.1.1.1 Latitude and longitude of the site.

119.1.1.2 All boundaries and names of present owners of record of land and including easements, rights of way, and other property interests, for the proposed permit area and contiguous area; and a description of all title, deed, or usage restrictions affecting the proposed permit area.

119.1.1.3 The boundaries of the land where sludge will be utilized over the estimated total life of the proposed operation, including the boundaries of the land that will be affected in each sequence of sludge utilization activity.

119.1.1.4 The boundaries of any land where sludge or sludge product will be stored at various times over the estimated total life of the proposed operation.

119.1.1.5 The location and name of any domestic wells within 1000 feet and irrigation, commercial, industrial and public wells within 2500 feet of the outer edge of the buffer zone as defined in 137.4. Information may be obtained (for a fee) through the Department from the Delaware Water User Data System (DWUDS).

119.1.1.6 The location and type of existing or proposed erosion control practices following NRCS guidelines.

119.1.1.7 Other information that the Department deems relevant or necessary.

119.1.2 Each Project Development Report shall contain a *NRCS* soil map which shows the locations and types of soils, depth to ground water, and depth to impermeable strata within the proposed permit area.The Department may require additional detailed mapping and soils investigations conducted by a Professional Soil Scientist registered with the American Registry of Certified Professionals in Agronomy, Crops and Soils (ARCPACS). This element should be prepared and submitted to the Department early in the process so that unsuitable sites/areas can be eliminated from further analysis.

119.2 Soils description.

119.2.1 Each Project Development Report shall contain a description of:

119.2.1.1 Soils within the proposed permit area, including a description of the depth, matrix, color, texture, structure, pH, consistency, degree of mottling and, if present mottled colors and coarse fragment content for each horizon of soil from the surface to a depth of at least five (5) feet or bedrock, whichever is shallower.

119.2.1.2 Any subsurface conditions adversely affecting lateral or vertical drainage of the land.

119.2.1.3 A delineation of soil areas at the site which are not suitable for land application of sludge.

119.2.1.4 The applicant shall base the description on a sufficient number of pits, hand augerings, or excavations to allow an accurate characterization of the soils within the proposed permit area. As a minimum, however, the Department requires that at least one sample be taken for every 5 to 10 acres of each soil series to confirm NRCS.

119.2.2 All classifications and interpretations of soil materials required by this section shall be based on criteria specified in the United States Department of Agriculture Handbooks 436 (Soil Taxonomy) and 18 (Soil Survey Manual).

119.2.3 The Project Development Report shall include a chemical analyses for each major soil series per field at the proposed site. Soil chemistry testing must be in accordance with the Methods of Soil Analysis published by the American Society of Agronomy, or otherwise shall be consistent with Department guidance. Results are to be expressed on a dry soil basis. The constituents to be tested are pH, cation exchange capacity, percent organic matter, plant nutrient status, total cadmium, total copper, total lead, total nickel, total zinc.

119.2.4 For sites where sludge was previously applied within 5 years to the proposed permit area, the application shall also describe background concentrations for all constituents identified above for similar soils where sludge has not been applied.

119.2.5 The information required by this section shall be prepared by qualified persons in soil science or land treatment.

119.3 Ground water information. The Project Development Report shall contain a description of the ground water hydrology of the proposed site and adjacent area. The following information shall be prepared by a Geologist or a Professional Engineer qualified in hydrology and licensed to practice in the State of Delaware.

119.3.1 A map of the site and surrounding area showing all potential contamination sources (such as large on-site systems, feedlots, bulk storage facilities, etc.). Surface water bodies within 1,000 feet of the site boundary of the proposed sludge application area shall also be located.

119.3.2 Description of the geology of the area, including the lithology and thickness of the outcropping and subcropping or underlying formations. Any unique or important geomorphological features which could influence ground water flow directions should also be indicated.

119.3.3 The following hydrogeological information should be provided to the Department:

119.3.3.1 The thickness, saturated thickness, and depth to water (DTW) of the water table aquifer. The depth to water measurement should indicate the level of the local seasonal high water table.

119.3.3.2 The DTW of the seasonal high water table formed by a perched water table when these water table types exist.

119.3.3.3 The thickness, lithology, and name of the geological formation which forms the first aquitard of aquiclude beneath the water table aquifer.

119.3.3.4 The name of the first confined aquifer beneath the ground surface including the name(s) of the formation(s) composing this aquifer.

119.3.4 A description of the ground water flow patterns under the proposed site. A hydraulic head contour map with ground water flow lines should be included in the description. When the direction of the ground water flow cannot be determined with any degree of confidence, observation wells (piezometers) in numbers sufficient enough to determine ground water flow direction *may* be required.

119.3.5 Reference must be provided for all the geological and hydrogeological information which was researched.

119.4 Surface water information.

119.4.1 Each Project Development Report shall contain a description of the surface waters in the proposed site and adjacent area, including the name of the watershed which will receive any water discharges, the location of all surface water bodies such as streams, lakes, ponds, and descriptions of major surface drainage systems within the proposed permit area and adjacent areas.

119.4.2 Each Project Development report shall also include a plan to manage runoff and control erosion during the lifetime of the facility. These plans will use best management practices for nonpoint source pollution control such as developed by the *NRCS*.

119.5 Plan of Operation and Management - each Project Development Plan shall contain a narrative description of the following:

119.5.1 The origin, annual production (dry weight and volume) and pathogen reduction method for the proposed sludge source.

119.5.2 The type of operation (e.g. agricultural, silvicultural, reclamation or research) to be conducted at the proposed site, and the expected life of the operation.

119.5.3 The equipment to be used for site preparation, sludge handling, and land application.

119.5.4 A projected three year crop rotation plan, including type of farming operation, type of crop, planting sequence, crop management, and use of the crops.

119.5.5 Crop fertility worksheets for each field including: a nitrogen balance and the proposed sludge or septage application rate per acre (calculated according to the requirements of Subsection 702.1); phosphorus loading rate; lime loading rate; and a determination of the most limiting constituent, for land application for each sludge source.

119.5.6 The expected dates and climatic conditions when sludge will be land applied.

119.5.7 A control plan to prevent health hazards or nuisances and odors.

119.5.8 A sludge sampling plan documenting how the applicant will comply with the monitoring and record keeping and reporting requirements of Section 700.

119.5.9 A map showing the location of any ground water monitoring devices if they exist or are proposed for the facility.

119.5.10 Evidence of landowner and operator consent for the proposed operation.

119.6 Endangered Species Assessment - no sludge or products derived from sludge shall be applied to land in a manner likely to adversely affect a threatened or endangered species or its designated habitat. An endangered or threatened species impact report may be required.

119.7 Additional requirements for land reclamation sites:

119.7.1 A complete revegetation plan for the site, including methods of site preparation, seeding mixtures, and seeding rates.

119.7.2 Calculations or modeling demonstrating that the Cumulative Pollutant Loading Rates established by these regulations (see Table 402.4) shall not be exceeded.

119.8 Additional requirements for Research Projects:

119.8.1 Applications for permits shall include five copies of a complete description of the project. After a preliminary review, the Department may request such additional information as is necessary to evaluate and document the project.

119.8.2 As a condition of any permit under this section the titleholder must execute and record in the appropriate County Office of Recorder of Deeds an affidavit in a form approved by the Department which notifies prospective purchasers that the property has been used to conduct sludge utilization research.

120.0 Project Development Reports: Specific Requirements for Marketing and Distribution of Exceptional Quality Sludge or Sludge Products

Sewage sludge or sludge products that contain sewage sludge which has been stabilized as per Subsection 603 by a Process to Further Reduce Pathogens, meets one of the Vector Attraction Reduction Requirements specified in Subsection 88.2.1 through 88.2.8 and contains lower metal concentrations than the allowable Pollutant Concentration specified Table 402.3 may be marketed and distributed in the State. Specific information required for the Project Development Report includes:

120.1 Identification of the site(s) where the Exceptional Quality sludge or sludge product is generated. A description of the source and quantity of sludge or sludge products generated.

120.2 A detailed description of the treatment process and facility equipment, which clearly explains how the end-product is treated to meet the Exceptional Quality criteria.

120.3 A description of the quality control and monitoring program(s) utilized at the facility.

120.4 A description of the record keeping and reporting system used at the facility producing the exceptional quality material.

120.5 A copy of the proposed label which includes the following information:

120.5.1 It shall identify the product as containing sludge and provide the name and address of the preparer.

120.5.2 Provide information on essential plant nutrient content and instructions for proper use on different plant types, soils and slopes, maximum loading rates (such as number of square feet per bag, ratio of sludge to soil in sludge-soil mixture, etc.).

120.5.3 For sludge or sludge products for general distribution to the public which contain more than 4 percent iron on a dry weight basis, it shall warn against using the sludge or sludge product on pasture land.

120.5.4 Describe proper procedures for storage and stockpiling of the material.

120.5.5 A statement indicating that the product should not be applied to any site that is flooded, frozen or snow covered, and identify any unacceptable uses of the material.

120.5.6 Shall include a statement that land application of sewage sludge is prohibited except in accordance with the instructions on the label or information sheet.

120.6 Information confirming that all requirements of the Delaware Department of Agriculture Regulations (Chapter 21, Title 3, **Delaware Code**) governing the sale of commercial fertilizers and soil conditioners have been met.

121.0 Site Inspection and Concurrence.

The Project Development Report is submitted for Department review along with a request for general site concurrence.Upon receipt of the report, a Department representative will inspect the selected site(s) and a written site concurrence or denial letter will be sent to the applicant. Upon receipt of a site concurrence the applicant may submit a permit application. Site concurrences for land treatment of sludges are valid for one year.

122.0 Facility Plans and Specifications.

After Department acceptance of the permit application and completed Project Development Report (prepared under Subsection 118.0), the applicant must submit final detailed plans and specifications. The plans and specifications will be reviewed for consistency with the Project Development Report and accepted engineering standards.

123.0 Approval to Commence Operations.

Upon final Departmental review and approval of any required revisions to the Project Development Plan, a permit and a letter of authorization to commence operation will be issued on a timely basis. The Department shall give notice of such approval to any person who has submitted a written request for such notice.

124.0 Bonding

125.0 Bond Required.

Unless excepted under the provisions of Subsection 126.0, as a requirement for keeping a Permit issued under these regulations, a person shall file with the Department a bond or other security in a form approved by the Department. The bond shall be payable to the Department and the obligation of the bond shall be conditioned upon the fulfillment of all requirements related to the permit.

126.0 Exceptions.

Bond is not required for the following persons or entities:

126.1 A landfill, which is owned and operated by the Delaware Solid Waste Authority pursuant to state laws and regulations;

126.2 Persons using treated sludge that complies with all the requirements for distribution of these regulations and that is distributed in accordance with a valid permit issued by the Department;

126.3 Any local, municipal, county, state, or federal governmental agency, or political subdivision; or

126.4 Septage land treatment systems utilizing a limited application rate of 7,100 gallons per acre per year or less.

127.0 Amount of Bond.

The amount of the bond shall be:

127.1 $5,000 for transportation permits and research projects;

127.2 $25,000 for permits to apply sludge to land at agricultural rates;

127.3 $50,000 for permits to land apply sludge for land reclamation;

127.4 $125,000 for land disposal facilities;

127.5 $75,000 for projects other than those in Subsection 127.4.

127.6 $10,000 for distribution and marketing.

128.0 Consolidation of Bonds.

For permits to apply sludge to land at agricultural rates or at land reclamation rates the Department may allow a sludge utilizer to file one bond to cover more than one utilization site. The amount of the bond shall be the amount shown in Subsection 127.0 for the first site plus 40 percent of the amount shown in Subsection 127.0 for each additional site up to a minimum total of $200,000.

129.0 Liability.

Liability under the bond shall remain in effect until the expiration date of the permit. The Department shall release the bond after the Department determines that all of the conditions of the permit or permits covered by the bond have been fulfilled.

130.0 Execution and Payment of Bond.

130.1 The bond shall be executed by the applicant and by a corporate surety licensed to do business in this State. Instead of having a bond executed by a corporate surety, the applicant may elect to deposit, with the Department, cash or negotiable bonds of the federal government or of this State or any other securities acceptable to the Department. The amount of the cash deposit or the market value of any securities shall be at least equal to the required sum of the bond. The Department shall receive and hold the cash or securities in trust, for the purposes for which the deposit is posted.

130.2 The obligation of the applicant and of any corporate surety under the bond shall become due and payable, and all or any part of any cash or securities shall be applied to payment of the costs of properly fulfilling any requirement of the Permit if the Department has:

130.2.1 Notified the applicant and any corporate surety that the conditions of the Permit have not been fulfilled, and specified in the notice the particular deficiencies in the fulfillment of the permit conditions;

130.2.2 Given the applicant and any corporate surety a reasonable opportunity to correct the deficiencies and to fulfill all of the conditions of the permit; and

130.2.3 Determined that, at the end of a reasonable length of time, some or all of the deficiencies specified under Subsection 130.2.1, above, remain uncorrected.

131.0 Pathogens and Vector Attraction Reduction Requirements.

132.0 Requirements for Pathogen Control.

132.1 All sewage sludges and domestic septage prepared for land application in Delaware must at a minimum be treated by one of the processes described in this section to significantly reduce pathogens (PSRP). Sludges treated to meet PSRP requirements will be defined as Class B sludges for the purpose of these regulations.

132.2 All sewage sludges prepared for Distribution and Marketing in Delaware must be treated by one of the processes to further reduce pathogens as described in the section (PFRP). Sludges treated to meet the PFRP requirements will be defined as Class A sludges for the purpose of these regulations.

132.3 Any sewage sludge or domestic septage prepared in a manner to meet the Class A or Class B requirements of this section must also meet the additional requirements found in these regulations prior to being applied to land, given away or sold in bulk or bag.

133.0 Class B Sludge - Sewage sludges processed to Significantly Reduce Pathogens (PSRP). (Septage included herein as sewage sludge)

133.1 Sludges prepared to meet the Class B requirements of this section must be processed by means of one of the following alternatives:

133.1.1 Class B Alternative 1.

133.1.1.1 Seven samples of the sewage sludge shall be collected at the time the sewage sludge is used or disposed.

133.1.1.2 The geometric mean of the density of fecal coliform in the samples shall be less than either 2,000,000 Most Probable Number per gram of total solids (dry weight basis) or 2,000,000 Colony Forming Units per gram of total solids (dry weight basis).

133.1.2 Class B Alternative 2.

133.1.2.1 Aerobic digestion - Sewage sludge is agitated with air or oxygen to maintain aerobic conditions for a specific mean cell residence time at a specific temperature. Values for the mean cell residence time and temperature shall be between 40 days at 20 degrees Celsius and 60 days at 15 degrees Celsius.

133.1.2.2 Air drying - Sewage sludge is dried on sand beds or on paved or unpaved basins. The sewage sludge dries for a minimum of three months. During two of the three months, the ambient average daily temperature is above zero degrees Celsius.

133.1.2.3 Anaerobic digestion - Sewage sludge is treated in the absence of air for a specific mean cell residence time at a specific temperature. Values for the mean cell residence time and temperature shall be between 15 days at 35 to 55 degrees Celsius and 60 days at 20 degrees Celsius.

133.1.2.4 Composting - Using either the within-vessel, static aerated pile or windrow composting methods, the temperature of the sewage sludge is raised to 40 degrees Celsius or higher and remains at 40 degrees Celsius or higher for five days. For four hours during the five days, the temperature in the compost pile exceeds 55 degrees Celsius.

133.1.2.5 Lime stabilization - Sufficient lime is added to the sewage sludge to raise the pH of the sewage sludge to 12 after 2 hours of contact.

133.1.3 Class B - Alternative 3. Sewage sludge that is used or disposed shall be treated in a process that is equivalent to a Process to Significantly Reduce Pathogens, as determined by the Department.

133.2 Monitoring and Reporting.

133.2.1 Sludge processed to significantly reduce pathogens must be monitored in accordance with the requirements described in the alternative used. Additional monitoring may be required by the Department as a condition of the preparer's permit.

133.2.2 The preparer must submit a report of process monitoring on a form provided by the Department. The frequency of reporting shall conform with the reporting frequency specified in Section 701 of the regulations or as specified in any permit issued for preparation.

134.0 Class A Sludge - Sludges processed to further reduce pathogens (PFRP).

134.1 Sludges prepared to meet Class A requirements must be processed by means of one of the following alternatives. The Class A pathogen requirements in Subsection 134.1.1 through 134.1.5 shall be met either prior to meeting or at the same time the vector attraction reduction requirements in Subsection 135.0 (except for 135.6, 7, 8,) are met.

134.1.1 Class A - Alternative 1.

134.1.1.1 Either the density of fecal coliform in the sewage sludge shall be less than 1000 Most Probable Number per gram of total solids (dry weight basis), or the density of *SALM*onella sp. bacteria in the sewage sludge shall be less than three Most Probable Number per four grams of total solids (dry weight basis) at the time the sewage sludge is prepared for sale or give away in as bag or other container for application to the land; or at the time the sewage sludge or material derived from sewage sludge is prepared to meet the requirements in Section 700.

134.1.1.2 The temperature of the sewage sludge that is used or disposed shall be maintained at a specific value for a period of time.

134.1.1.2.1 When the percent solids of the sewage sludge is seven percent or higher, the temperature of the sewage sludge shall be 50 degrees Celsius or higher; the time period shall be 20 minutes or longer; and the temperature and time period shall be determined using equation (2), except when small particles of sewage sludge are heated by either warm gases or an immiscible liquid. Where,

D = time in days.

t = temperature in degrees Celsius.

134.1.1.2.2 When the percent solids of the sewage sludge is seven percent or higher and small particles of sewage sludge are heated by either warmed gases or an immiscible liquid, the temperature of the sewage sludge shall be 50 degrees Celsius or higher; the time period shall be 15 seconds or longer; and the temperature and time period shall be determined using equation 2.

134.1.1.2.3 When the percent solids of the sewage sludge is less than seven percent and the time period is at least 15 seconds but less than 30 minutes, the temperature and time period shall be determined using equation (2).

134.1.1.2.4 When the percent solids of the sewage sludge is less than seven percent; the temperature of the sewage sludge is 50 degrees Celsius or higher; and the time period is 30 minutes or longer, the temperature and time period shall be determined using equation (3). Where,

D = time in days.

t = temperature in degrees Celsius.

134.1.2 Class A - Alternative 2.

134.1.2.1Either the density of fecal coliform in the sewage sludge shall be less than 1000 Most Probable Number per gram of total solids (dry weight basis), or the density of Salmonella sp. bacteria in the sewage sludge shall be less than three Most Probable Number per four grams of total solids (dry weight basis) at the time the sewage sludge is used or disposed; at the time the sewage sludge is prepared for sale or give away in a bag or other container for application to the land; or at the time the sewage sludge or material derived from sewage sludge is prepared to meet the requirements in Section 700.

134.1.2.2

134.1.2.2.1 The pH of the sewage sludge that is used or disposed shall be raised to above 12 and shall remain above 12 for 72 hours.

134.1.2.2.2 The temperature of the sewage sludge shall be above 52 degrees Celsius for 12 hours or longer during the period that the pH of the sewage sludge is above 12.

134.1.2.2.3 At the end of the 72 hour period during which the pH of the sewage sludge is above 12, the sewage sludge shall be air dried to achieve a percent solids in the sewage sludge greater than 50 percent.

134.1.3 Class A - Alternative 3.

134.1.3.1Either the density of fecal coliform in the sewage sludge shall be less than 1000 Most Probable Number per gram of total solids (dry weight basis), or the density of *Salmonella sp.* bacteria in sewage sludge shall be less than three Most Probable Number per four grams of total solids (dry weight basis) at the time the sewage sludge is used or disposed; at the time the sewage sludge is prepared for sale or give away in a bag or other container for application to the land; or at the time the sewage sludge is prepared to meet the requirements of Section 700.

134.1.3.1.1

134.1.3.2The sewage sludge shall be analyzed prior to pathogen treatment to determine whether the sewage sludge contains enteric viruses.

134.1.3.2.2 When the density of enteric viruses in the sewage sludge prior to pathogen treatment is less than one Plaque-forming Unit per four grams of total solids (dry weight basis), the sewage sludge is Class A with respect to enteric viruses until the next monitoring episode for the sewage sludge.

134.1.3.2.3 When the density of enteric viruses in the sewage sludge prior to pathogen treatment is equal to or greater than one Plaque-forming Unit per four grams of total solids (dry weight basis), the sewage sludge is Class A with respect to enteric viruses when the density of enteric viruses in the sewage sludge after pathogen treatment is less than one Plaque-forming Unit per four grams of total solids (dry weight basis) and when the values or ranges of values for the operating parameters for the pathogen treatment process that produces the sewage sludge that meets the enteric virus density requirement are documented.

134.1.3.2.4 After the entric virus reduction in paragraph 134.1.3.2.3of this section is demonstrated for the pathogen treatment process, the sewage sludge continues to be Class A with respect to enteric viruses when the values for the pathogen treatment process operating parameters are consistent with the values or ranges of values documented in paragraph 134.1.3.2 of this section.

134.1.3.3

134.1.3.3.1 The sewage sludge shall be analyzed prior to pathogen treatment to determine whether the sewage sludge contains viable helminth ova.

134.1.3.3.2 When the density of viable helminth ova in the sewage sludge prior to pathogen treatment is less than one per four grams of total solids (dry weight basis), the sewage sludge is Class A with respect to viable helminth ova until the next monitoring episode for the sewage sludge.

134.1.3.3.3 When the density of viable helminth ova in the sewage sludge prior to pathogen treatment is equal to or greater than one per four grams of total solids (dry weight basis), the sewage sludge is Class A with respect to viable helminth ova when the density of viable helminth ova in the sewage sludge after pathogen treatment is less than one per four grams of total solids (dry weight basis) and when the values or ranges of values for the operating parameters for the pathogen treatment process that produces the sewage sludge that meets the viable helminth ova density requirement are documented.

134.1.3.3.4 After the viable helminth ova reduction in 134.1.3.2.3 of this subsection is demonstrated for the pathogen treatment process, the sewage sludge continues to be Class A with respect to viable helminth ova when the values for the pathogen treatment process operating parameters are consistent with the values or ranges of values documented in 134.1.3.2.3 of this subsection.

134.1.4 Class A - Alternative 4.

134.1.4.1Either the density of fecal coliform in the sewage sludge shall be less than 1000 Most Probable Number per gram of total solids (dry weight basis), or the density of Salmonella sp. bacteria in the sewage sludge shall be less than three Most Probable Number per four grams of total solids (dry weight basis) at the time the sewage sludge is used or disposed; at the time the sewage sludge is prepared for sale or give away in a bag or other container for application to the land; or at the time the sewage sludge or material derived from sewage sludge is prepared to meet the requirements in Section 700.

134.1.4.2The density of enteric viruses in the sewage sludge shall be less than one Plaque-forming Unit per four grams of total solids (dry weight basis) at the time the sewage sludge is used or disposed; at the time the sewage sludge is prepared for sale or give away in a bag or other container for application to the land; or at the time the sewage sludge or material derived from sewage sludge is prepared to meet the requirements in Section 700 unless otherwise specified by the permitting authority.

134.1.4.3The density of viable helminth ova in the sewage sludge shall be less than one per four grams of total solids (dry weight basis) at the time the sewage sludge is used or disposed; at the time the sewage sludge is prepared for sale or give away in a bag or other container for application to the land; or at the time the sewage sludge or material derived from sewage sludge is prepared to meet the requirements in Section 700, unless otherwise specified by the permitting authority.

134.1.5 Class A - Alternative 5.

134.1.5.1Either the density of fecal coliform in the sewage sludge shall be less than 1000 Most Probable Number per gram of total solids (dry weight basis), or the density of Salmonella sp. bacteria in the sewage sludge shall be less than three Most Probable Number per four grams of total solids (dry weight basis) at the time the sewage sludge is used or disposed; at the time the sewage sludge is prepared for sale or given away in a bag or other container for application to the land; or at the time the sewage sludge or material derived from sewage sludge is prepared to meet the requirements in Section 700.

134.1.5.2Sewage sludge that is used or disposed shall be treated in one of the Processes to Further Reduce Pathogens described below:

134.1.5.2.1 *Composting* - Using either the within-vessel composting method or the static aerated pile composting method, the temperature of the sewage sludge is maintained at 55 degrees Celsius or higher for three days.

134.1.5.2.2 Using the windrow composting method, the temperature of the sewage sludge is maintained at 55 degrees or higher for 15 days or longer. During the period when the compost is maintained at 55 degrees or higher, there shall be a minimum of five turnings of the windrow.

134.1.5.2.3 *Heat drying* - Sewage sludge is dried by direct or indirect contact with hot gases to reduce the moisture content of the sewage sludge to 10 percent or lower. Either the temperature of the sewage sludge particles exceeds 80 degrees Celsius or the wet bulb temperature of the gas in contact with the sewage sludge as the sewage sludge leaves the dryer exceeds 80 degrees Celsius.

134.1.5.2.4 *Heat treatment* - Liquid sewage sludge is heated to a temperature of 180 degrees Celsius or higher for 30 minutes.

134.1.5.2.5 *Thermophilic aerobic digestion* - Liquid sewage sludge is agitated with air or oxygen to maintain aerobic conditions and the mean cell residence time of the sewage sludge is 10 days at 55 to 60 degrees Celsius.

134.1.5.2.6 *Beta ray irradiation* - Sewage sludge is irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature (ca. 20 degrees Celsius).

134.1.5.2.7 *Gamma ray irradiation* - Sewage sludge is irradiated with gamma rays from certain isotopes, such as Cobalt 60 and Cesium 137, at room temperature (ca. 20 degrees Celsius).

134.1.5.28 *Pasteurization* - The temperature of the sewage sludge is maintained at 70 degrees Celsius or higher for 30 minutes or longer.

134.1.6 Class A - Alternative 6.

134.1.6.1 Either the density of fecal coliform in the sewage sludge shall be less than 1000 Most Probable Number per gram of total solids (dry weight basis), or the density of Salmonella, sp. bacteria in the sewage sludge shall be less than three Most Probable Number per four grams of total solids (dry weight basis) at the time the sewage sludge is used or disposed; at the time the sewage sludge is prepared for sale or given away in a bag or other container for application to the land; or at the time the sewage sludge is prepared to meet the requirements in Section 700.

134.1.6.2 Sewage sludge that is used or disposed shall be treated in a process that is equivalent to a Process to Further Reduce Pathogens, as determined by the permitting authority.

134.1.6.3 Monitoring and Reporting.

134.1.6.3.1 Any sludge processed to further reduce pathogens must be monitored in accordance with the requirements described in the alternative used. Additional monitoring may be required by the Department as a permit condition.

134.1.6.3.2 Anyone who prepares a Class A sludge must report the results of all monitoring for the processing alternative used on a form provided by the Department. The frequency of reporting shall comply with the reporting frequency described in Section 701 or as specified in the permit.

135.0 Vector Attraction Reduction Requirements.

135.1 All sludge prepared for land application and for sale or give away in bulk or bag must meet the requirements of this subsection for Vector Attraction Reduction in addition to the requirements in Section 700 and in Subsections 117.0, 86.0 and 87.0.

135.2 Vector Attraction Reduction requirements may be achieved by application of one of the following processes:

135.2.1 The mass of volatile solids in the sewage sludge shall be reduce by a minimum of 38 percent (see calculation procedures in "Environmental Regulations and Technology - Control of Pathogens and Vector Attraction in Sewage Sludge", EPA-625/R-92/013, 1992, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268).

135.2.2 When the 38 percent volatile solids reduction requirement in 135.2.1 cannot be met for an anaerobically digested sewage sludge, vector attraction reduction can be demonstrated by digesting a portion of the previously digested sewage sludge anaerobically in the laboratory in a bench-scale unit for 40 additional days at a temperature between 30 and 37 degrees Celsius. When at the end of the 40 days, the volatile solids in the sewage sludge at the beginning of that period is reduced by less than 17 percent, vector attraction reduction is achieved.

135.2.3 When the 38 percent volatile solids reduction requirement in 135.2.1 cannot be met for an aerobically digested sewage sludge, vector attraction reduction can be demonstrated by digesting a portion of the previously digested sewage sludge that has a percent solids of two percent or less aerobically in the laboratory in a bench-scale unit for 30 additional days at 20 degrees Celsius. When at the end of the 30

days, the volatile solids in the sewage sludge at the beginning of that period is reduced by less than 15 percent, vector attraction reduction is achieved.

135.2.4 The specific oxygen uptake rate (SOUR) for sewage sludge treated in an aerobic process shall be equal to or less than 1.5 milligrams of oxygen per hour per gram of total solids (dry weight basis) at a temperature of 20 degrees Celsius.

135.2.5 Sewage sludge shall be treated in an aerobic process for 14 days or longer. During that time, the temperature of the sewage sludge shall be higher than 40 degrees Celsius and the average temperature of the sewage sludge shall be higher than 45 degrees Celsius.

135.2.6 The pH of sewage sludge shall be raised to 12 or higher by alkali*ne* addition and, without the addition of more alkali shall remain at 12 or higher for two hours and then at 11.5 or higher for an additional 22 hours.

135.2.7 The percent solids of sewage sludge that does not contain unstabilized solids generated in a primary wastewater treatment process shall be equal to or greater than 75 percent based on the moisture content and total solids prior to mixing with other materials.

135.2.8 The percent solids of sewage sludge that contains unstabilized solids generated in a primary wastewater treatment process shall be equal to or greater than 90 percent based on the moisture content and total solids prior to mixing with other materials.

135.2.9 Sewage sludge shall be injected below the surface of the land.

135.2.9.1 No significant amount of the sewage sludge shall be present on the land surface within one hour after the sewage sludge is injected.

135.2.9.2 When the sewage sludge that is injected below the surface of the land is Class A with respect to pathogens, the sewage sludge shall be injected below the land surface within eight hours after being discharged from the pathogen treatment process.

135.2.10 Sewage sludge applied to the land surface disposal site shall be incorporated into the soil within six hours after application to or placement on the land.

135.2.10.1 When sewage sludge that is incorporated into the soil is Class A with respect to pathogens, the sewage sludge shall be applied to or placed on the land within eight hours after being discharged from the pathogen treatment process.

135.2.11 The pH of domestic septage shall be raised to 12 or higher by alkali*ne* addition and, without the addition of more alkali, shall remain at 12 or higher for 30 minutes.

135.3 Vector Attraction Reduction requirements may also be met by employment of any one of the following practices in lieu of a specific Vector Reduction process found in Subsection 88.2.1 through 88.2.10.

135.3.1 One of the vector attraction reduction requirements in Subsection 88.2.1 through 88.2.10 shall be met when bulk sewage sludge is applied to agricultural land, forest, a public contact site, or a reclamation site.

135.3.2 One of the vector attraction reduction requirements in Subsection 88.2.1 through 88.2.10 shall be met when bulk sewage sludge is applied to a lawn or a home garden.

135.3.3 One of the vector attraction reduction requirements in Subsection 88.2.1 through 88.2.10 shall be met when sewage sludge is sold or given away in a bag or other container for application to the land.

135.3.4 One of the vector attraction reduction requirements in Subsection 88.2.9, 88.2.10, or 88.2.11 shall be met when domestic septage is applied to agricultural land, forest, or a reclamation site.

135.4 Monitoring and Reporting.

135.4.1 Any sludge prepared for land application or for sale or give away in bulk or bag must be monitored for vector attraction reduction according to the conditions specified in the processes outlined in Subsection 88.2.1 through 88.2.10 or practices outlined in Subsection 88.3.1 through 88.3.4.

135.4.2 Any person that prepares a sludge for land application or for sale or give away in bulk or bag must report vector attraction reduction monitoring results to the Department on a form provided by the Department. The frequency of reporting must comply with the schedule outlined in Subsection 137.0 of these regulations or as specified in the permit.

136.0 Utilzation Methods

137.0 General Operating Requirements.

137.1 Each person that conducts sludge utilization shall comply with all of the following:

137.1.1 The requirements of the Delaware Environmental Protection Act, 7 **Del.C.**, Ch. 60, these regulations and the additional operating requirements for the specific type of operation that are set forth in these regulations.

137.1.2 The plans and specifications in the permit, the terms and conditions of the permit, and any orders issued by the Department.

137.1.3 The Departmental regulations for agricultural utilization, unless the person is operating pursuant to a permit that allows use of the loading rate guidelines for land reclamation, utilization or disposal at landfills, research projects, land disposal, or sludge distribution program, in which case the person shall comply with the applicable guidelines for such operation.

137.1.4 Prior to utilization all sewage sludge shall be stabilized according to a method specified in Section 131.0.

137.1.5 Before sewage sludge subject to the cumulative pollutant loading rates in Table 402.4 is applied, the Applier shall contact the Department to determine whether sewage sludge subject to the cumulative pollutant loading rates in Table 402.4 has been applied to the site since July 20, 1993.

137.1.5.1 If such sewage sludge has not been applied to the site since July 20, 1993, the cumulative amount for each pollutant listed in Table 402.4 may be applied to the site in accordance with these Regulations.

137.1.5.2 If such sewage sludge has been applied to the site since July 20, 1993, and the cumulative amount of each pollutant applied to the site in the sewage sludge since that date is known, the cumulative amount of each pollutant applied to the site shall be used to determine the additional amount of each pollutant that can be applied in accordance with Table 402.4.

137.2 Monitoring requirements for all sludge utilization methods.

137.2.1 The monitoring frequency for the parameters identified in SubSection 117.0 (Tables 402.2-402.3, 402.4, 402.5), 86.1, 87.1 and 88.2 shall be based on the amount of sewage sludge generated, prepared, or applied (in metric tons on a dry weight basis) per 365-day period as follows:

137.2.1.1 Greater than 0 but less than 290 - once per year

137.2.1.2 Equal to or greater than 290 but less than 1,500 - once per quarter (four times a year)

137.2.1.3 Equal to or greater than 1,500 but less than 15,000 - once per 60 days (six times per year)

137.2.1.4 Equal to or greater than 15,000 - once per month (12 times per year)

137.3 The Department may specify additional monitoring in any permit issued for the utilization of sludge.

137.4 The Department may reduce the frequency of monitoring for the pollution concentrations in Section115.0 and for the pathogen density requirements in Section 131.0 after two years of monitoring to a minimum of yearly monitoring unless otherwise specified in a sludge utilization permit.

137.5 Sampling and analysis shall be conducted in accordance with the requirements of Section 151.0.

137.6 The sludge generator shall submit to the Department, land applier and landowner annual copies of a chemical analysis of the sludge unless the Department approves a different schedule in the permit.

137.7 The sludge generator shall perform and submit to the Department and landowner additional analyses as used in the permit application and design if there has been a significant change (greater than 25%) in the quality of sludge.

137.8 The Department may modify the approved sludge application rate based upon review of continuing or additional analyses.

138.0 Agricultural Utilization of Sludge and Septage.

138.1 This section applies to the land application of sewage sludges, sludge products, and septage which meet the minimum quality criteria specified in Subsection 117.0 and pathogen reduction requirements of Section 131.0, but do not meet the Exceptional Quality standards for general distribution and marketing.

138.1.1 Agronomic Rate:

138.1.1.1 Sewage sludge application rates must be calculated based on the following:

138.1.1.1.1 The nitrogen required by the crop to be grown according to University of Delaware Cooperative Extension Service crop fertility recommendations. Crop demand must be based on realistic yield goals determined either through the average of the three highest yields from the previous five years for each field for each specific crop, or Extension recommendations.

138.1.1.1.2 The total crop nitrogen requirement less any nitrogen that will be available from mineralization of previous manure or sludge applications, legumes, or expected manure applications.

Table 702-1. Estimated Percentages and Amounts of Organic N Mineralized After Sludge of Various Types are Applied to Soils

Time After sludge Applic. (years)	Unstabilized Primary and Waste Activated		Aerobically Digested		Anaerobically Digested		*Composted*	
	F % N_o*	K_m[HI] kg/mt/%N_o	F % N_o	K_m kg/mt/%N_o	F % N_o	K_m kg/mt/%N_o	F % N_o	K_m kg/mt/%N_o
0-1	40	4.00	30	3.00	20	2.00	10	1.00
1-2	20	1.20	15	1.05	10	0.80	5	0.45
2-3	10	0.48	8	0.45	5	0.36	3	0.25
3-4	5	0.22	4	0.21	3	0.21	3	0.25
4-5	3	0.12	3	0.16	3	0.20	3	0.24
5-6	3	0.12	3	0.15	3	0.19	3	0.23
6-7	3	0.12	3	0.15	3	0.19	3	0.23
7-8	3	0.11	3	0.15	3	0.18	3	0.22
8-9	3	0.11	3	0.15	3	0.18	3	0.21
9-10	3	0.11	3	0.15	3	0.17	3	0.21
10-yr steady state	93		75		56		39	

**Percentage of organic N (N_o) present mineralized during time interval shown.*

[H]kg N released per metric ton of sludge applied per % organic N in the sludge. For example, application of an anaerobically digested sludge containing 3% organic N at 10 mt/ha would result in the following amounts of N mineralization: year 0, 3% N_o x 10 mt/ha x 2.0 = 60 kg N/ha; year 1 3% N_o x 10 mt/ha x 0.80 = 24 kg N/ha; year 2, 3% N_o x 10 mt/ha x 0.36 = 10.8 kg N/ha.

[I] Multiply kg/mt by 2 to obtain lbs./ton.

138.1.2 For domestic septage - the annual application rate for domestic septage applied to agricultural land, forest, or a reclamation site shall not exceed the annual application rate calculated using equation (138.1.2.1)

138.1.2.1 Equation: $AAR = \frac{N}{0.0026}$

Where:

AAR = Annual application rate in gallons per acre per 365 day period.

N = Amount of nitrogen in pounds per acre per 365 day period needed by the crop or vegetation grown on the land.

138.1.3 The Plant Available Nitrogen (N_p) of the sewage sludge or sludge product shall be calculated at the summation of the ammonia, nitrate and % inorganic Nitrogen mineralized in the first year, bases on a recent rolling average analyses for the sludge source.

Equation (1): $N_p = S [No_3^-) + Kv (NH_4^+) + F (No)](10)$

Where:

N_p = Plant available N from the current year's sludge application only.

S = Sludge application rate (dry mt tons/ha).

No_3^- = Percent nitrate-N in sludge (as percent, e.g. 1% = 1.0).

Kv =Volatilization factor = 0.5 for surface applied liquid sludge, or 1.0 for incorporated liquid sludge and dewatered sludge applied in any manner.

NH_4^+ = Percent ammonia-N in the sludge, as percent (e.g. 3% = 3.0).

F =Organic Nitrogen mineralization factor (year 0-1) from Table 702.1 (percentage expressed as a fraction e.g. 20% = .20).

N_o = Percent organic nitrogen in the sludge (as percent e.g. 3% = 3.0).

138.1.1.1.4 If sludge has been applied in previous years the nitrogen available in the current year from each previous application can be calculated as follows:

Equation (2): $N_m = (K_m)(N_o)(s)$

Where:

N_m = The quantity of N mineralized in the year under consideration, in kg/ha.

K_m = Mineralization factor for the year under consideration from Table 702.1 (in kg/mt/%N_o).

N_o = Percent organic N originally present in the sludge (as percent e.g. 3% = 3.0).

S = Sludge Application rate (mt/ha) in the year under consideration.

138.1.1.1.5 If the sludge is only applied one time, the N_o available in subsequent years is the amount calculated in eq (2). Sites which have received multiple sludge applications must include the summation of currently available N_p from N_o mineralization calculations for each previous sludge application.

138.2 Buffer Zones.

138.2.1 Unless treated by PFRP, sewage sludge may not be land applied within the following buffer zones:

	Surface Application	**Surface Injection**
Occupied off-site dwelling	200 feet	100 feet
Occupied on-site dwelling	100 feet	50 feet
Potable wells	100 feet	100 feet
Non-potable wells	25 feet	25 feet

Public roads	25 feet	15 feet
Property lines	50 feet	25feet
Bedrock outcrops	50 feet	25 feet
Streams, tidal waters, or other water bodies	50 feet	25 feet
Drainage ditches	25 feet	25 feet

138.2.2 The Department may require increased buffer distances or may reduce buffer distances, and may set buffer zones between sludge boundaries and other land uses such as wetlands. In making these determinations, the Department may consider adjacent land use, type of sludge, sludge application method, sludge application rate, sludge quality and level of treatment, land slopes, vegetative cover used, the nature of any surrounding bodies of water, and any other factors considered relevant by the Department.

138.3 Pathogen Control.

138.3.1 Sewage sludge and septage treated by a PSRP process as described in Subsection 86.0 may be land applied in the State with the following restrictions:

138.3.1.1 Food crops with harvested parts that touch the sewage sludge/soil mixture and are totally above the land surface shall not be harvested for 14 months after application of sewage sludge.

138.3.1.2 Food crops with harvested parts below the surface of the land shall not be harvested for 20 months after application of sewage sludge when the sewage sludge remains on the land surface for four months or longer prior to incorporation into the soil.

138.3.1.3 Food crops with harvested parts below the surface of the land shall not be harvested for 38 months after application of sewage sludge when the sewage sludge remains on the land surface for less than four months prior to incorporation into the soil.

138.3.1.4 Food crops, feed crops, and fiber crops shall not be harvested for 30 days after application of sewage sludge.

138.3.1.5 Animals shall not be allowed to graze on the land for 30 days after application of sewage sludge.

138.3.1.6 Turf grown on land where sewage sludge is applied shall not be harvested for one year after application of the sewage sludge when the harvested turf is placed on either land with a high potential for public exposure or a lawn, unless otherwise specified by the permitting authority.

138.3.1.7 Public access to land with a high potential for public exposure shall be restricted for one year after application of sewage sludge.

138.3.1.8 Public access to land with a low potential for public exposure shall be restricted for 30 days after application of sewage sludge.

138.3.1.9 Bulk sewage sludge shall not be applied to a public contact site unless the sludge meets exceptional quality standards.

138.3.1.10 Tobacco is grown or will be grown.

138.3.2 No person shall use spray irrigation equipment to apply sludge unless such person has demonstrated to the Department in his permit application the specific means by which pathogens will be controlled so as not to present a public health hazard. At a minimum, the report shall include the design effectiveness of the proposed bactericidal and viricidal equipment, the means by which aerosol-borne bacteria and viruses will be contained and the impact of wind velocity on the latter's transport offsite or that appropriate buffer zones have been included, and the Department has approved such equipment or areas as part of the permit.

138.4 In no case shall the pollutant loading rate to a field exceed the levels set forth in Section 115.0 Table 402.4 and Table 402.5.

138.5 The Department may deny an application to apply lime stabilized sludge or high lime content sludge on a specific site if the Department determines that the application will result in the average soil pH on the site exceeding the optimum pH range for the crop to be grown.

138.6 Site characteristics. No person shall apply sludge to a site unless the site complies with all of the following:

138.6.1 The soils shall have a minimum depth from surface to impermeable strata of 20 inches.

138.6.2 The site shall have a minimum depth from surface to seasonal high water table of 20 inches. The operator may establish this minimum depth through the use of a tile drain system. An NPDES permit will be required for the discharge from the tile drain. Sites where the minimum depth from surface to seasonal high water

table is less than 20 inches but no less than 12 inches may be considered if application to the soil is restricted to:

138.6.2.1 May, June, July or August and appropriate vegetation is established and harvested as practicable, and

138.6.2.2 Those periods when actual water table depth is at least 20 inches below the maximum depth of tillage to be used for the vegetation.

138.6.3 Slopes to be utilized for sludge application may not exceed 15 percent, except that the Department may allow slopes of up to 30 percent for forest systems in the permit.

138.6.4 Soil pH is to be adjusted to values of 6.2 or above unless the natural climatic conditions and soil chemistry preclude such values. In these cases, lime additions suitable to the vegetation used are to be applied in conjunction with annual metal monitoring of that vegetation.

138.6.5 For silvicultural application the soil may remain at ambient pH provided sufficient litter exist on the forest tract floor as determined by the Department.

138.6.6 If the site is planted with nursery crops that require a pH of less than 6.2, the Department may approve a soil pH of 5.8 or greater in the permit.

138.7 Application to soil.

138.7.1 Sludge shall be spread evenly over the site using conventional agronomic equipment such as manure spreaders, spray equipment, or other applicators, or by commercial equipment specifically designed for sludge application on agricultural land.

138.7.2 Sludge or products derived from sewage sludge shall be applied to the soil surface or incorporated in a manner that prevents unreasonable nuisance or odor conditions.

138.7.3 The sludge applied shall be incorporated into the soil as required in Section 600 or by the end of each working day except under the following circumstances when:

138.7.3.1 Liquid sludge is surface sprayed, odors and nuisances are controlled, and the Department determines that there will be no adverse impact on the environment or public health; or

138.7.3.2 Site management plans such as no till farming or the presence of an established crop precludes sludge incorporation, adequate site features exist to preclude sludge migration from the site, odors and nuisances are controlled, and the Department determines that there will be no adverse impact on the environment or public health.

138.7.4 For the surface application of sludge for top or side dressing on hayfields, for pastures, for cover crops, in forests or for no-till crops when the previous no-till crop was harvested for grain in a manner that left adequate crop residue, the Department may either:

138.7.4.1 Approve a greater than 24 hour time period for incorporating sludge into the soil as part of the permit, or

138.7.4.2 Not require incorporation as part of the permit.

138.7.5 The areas to receive sludge application shall be clearly marked with stakes or contain other markers before the sludge application.

138.7.6 Trucks shall be reasonably cleaned on the site to prevent drag-out of soil or sludge onto public roads.

138.8 Weather.

138.8.1 No person may apply sludge when the ground surface is saturated or covered with snow, or during periods of rain or runoff.

138.8.2 No person may apply sludge when the ground is frozen, unless the Department has approved such application in the permit and all of the following conditions exist:

138.8.2.1 The slopes at the site do not exceed three percent.

138.8.2.2 The site contains sufficient vegetation or a well-established cover crop to prevent runoff of sludge.

138.8.2.3 No sludge storage capacity or other means of storage or disposal exists at the generating facility.

138.8.2.4 No run-off.

138.9 Daily Record Keeping and Reporting Requirements.

138.9.1 Permit applicants must provide the landowner and operator or the proposed site with a copy of the Project Development Report and permit application and information as specified in Section 1100.

138.9.2 Any person that land applies sludge shall make and maintain an operational record for each day that sludge is applied and when any other management activities are conducted at the land application site. The daily operational record shall be recorded on a form supplied by the Department and include the following:

138.9.2.1 The date, type, and wet and dry weights of the sludge applied.

138.9.2.2 The facility from which the sludge originated.

138.9.2.3 The transporters of the sludge.

138.9.2.4 The particular map location of the area currently being used for land application of sludge, and the areas where sewage sludge was previously applied within 5 years.

138.9.2.5 A record of any major deviations from the operating plan.

138.9.2.6 General daily weather conditions.

138.9.2.7 The application rate for sludge.

138.9.2.8 A record of all actions taken to correct violations of the Delaware Environmental Protection Act and the Department's regulations.

138.9.2.9 Management undertaken, such as planting and harvesting of crops, fertilizers and chemicals added, tillage practices, etc.

138.9.3 When sludge is being stored at the site, the operator shall maintain accurate operational records sufficient to determine whether the sludge is being stored in accordance with the Department's requirements for such operations.

138.10 Annual Record Keeping and Reporting Requirements.

138.10.1 Any person that utilizes sludge by land application shall submit to the Department and landowner an annual operation report on or before February 1 of each year.

138.10.2 The annual operation report, which shall be submitted in a format specified by the Department, shall include the following:

138.10.2.1 The weight or volume of each type of sludge received.

138.10.2.2 The type, weight, and volume of sludge received from each generator location where the sludge originated.

138.10.2.3 A copy of the *applier's* current public liability insurance policy.

138.10.2.4 Any changes in ownership of the land where the operation is conducted or any change in any lease agreement for the use of such land that may affect or alter the applier's rights upon such land.

138.10.2.5 The annual ground water monitoring evaluation if ground water monitoring is required by the Department.

138.10.2.6 A chemical analysis of soil for each field at the facility for those constituents identified in the sludge, unless otherwise specified by the Department in the permit. The procedure for soil analysis shall be consistent with the Department guidance.

138.10.2.7 Any other information required by the Department.

138.10.3 The annual operation report shall also contain a topographic map of the same scale and contour interval as the map required for the initial permit application, showing the field boundaries where sludge has been applied.

139.0 Land Reclamation.

139.1 Slopes to be utilized for sludge application may not exceed 20 percent, exception that the Department may approve slopes up to 35 percent in the permit if the applicant demonstrates to the Department's satisfaction that such slopes will not cause substantial erosion or off-site run-off.

139.2 The applier shall incorporate sludge into the soil within 24 hours unless otherwise specified in Section 131.0, following surface application.

139.3 Weather.

139.3.1 The operator shall not apply sludge:

139.3.1.1 When the ground is saturated, snow covered, frozen, or during periods of rain or runoff.

139.3.1.2 Between October 15 and April 15, unless a cover crop can be established.

139.3.2 The Department may approve the storage of sludge between October 15 and May 30 in the permit if the operator makes a satisfactory demonstration that the requirements for storage in Section 900 are to be met. Storage may not exceed in amount the sludge necessary to reclaim the permitted area that was prepared for sludge application prior to October 15.

139.4 Revegetation.

139.4.1 Vegetation shall be established on all land where sludge has been incorporated. The standard for successful revegetation shall be the percent ground cover of the vegetation which exists on undisturbed lands that are nearby or adjacent to the area where land reclamation is proposed. In no case shall the Department approve less than 70 percent ground cover of permanent plant species. No more than 1

percent of the area shall have less than 30 percent ground cover. No single or contiguous area exceeding 3,000 square feet shall have less than 30 percent ground cover.

139.4.2 Revegetation shall provide for an effective and permanent vegetative cover capable of self-regeneration and plant succession. Introduced species may be used in the revegetation process when approved by the Department in the revegetation plan. Vegetative cover shall be considered of the same seasonal variety when it consists of a mixture of species that is of equal or superior utility during each season of the year.

139.4.3 Revegetation shall provide a quick germinating, fast growing vegetative cover capable of stabilizing the soil surface from erosion.

139.4.4 Disturbed areas shall be seeded and planted when weather and planting conditions permit but such seeding and planting of disturbed areas shall be performed no later than the first normal period for favorable planting after final grading.

139.4.5 Mulch shall be applied to all regraded areas at rates adequate to control erosion, promote germination of seeds and increase the moisture retention of the soil.

139.4.6 The Department may require a chemical analysis of the vegetation.

139.4.7 Vegetation shall not be harvested for 2 years for food chain use following the application of sludge, unless otherwise approved by the Department.

139.6 Water Quality Monitoring. Since the use of sludge for land reclamation is often a one-time or short term application the Department may accordingly waive or reduce groundwater monitoring requirements.

139.7 Soils analysis. If the land to which sludge is applied will be used for agriculture, the operator shall conduct a soil analysis 2 years after the application of sludge to the land. The soil analysis shall be consistent with Department guidance.

139.8 The Department may impose other restrictions if considered necessary to protect public health and the environment.

139.9 All monitoring performed on the sludge utilized at the reclamation site shall be reported to the Department on approved reporting forms as specified in the permit.

140.0 Research Projects.

140.1 The Department may issue permits to utilize sludge as part of legitimate research projects to be carried out by qualified persons. Research projects may be designed to improve current sludge utilization methods, develop new methods, determine the environmental or health effects of sludge utilization, or all of these.

140.2 The Department may allow the application of sludge at high rates which exceed crop nitrogen requirements and/or the heavy metals limitations stated in the guidance and these regulations, on land specifically set aside for research purposes.

140.3 The Department may allow use of unstabilized sludge if appropriate precautions are taken to assure that viable pathogens do not enter ground water, surface water, or in any way adversely affect the public health.

140.4 The Department may allow the growth of crops such as vegetables and tobacco if the purpose of the research is to determine the effect of sludge on these crops, and the crops are not allowed to enter the human food chain.

140.5 Applications for permits shall include five copies of a complete description of the project. After a preliminary review, the Department may request such additional information as is necessary to evaluate and document the project.

140.6 As a condition of any permit under this section the titleholder must execute and record in the appropriate County Office of Recorder of Deeds an affidavit in a form approved by the Department which notifies prospective purchasers that the property has been used to conduct sludge utilization research.

141.0 Sludge Distribution and Marketing .

141.1 Quality Criteria:

141.1.1 Sludge and sludge products for Distribution and Marketing must meet one of the PFRP pathogen reduction standards specified in subsection 87.0, vector attraction methods described in subsection 88.2 as alternative a through h, and the Pollutant Concentration Limits in Table 402.3 at the time of distribution.

141.1.2 All sludge or sludge products shall be dried or otherwise amended to a minimum of twenty percent solids prior to distribution or marketing.

141.2 Monitoring Requirements for Distribution and Marketing:

141.2.1 A quality control program approved by the Department shall be instituted to assure that all treated sludge and sludge products to be distributed meet the Department's standards regarding the destruction of primary pathogen organisms (PFRP) and the limitations for heavy metals and other contaminants. During the stabilization process, temperature shall be monitored regularly until temperatures recorded in the material (or off-gas from a heat-drying process) exceed the level and duration required for adequate

pathogen destruction. For aerobic stabilization processes, oxygen levels shall also be monitored frequently to assure that aerobic conditions are maintained. Additional monitoring of the treatment process may be required on a case-by-case basis.

141.2.2 The sludge or sludge products shall be tested according to the frequencies specified in Subsection 401, unless the Department requires a different monitoring as a permit condition.

141.2.3 The sludge distribution facility shall perform and submit to the Department additional analyses if there has been a significant change in the quality of the sludge or sludge products.

141.3 Records and recordkeeping.

141.3.1 Any person that distributes and markets sludge or sludge products shall keep a log of all persons that receive more than ten (10) cubic yards of material per year.

141.3.2 Before distributing sludge or sludge products to any person who will utilize more than 100 tons of the material in a twelve (12) month period, the permittee shall submit a plan to the Department which addresses the following:

141.3.2.1The end use(s) of the material

141.3.2.2Maximum application rates

141.3.2.3Total amount of material to be utilized

141.3.2.4Storage practices

141.3.2.5Transportation methods

141.4 Application limitations.

141.4.1 No person who receives or applies sludge or sludge products pursuant to a distribution and marketing program may exceed the application rates for particular uses as listed in the instructional materials provided with the product, or otherwise use the pr

141.4.2 No sludge or sludge products may be stored or applied so as to cause surface or groundwater pollution, runon/runoff, cause odor, adversely affect the food chain, attract vectors, or adversely affect private or public water supplies.

142.0 Utilization or Disposal of Sludge at Sanitary Landfills.

142.1 Sludge utilized or disposed of in a sanitary landfill must not contain free liquids and must contain a minimum of 20% solids as determined by the EPA paint filter test.

142.2 Utilization or disposal of sludges governed by these regulations must comply with 40 CFR part 258, the "*Regulations Governing Solids Waste*" and Delaware Solid Waste Authority *Policy on Special Solid Wastes.*

142.3 Persons with a valid permit from the Delaware Solid Waste Authority or the Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management to dispose or utilize sludge at an approved landfill are exempt from the permit requirements of these regulations.

142.4 Reporting and Record Keeping.

142.4.1 Unless specified in an NPDES or Ground Water Discharges Permit, all facilities must record the volume of sludge generated and disposed of on a dry weight basis under this subsection.

142.4.2 Unless specified in an NPDES or Ground Water Discharges Permit, all facilities must report on a yearly basis the volume of sludge generated and disposed of under this subsection.

143.0 Transportation of Sludge or Septage.

144.0 General Requirements.

144.1 For the purpose of this section, sludge and septage are divided into three types as shown in the table below.

Sludge Type	Percent Solids
Liquid	Less than 15
Cake	15-35
Dried	Greater than 35

144.2 The Department may issue permits to transport sludge off-site if the Department approves of the equipment to be used, the operations plan, and the destination of the sludge.

144.3 Liquid sludge or septage can be pumped and transported by pipeline. If liquid sludge is transported by truck, rail, or barge, closed watertight vessels shall be used such as tank trucks and railroad tank cars or other vessels which can provide equivalent protection against spills and leakage.

144.4 Cake may be transported in watertight boxes, such as dump trucks properly sealed to prevent leaks, or cement type vehicles. Unless the applicant demonstrates equivalent protection against spills and leakage, when sludge cake is transported in dump trucks, the following standards shall be met:

144.4.1 The trucks shall be equipped with splash guards firmly attached horizontally at the front and rear of the trailer;

144.4.2 Each splash guard shall cover at least 25 percent of the trailer's open area; and

144.4.3 A minimum 2 feet of freeboard shall be maintained between the sludge and the top of the trailer unless the top of the trailer is completely sealed.

144.5 The Department may require certain cake sludges to be transported as liquid sludge.

144.6 Dried sludge may be transported in open boxes, such as dump trucks, which are properly sealed to prevent leakage. The trucks shall be covered with tarps or the equivalent.

144.7 All vehicles used to transport sludge or septage shall be operated and maintained so as to be in compliance with all state and federal regulations and not present a hazard to human health or the environment through unsafe vehicle conditions. The permittee is responsible for the operation and maintenance of all vehicles operated under the permit.

144.8 All transporters of sludge or septage shall submit to the Department a plan for the prevention, control, and cleanup of accidental discharges. No transportation permit will be issued until such a plan has been submitted to and approved by the Department.

144.9 All transporters shall at all times maintain commercial automobile liability insurance with a combined single limit of at least $100,000, and shall submit a Certificate of Insurance demonstrating compliance with this regulation. All persons subject to these regulations that were permitted to transport in Delaware before the adoption of this requirement shall be subject to the requirement upon renewal of their permit, or 90 days after adoption of the part, whichever is first.

145.0 Permit Application for Transportation.

An applicant for a Permit to transport sludge or septage in the State shall submit copies of the following information along with the initial application forms supplied by the Department:

145.1 A description of the sludge to include the source of the sludge, the quantity to be transported, and any treatment the sludge has undergone before transportation (for example anaerobic digestion, aerobic digestion, lime stabilization, composting, or dewatering).

145.2 Results of a laboratory analysis of a representative sample of the sludge which was obtained not more than 6 months before submission of the application unless these results would be submitted as a part of the land application program. The analysis shall include, as a minimum, percent solids, pH, and the dry weight concentration of total nitrogen, ammonium, nitrate, total phosphorous, total potassium, cadmium, copper, mercury, nickel, lead, zinc, arsenic, selenium, and molybdenum. The Department may require more frequent analyses and analyses for other sludge constituents if considered necessary to adequately assess the potential public health, environmental, and nuisance impacts of the project. The Department will waive the requirement for domestic septage.

145.3 A description of all equipment to include collection, short-term holding, handling, and wash down equipment, as well as a detailed description of the transport vehicles to include type, size, number, and all modifications made to prevent spills and leaks.

145.4 An operations plan to include transportation route, days and hours of operation, spill reporting and cleanup plans, plans to keeping transportation vehicles clean, and recordkeeping procedures.

145.5 The destination of the sludge and a description of what is to be done with the sludge at the destination.

145.6 Other relevant information requested by the Department.

146.0 Storage.

147.0 General Requirements.

Adequate storage capacity for sludge is recognized as an integral and necessary element of an acceptable sludge management program. Storage facilities are to be used as proactive staging areas for sludge or sludge products and not to be used for final or permanent disposal. Storage facilities used in a manner that constitutes final or permanent disposal shall be classified a surface disposal unit and subject to the requirements of *The Regulations Governing the Disposal of Solid Waste in Delaware.*

147.1 The Department may issue permits for the construction and operation of temporary or permanent sludge storage facilities.

147.1.1 A facility is a temporary facility if it exists for less than one (1) year or it is used for storage for less than six (6) months in any one year.

147.1.2 A facility is a permanent facility if it is not a temporary facility.

147.2 Unless governed by another permitting authority, facilities for the temporary storage of sludge unless authorized only as an interim measure to provide sufficient time for the location, authorization, design and construction of permanent sludge storage facilities.

147.3 The Department may deny authorization to construct temporary storage facilities if it determines that the applicant or the generator is not actively pursuing efforts to secure adequate permanent storage facilities, or for other good cause.

147.4 When feasible, storage shall be limited to permanent facilities, specifically designed and constructed to safely contain sludge without resulting in public health or environmental problems, or creation of nuisance conditions.

147.5 Portable equipment used for the short-term holding of sludge (i.e., dumpsters and roll-offs) shall not be considered as storage facilities under this Section provided this equipment is included in the list of equipment provided in Subsection 144.3.

148.0 Temporary Sludge Storage Facilities.

Temporary sludge storage facilities shall be designed and constructed in accordance with the following specifications:

148.1 Storage facilities shall not be placed in flood prone areas.

148.2 Storage facilities within the 100-year floodplain shall be evaluated as to potential effects on adjoining landowners.

148.3 Storage facilities shall be located on soils of low to moderate permeability or on soils that seal through sedimentation and biological action. If a storage facility is proposed on other soils, the Department shall require permeability tests or use of an impermeable membrane liner or soil sealant, or all of these.

148.4 The minimum design volume of a storage facility which is not completely enclosed shall be the volume of sludge to be stored plus the expected volume of precipitation during the period of storage minus expected evaporation on the pond surface plus the volume of the maximum expected 25 years, 24 hours precipitation event.

148.5 Storage facilities shall be constructed of:

148.5.1 Suitably compacted soils; or

148.5.2 Manufactured materials such as asphalt, steel, reinforced concrete; or

148.5.3 Fiberglass; or

148.5.4 Other materials approved by the Department.

148.6 Storage facilities made by constructing an above ground embankment shall meet the following conditions:

148.6.1 The minimum combined slopes of the embankment shall be five horizontal to one vertical with the wet side not steeper than 2:1 and the dry side not steeper than 3:1.

148.6.2 Embankments having a height of 14 feet or less shall have a minimum top width of 8 feet. Embankments having a height of 15 feet to 19 feet shall have a minimum top width of 10 feet.

148.6.3 The design height of the embankment shall be increased by the amount needed to insure that the design top elevation is maintained after all settlement has taken place. This increase may not be less than 5 percent when compaction rollers are used and not less than 10 percent when bulldozers or scrapers, or both, are used.

148.7 The minimum top elevation of the facility shall be 10 percent above the design depth after settlement. A minimum of one foot of freeboard must be provided in all cases. These provisions may be waived by the Department, or the freeboard requirements reduced if the facility design includes secondary containment capability, and the accumulated liquids are routinely removed from the facility.

148.8 The side slopes of an excavated storage facility may not be steeper than 1:1.

148.9 Storage facilities constructed by both the embankment and excavation method shall meet all of the requirements for above ground embankments of these regulations if the design depth of the sludge impounded against the embankment is 3 feet or more.

148.10 Public access to the storage facility shall be controlled.

148.11 The storage facility shall be located in a relatively level area (usually less than 5 percent slope) and shall be located at least 150 feet from any drainage ditch, swale, or gully, and bermed to prevent run-on or surface water. Areas with slopes greater than 5 percent may be deemed suitable for storage provided that diversion ditches, additional buffer distances, or other provisions can be installed to further control storm water in the areas of the storage facilities.

148.12 The cell floor shall be located at least 2 feet above the maximum seasonal high ground water elevation.

148.13 Adequate specific conditions are included to control odors and potential nuisances.

149.0 Permanent Storage Facilities.

Permanent storage facilities shall be designed and constructed in accordance with all the requirements listed for temporary storage facilities in these regulations with the following additions:

149.1 The facility shall be lined to prevent loss of materials to ground waters. Acceptable liners shall include:

149.1.1 1-foot thick clay or other suitable material with an installed permeability of 1.0×10^{-7} cm/sec. or less;

149.1.2 2-foot thick clay or other suitable material with an installed permeability of 1.0×10^{-6} cm/sec or less;

149.1.3 2-foot thick compacted soil with an installed permeability of 1.0×10^{-5} cm/sec. or less in combination with an artificial liner at least 30 mil in thickness with a permeability of 1.0×10^{-7} cm/sec. or less; or

149.1.4 Other manufactured facilities including but not limited to asphalt or reinforced concrete structures, steel tanks, fiberglass tanks, or their equivalent.

149.2 A ground water monitoring program shall be conducted in accordance with a plan approved by the Department. At a minimum, three wells, one upgradient and two downgradient of the facility, shall be installed. The Department may waive this provision for facilities which store sludge in above ground manufactured facilities such as tanks or similar structures.

149.3 The Department may approve the storing or stockpiling of dried sludge on a storage pad without groundwater monitoring if the pad meets the Department's standards for permanent storage facility liners and all runoff from the pad is collected and disposed of in a manner approved by the Department.

149.4 Other methods of storing or stockpiling dried sludge may be approved by the Department if the Department determines that they do not have significant potential to cause nuisances or adversely affect the public health or the environment.

149.5 If the facility is constructed after the date when these regulations are adopted by the Department a 1,000 foot buffer zone shall be maintained between the sludge processing or storage area, or both, and the nearest inhabited off-site dwelling. This buffer distance may be reduced if the Department considers that the facility has adequate specific conditions to control odors and potential nuisances.

150.0 Application for a Storage Permit.

Applications for permits to store sludge shall include the following information:

150.1 Written permission from the landowner or landowners and evidence of zoning approval as required by 7 **Del.C.** 6003(c) and Section 1100 of these regulations.

150.2 Results of a laboratory analysis of a representative sample of the sludge which was obtained not more than 6 months before submission of the application. The analysis shall include, as a minimum, the metals and nutrients parameters found in Section115.0 of these regulations. The Department may require more frequent analyses and analyses for other sludge constituents if considered necessary to adequately assess the potential public health and environmental impacts of the project.

150.3 A site specific topographic map of sufficient scale to include:

150.3.1 The areal extent of the site;

150.3.2 The property boundaries;

150.3.3 The size and location of the storage facility;

150.3.4 The location of any streams, springs, or seeps in the area;

150.3.5 The residences or buildings on the site or bordering on the site;

150.3.6 Any roads on the site;

150.3.7 The location of any wells on the site or within 1/2 mile of the site; and

150.3.8 The location of all soil tests, soil borings, or test pits (attach test results).

150.4 A tax map of the site showing the owner's name, site acreage, and property identification number.

150.5 Evidence showing the frequency of flooding at the site based on available flood maps and other information along with an evaluation of stormwater management for the facility.

150.6 The source and volume of sludge to be stored.

150.7 Design volume calculation.

150.8 For facilities constructed of earthen material, and for facilities constructed or installed below grade, the following information shall be submitted:

150.8.1 Soil permeability test results both on the soil used to construct side slopes and at the proposed depth of the facility.

150.8.2 Representative test borings or test pits on the site, to include a description of the texture, color, and evidence of mottling of the soils encountered, and the depth to the ground water. The interpretation of test pit or boring information shall be made by a qualified person.

150.9 Evidence showing the maximum seasonal high ground water elevation.
150.10 The specifications of any liners or soil sealants, if required.
150.11 Detailed construction specifications.
150.12 Method of restricting public access to the site.
150.13 An operations plan to include a description of all sludge handling equipment, daily operating procedures, days and hours of operation, an odor and nuisance control plan, emergency plans, and recordkeeping procedures.
150.14 A description of the truck cleaning facility.
150.15 For permanent facilities constructed of earthen materials, or for facilities constructed or installed below grade, the following information shall be submitted:
150.15.1 Adequate test boring logs, at a minimum of three per 10 acres. These shall be specific as to the soil, sediment, and rock types encountered, depth of groundwater at completion and at 24, 48, and 72 hours after completion, and depth of auger refusal, if applicable. The location of each boring shall be accurately mapped.
150.15.2 Description of the geology at the site, including a discussion of the geologic formations directly involved, the present and future use of these formations as a ground water source and their relationship to underlying formations, providing cross sections based on the information compiled from borehole data.
150.15.3 Hydraulic characteristics of the site, including a ground water contour map, superimposed on a topographic map, showing the location of the water table and the direction and rate of ground water flow, a discussion of the infiltration capacity of surface soils, and the percolation capacity of subsurface soils.
150.15.4 A proposed ground water monitoring program consisting of at least three wells, one upgradient and two downgradient of the facility.
150.15.5 A sediment and erosion control plan for the site.
150.16 For manufactured facilities, the following information shall be submitted:
150.16.1 Information on the structural materials to be used;
150.16.2 Design specifications, such as structural capacity, maximum load, restrictions on use, and dimensions;
150.16.3 Installation or construction techniques and procedures;
150.16.4 A plan for cleaning and periodic inspection of the facility for leaks or other structural defects;
150.16.5 A contingency plan for repairs of the facility, if necessary.
150.17 For above ground enclosed facilities, a plan for controlling emission gases.
150.18 Other relevant information requested by the Department.

151.0 Temporary Stockpiling.

The Department may authorize the temporary stockpiling of sludge on a permitted utilization site provided that the following conditions are satisfied:
151.1 The sludge shall be utilized on the site within 7 days of delivery to the site;
151.2 The sludge has been dewatered to a minimum solids content which will allow it to pass the free liquids test under Subsection 141.0.
151.3 The Department determines that the stockpile area is situated in an area where runoff is adequately controlled and odor or other nuisance conditions do not occur.
151.4 The Department may approve stockpiling beyond 14 days if adequate covering or shelter is provided for the material.

152.0 Sampling and Laboratory Analyses

The Department recognizes that sludge analysis is difficult due to the inherent complexity of sludge matrices. Sludge is rich in organic matter and highly variable in physical and chemical properties. However, sampling accuracy can be greatly enhanced if the correct protocol is established for the collection, storage, transportation, and analysis of the sludge sample. The Department may reject the method of analysis if it determines that the method of analysis is inaccurate, or for any other good cause.

153.0 Sample Collection and Analysis

153.1 Sample Collection. All sludge generators and preparers shall develop a sludge sampling program which addresses random and cyclic variations within the sludge stream. The generator or preparer must receive Department approval prior to execution of this program. The EPA publication *POTW Sludge Sampling and Analysis Guidance Document* may be helpful in establishing a sampling and analysis program. Specifically, the program shall address, with respect to both stabilized and unstabilized sludges, the following:
153.1.1 Sampling equipment, personnel, and containers, including set-up, tear-down and cleaning procedures
153.1.2 Representative sampling (collection points, compositing method, frequency and timing of sampling)
153.1.3 Sample preservation
153.1.4 Recordkeeping/logbook

153.1.5 Transfer and Chain-of-Custody Samples

153.2 Methods in the publications listed below shall be used to analyze samples of sewage sludge. The publications are listed as they existed on the effective date of this Regulation. Notice of and change in the listed methods will be published in the *Federal Register*. The Department will make a sincere effort to notify permittees of any testing method changes; however, it is the responsibility of all parties governed by these regulations to perform analysis using current EPA approved testing methods.

153.2.1 Enteric viruses. ASTM Designation: D 4994-89, "Standard Practice for Recovery of Viruses From Wastewater Sludges", 1992 Annual Book of ASTM Standards: Section 11 - Water and Environmental Technology.

153.2.2 Fecal coliform. Part 9221 E. or Part 9222 D., "Standard Methods for the Examination of Water and Wastewater", 19th Edition, 1992.

153.2.3 Helminth ova. Yanko, W.A., "Occurrence of Pathogens in Distribution and Marketing Municipal Sludges", EPA 600/1-87-014, 1987.

153.2.4 Inorganic pollutants. "Test Methods for Evaluating Solid Waste, Physical; Chemical Methods", EPA Publication SW-846, Second Edition (1982) with Updates I (April 1984) and II (April 1985) and Third Edition (November 1986) with Revision I (December 1987).

153.2.5 Salmonella sp. bacteria. Part 9260 D., "Standards Methods for the Examination of Water and Wastewater" 18th Edition, 1992. Kenner, B.A. and H.P. Clark, or "Detection and Enumeration of Salmonella and Pseudomonas aeruginosa", Journal of the Water Pollution Control Federation, Vol. 46, No. 9, September 1974, pp. 2163-2171.

153.2.6 Specific oxygen uptake rate. Part 2710 B., "Standard Methods for the Examination of Water and Wastewater" 18th Edition, 1992.

153.2.7 Total, fixed, and volatile solids.Part 2540 G., "Standard Methods for the Examination of Water and Wastewater", 18th Edition, 1992.

153.3 All laboratory results submitted to the Department must list the method used for analysis. The laboratory may be required to submit a documented Quality Assurance (QA) program for Department approval; the QA program must identify sampling and test procedures in sufficient detail so as to allow a technical evaluation. All sludge generating facilities shall submit a description of the proposed sludge analysis program, which shall address:

153.3.1 Laboratories used, addresses, qualifications

153.3.2 Parameters analyzed at each laboratory for each medium (water, soil, sludge)

153.3.3 QA/QC procedures utilized, results of procedures

153.3.4 Methodologies employed, citation for methodologies

The applicant must receive Department approval prior to execution of this program.

153.4 Where the regulations require a soils analysis to be performed in order to determine cumulative metals loading, a complete digestion process is required, and the specific testing method shall be referenced in the report; leachate tests would only be appropriate when testing to determine exchangeable cations uptake of metals by the plant-root system.

154.0 Other Treatment Methods.

The Department may issue permits for the treatment of sludge by other processes if it can be demonstrated by the applicant that the following conditions will be met:

154.1 The treatment process does not contaminate the sludge to an extent that subsequent utilization of the treated sludge presents a public health hazard or danger to the environment.

154.2 Health hazards, environmental degradation, or nuisances do not result from the operation of the treatment process.

154.3 If the facility is constructed after the date when these regulations are adopted by the Department, a 1,000 foot buffer zone shall be maintained between the sludge processing or storage area and nearest inhabited off-site dwelling. This buffer distance may be reduced if the Department considers that the facility had adequate specific conditions to control odors and nuisances.

155.0 Information Required for Permits.

Applications for permits for the treatment of sludge shall include a description of the treatment method, the source of the sludge, the quantity of sludge involved, and a map showing the location of the treatment facility. After a preliminary review the Department will specify the additional information necessary to evaluate the project and complete the application. Copies of this information shall be submitted and may include the following:

155.1 A site specific topographic map with a minimum scale of 1 inch = 200 feet and a contour interval of not more than 5 feet, showing the areal extent of the site, the property boundaries, the exact acreage of the facility, location of all buffer zones, and surrounding land uses within 2500 feet including residences, streams, roads and wells.

155.2 Site specific geologic and hydrogeologic information as required by the Department to ensure that the treatment facility does not constitute a threat to ground or surface waters of the State.

155.3 Detailed discussion of the methods to be used for the protection of the ground water, such as leachate control or natural attenuation.

155.4 A laboratory analysis of each sludge in conformance with Subsection 117.(2) of these regulations. The analysis shall include, as a minimum, percent solids, pH, and the dry weight concentration of total nitrogen, ammonium, nitrate, total phosphorous, total potassium, cadmium, copper, mercury, nickel, lead, and zinc. The Department may require the analysis of other parameters if considered necessary to protect public health or the environment.

155.5 A proposed program for monitoring the chemical quality of the ground water and surface waters on the site, including the depth and location of monitoring wells if applicable.

154.6 Written permission of the landowner or landowners for the operation to be carried out, and evidence of zoning approval as required by 7 **Del. Code** 6003(c).

154.7 Procedures to be employed to control odors, nuisances, and public access.

155.8 Location of the 100-year flood plain, if applicable.

155.9 Tax maps and property identification numbers.

155.10 Detailed design calculations.

155.11 Detailed engineering plans and specifications.

155.12 A detailed description of the treatment process.

155.13 Plans for storage and ultimate utilization of the treated sludge.

155.14 Plan to monitor efficiency of treatment device or process.

155.15 Contingency or emergency plans.

155.16 Other relevant information requested by the Department.

156.0 Generator, Preparer, Applier, Owner, and Leaseholder Responsibilities.

157.0 Generator's Responsibility.

157.1 Each sludge generator who generates or otherwise produces sludge in Delaware shall maintain the following information for a minimum of five (5) years:

157.1.1 Volume of sludge generated monthly, or a dry weight basis.

157.1.2 The name, address, telephone number and NPDES permit number and the sludge utilization permit number of the person(s) who prepare and apply the sludge, if different from the generator.

157.1.3 The location, by either street address or longitude and latitude of all sludge storage, utilization, disposal, or reclamation sites where the generator's sludge has been placed.

157.1.4 The concentration of pollutants identified in Section 400 of these regulations as required by the Department.

157.1.5 A description of how pathogen and vector reduction requirements are met, including a signed certification statement approved by the Department.

157.1.6 Any additional information required by the Department.

158.0 Preparer's Responsibility.

158.1 Each sludge preparer who prepares or otherwise treats sludge for final utilization or disposal in Delaware shall submit to the Department the following information, at a frequency identified in Section 400 of these Regulations:

158.1.1 The concentration of total nitrogen of the prepared sludge.

158.1.2 The concentration of pollutants identified in Section 700 of these Regulations.

158.1.3 Other constituent concentrations identified in the sludge utilization or disposal permit.

158.1.4 A description of how pathogen and vector reduction requirements are met, including a signed certification statement approved by the Department.

158.2 The information required in 1 above, shall also be provided to the sludge applier, if the applier is different from the sludge preparers, and shall be maintained for a minimum of five (5) years.

159.0 Applier's Responsibility.

159.1 Each sludge applier who land applies or disposes of sludge in the state shall submit to the Department the following information at a frequency identified in Section 136.0 of these Regulations. This part does not apply to sludge appliers who transport sludge to a sanitary landfill in accordance with Subsection 142.0 of these Regulations or to sludge appliers who apply sludge or sludge products in accordance with a valid Distribution and Marketing permit issued by the Department. *Required information includes:*

159.1.1 The location, either by street address and longitude and latitude of all sludge utilization, disposal or reclamation sites where the applier has placed sludge.

159.1.2 The total volume of sludge (in dry metric tons per hectare) applied to each site annually; the number of hectares the sludge was applied to; and the total site acreage.

159.1.3 The cumulative pollutant loading rate (CPLR) of each pollutant listed in Table 402-4 applied to the site to date.

159.1.4 The applier shall provide a description of how the management requirements in Sections 702, 703, and 119.1.1.7 were met and shall certify that the managementrequirements were met.

159.2 For all Class B sludges that are land applied, the appliers shall provide a description of how all site restrictions were met and shall certify that all site requirements identified in Section 600 and 700 of these Regulations have been met.

159.3 When vector attraction reduction requirements are achieved using either method 135.2.9 or 135.2.10 as described in Section 135.2 of these Regulations, the applier shall maintain records documenting the methods employed to comply with these requirements. The applier shall also certify that the above vector attraction reduction requirements were met.

159.4 The applier shall provide to the landowner or lease holder notice and information necessary to comply with these regulations and the permit. The information shall include:

159.4.1 The date(s) sludge was applied to the site.

159.4.2 The areas on which sludge was applied, including acreage.

159.4.3 The loading rate of sludge in dry tons per acre.

159.4.4 The total amount of nitrogen available for crop uptake from the sludge application in pounds per acre.

159.4.5 A copy of a recent laboratory analyses of the sludge.

159.4.6 Any other information required by the Department.

160.0 Landowner or Leaseholder Responsibilities.

160.1 Prior to sludge application the landowner or leaseholder shall provide the sludge applier the following information:

160.1.1 Identification of crops to be grown.

160.1.2 Approximate dates for seeding or planting of crops.

160.1.3 A statement agreeing to comply with site and crop restrictions when Class B sludges are applied to the field(s).

160.1.4 Any other information required by the Department.

161.0 Fee Schedule.

The Department may establish a schedule of annual and/or one-time fees with respect to sludge treatment, storage, transportation, land application/treatment, and distribution. This fee schedule may be revised from time-to-time after notice and opportunity for hearing.

161.1 Fee Payment.

161.1.1 One time fees shall be submitted to the Department at the time of application. Fees shall be submitted to the Department upon receipt of notice from the Department, or in accordance with the following fee payment schedule:

Fee Amount	Payment Schedule
Less than $1,000	Upon receipt of notice from the Departmnet
Between $1,000 and $10,000	Quarterly payments
Over $10,000	Monthly payments

161.1.2 The Department shall impose late charges at the rate of 1 percent per month compounded, for any fee not received within 30 days of the due date.

161.1.3 Failure to pay fees shall constitute grounds for denial of subsequent applications for Permits, and revocation of previously issued permits involving sludge from the applicant.

Part V Land Treatment of Waste Products

162.0 Scope

162.1 This document provides regulations for all people engaged in the handling, marketing or agricultural utilization of non-hazardous waste products generated by industrial or commercial activities which will be utilized in agricultural or horticultural setting as a fertilizer or soil amendment agent. Materials subject to regulations under RCRA, TOSCA or other federal or state regulatory programs governing hazardous wastes are not included in the scope of these regulations. Nor do manures, waste vegetables or other materials produced under agricultural settings, or products of materials currently regulated or managed by the Delaware Department of Agriculture for use by farmers in agricultural activities.

162.2 The Delaware Department of Natural Resources and Environmental Control encourages the reuse of utilization of waste products as a viable alternative to disposal or incineration where appropriate. The regulations outlined herein apply to waste products that, because of their physical, chemical or biological characterization, may be used as soil conditioners or as substitutes to commercial fertilizers in agricultural settings.

163.0 Definitions – The following terms have the meanings indicated.

"Agricultural land" means land cultivated for the production of crops or used for raising livestock.

"Agricultural utilization" means the application rate of wastes products which shall not exceed nutrient needs of the crop grown on the particular soil plus the other assimilative pathways in soils (e.g. immobilization with organic material, volatilization, and leachate in compliance with drinking water standards). The department may require a lower application rate if the design criteria for pathogens, metals or organics contained in these Regulations plus generally accepted technical standards for land treatment technology (e.g. U.S. EPA Process Design Manuals or Overcash, M.R. and P. Pal. 1979 Design of Land Treatment Systems for Industrial Wastes – Theory and Practice) cannot be achieved at the above application rate. This term may be used interchangeably with **"agronomic rate".**

"Agricultural wastes" means wastes normally associated with the production and processing of food and fiber on farms, feedlots, ranches, ranges and forests which may include animal manure, crop residues and dead animals; also agricultural chemicals, fertilizers and pesticides which may find their way into surface and subsurface and subsurface water.

"Collection" means any action involved in the gathering or subsequent placement of waste products into a vehicle, container or any other vessel for transportation to some other location.

"Crops for direct human consumption" means crops that are consumed by humans without processing to minimize pathogens before distribution to the consumer.

"Department" means the Department of Natural Resources and Environmental Control.

"Disposal" means the discharge, deposit, injection, dumping, spilling, leaking or placing of waste products on or in the land, the air or any waters, including ground water and includes any method of waste products utilization that involves reuse of nutrients in the waste product at greater than agronomic rates.

"Distribute" means to barter, sell, offer for sale, consign, furnish, provide or otherwise supply a material as part of a commercial enterprise or a giveaway program.

"Food chain crops" means tobacco, crops grown for human consumption and crops grown to feed animals whose products are consumed by humans.

"Handling" means any way in which waste products are dealt with, other than collection, burning, storage, treatment, land application, disposal or transportation. It includes distribution of waste products.

"Household waste" means waste derived from households (including single and multiple residences, hotels and motels, bunkhouses, ranger stations, crew quarters, campgrounds and day-use recreation areas) which is not sewage or septage.

"Impermeable" means having a hydraulic conductivity equal to or less than 1 x 10-7 cm/sec as determined by field and laboratory permeability tests made according to standard test methods which may be correlated with soil densification as determined by compaction tests.

"Label" means the display of all written, printed or graphic material on the immediate container or information accompanying the material.

"Land application" means the placement of waste products within 2 feet below the surface of land used to support vegetative growth.

"Land reclamation" means the application of waste products at a rate mot greater than necessary to support and maintain immediate revegetation. Application may be in multiple cycles prior to establishment of vegetation, but must be accomplished within a single short-term operational period.

"Land treatment" means a technology for t the intimate mixing or dispersion of wastes into the upper zone of the plant-soil system with the objective of microbial stabilization, immobilization, selective dispersion, or crop recovery loading to an environmentally acceptable assimilation of the waste.

"Liquid waste" means any waste which is not a solid waste as defined for the purposes of these regulations.

"Person" means an individual, trust, firm, joint stock company, federal agency, corporation (including a government corporation), partnership, association, state, municipality, commission, political subdivision of a state, or any interstate body.

"Solid waste" means any garbage, refuse, rubbish and other discarded materials resulting from industrial, commercial, mining, agricultural operations and from community activities which does a not contain free liquids. Containers holding free liquids shall be considered solid waste when the container is designed to hold free liquids for use other than storage (e.g. radiators, batteries, transformers) or the waste is household waste.

"Usable waste product" means an industrial waste that the Department has approved as a product or feedstock for a specified use.

164.0 Waste Product characterization

Any person seeking authorization to utilize a by-product under this part shall be required to characterize the source and constituent make-up of the waste product.

165.0 Source Characterization

165.1 The applicant shall describe fully the process or systems that generate the waste product. At a minimum, the following information shall be submitted in characterizing the source of the waste product:

165.1.1 A process flow chart which identifies and explains each phase of the waste product generation process;

165.1.2 A description of all major equipment and components used in the process that generates the waste product;

165.1.3 A description of any stabilization or treatment process the waste product will undergo prior to final utilization, including (where applicable):

165.1.3.1A description of all major equipment used in the stabilization or treatment process;

165.1.3.2Location and type of all monitoring worksheets used in monitoring the stabilization or treatment process;

165.1.3.3Contingency or emergency operating plans; and

165.1.3.4Other relevant information requested by the Department.

165.2 The applicant shall l provide an estimate of the quantity of the waste product that is currently being produced and the anticipated quantity to be generated annually for utilization.

165.3 Waste products containing pathogenic agents shall be stabilized in accordance with a process cited in Part III, B, Section 600 of these regulations.

166.0 Constituent Characterization

166.1 Waste products to be utilized in land application projects may range from relatively clean by-products such as those from certain food processing industries to those which are potentially toxic above certain threshold limits and would require special considerations. As such it is important that the composition of the waste product be determined.

The degree of analysis required is dependent on the ability of the applicant to identify the composition of the waste product. By-products whose composition can be clearly determined through source identification may only need to be analyzed for nutrient status, providing it can be shown that the constituents identified in Part III, B, Subsection 117.2 of these regulations are either absent or at low enough concentrations that they pose no significant environmental or public health risks. However, waste products whose composition is difficult to consistently ascertain will be required to be analyzed for the constituents cited in Part III, B, Subsection 402 (2) (168.0) of these regulations.

166.2 The waste product generator shall submit to the Department a chemical analysis of the waste product in accordance with Part III, B, Subsection 402 (2) (168.0) of these regulations every three months following permit issuance for 402 (2) (b) (168.0) unless the Department approves a different schedule in the permit. The parameters for analysis will be developed based upon the critical or controlling constituents determined through the characterization of the by-product.

166.3 In no case shall the cumulative metals loadings exceed the levels set forth in Part III, A, Table 2 of these regulations. The applicant shall utilize table 2 in conjunction with Section 500 to calculate the potential site life for the constitute metals.

166.4 The waste product generator shall perform and submit to the Department and landowner additional analyses if there has been a significant change (greater than 25%) in the quality of the waste product from the original characterization.

167.0 Utilization Method

168.0 Waste Management Plan

168.1 An application for a permit to utilize a waste product for agricultural purposes or in a distribution and marketing program shall include a Waste Management Plan for Department review and approval. The Waste Management Plan shall, at a minimun, provide:

168.2 An explanation of how the waste product will be utilized; i.e. whether the proposed operation is for agricultural utilization, distribution and marketing, research, or land reclamation.

168.3 An operation plan to include proposed application rates and identification of land limiting constituents (LLC); the proposed life of the operation; equipment to be used for site preparation, land application and incorporation of the waste (if applicable); storage practices and specifications including storage volume, holding time, runon/ runoff control and site access control; and other relevant information requested by the Department.

169.0 Product Literature

The applicant shall develop a printed handout for the waste product that provides instructions for the proper use of the waste product. It shall identify the source and make-up of the waste product and provide detailed instructions for its proper use on different plant types, soils, and slopes, maximum loading rates for specified uses, any unacceptable use of the material and shall provide information on essential plant nutrient content. The printed handout shall also provide information on essential plant nutrient content. The printed handout shall also provide information on essential plant nutrient content, address maximum cumulative loading rates (if contaminant concentrations are of concern), provide instructions for proper storage, stockpiling and transportation of the waste product and application methods to be employed. The Department may require that specific restrictions, warnings or a caution statement be included in the hand out.

170.0 Quality Assurance / Quality Control (QA/QC) Plan

The applicant shall develop a QA/QC plan for department review and approval to assure that the consistency of the waste product is maintained. If the waste product is to be stabilized or other wise processed, the process shall be routinely monitored and the information recorded on a form approved by the Department. The QA/QC plan shall provide in detail, measures taken to assure product uniformity and consistency. In addition, the QA/QC plan shall include a waste product sampling plan in accordance with Part III, B, Section 1200 of these regulations.

171.0 Recordkeeping and Reporting

The applicant shall develop a recordkeeping and reporting system for department review and approval which at a minimum, provides for maintaining distribution records, application rates, results of all tests performed as part of the QA/QC plan, procedures for monitoring the stabilization process (if applicable) and procedures for reporting this information to the Department.

172.0 Additional Requirements

172.1 Agricultural Utilization. If the applicant proposes to repeatedly (more than two consecutive years) utilize the waste product at a specific agricultural site, the following additional information shall be submitted:

172.1.1 A topographic map or other map on a scale no less than 1" = 400'. The map shall include the following information:

172.1.2 The boundaries of the land where the waste product will be applied, including total acreage available for utilization;

172.1.3 The location of any watercourses, drainage structures or wetlands within 1000' of the proposed site;

172.1.4 Residences and habitable structures within 1000' of the proposed site:

172.1.5 Flood elevations:

172.1.6 A description of the soil characteristics of the site in accordance with Part III, B, Subsection 402 (3) (a), (b), (c), of these regulations; and

172.1.7 On-Site storage facility specifications (if applicable).

172.2 A Vegetable Management Plan which shall include, at a minimum, the following information:

172.2.1 A projected crop rotation plan which shall specify crops to be grown, anticipated yield, fertilizer requirements, planting and harvesting schedules, timing of application of the waste product, application rate of the waste product and final use of the crop;

172.2.2 The method and frequency for applying the waste product to the site and the method of incorporating the waste product to the site, if applicable;

172.2.3 The total volume of waste product to be applied to the site and the proposed life of the operation;

172.2.4 Methods to manage runoff and control erosion during the life of the project; and

172.2.5 If the waste product is to be applied to land owned by persons other than the generator of the waste product, the name and address of the landowner and evidence that the landowner has reviewed and approved by the project.

172.3 Distribution and Marketing. If the applicant proposes to utilize the waste product in a Distribution and Marketing program, the following additional information shall be submitted.

172.3.1 Evidence that pathogenic organisms are absent from the waste product;

172.3.2 Evidence that the waste product is dried of otherwise amended to a minimum of twenty percent (20%) solids prior to distribution and marketing;

172.3.3 Evidence that the waste product contains no Free Liquids;

172.3.4 Evidence that the waste product does not exceed the limitations for heavy metals and other constituents as established in Part III, B, Subsection 156.1.2 of these regulations;

172.3.5 Evidence that there is a market for the waste material; and

172.3.6 A description of the distribution and marketing system to include an identification of the end-users and the final use of the waste product.

172.4 Land Reclamation. In addition to the requirements cited in this part, each application for a permit to utilize a waste product for land reclamation shall adhere to the requirements of Part III, B, Subsection 138.0 of these regulations.

173.0 Storage

Storage facilities shall be designed and constructed in accordance with Part III, B, Section 145.0 of these regulations unless the applicant can demonstrate that the proposed storage practices for the waste product will not allow contaminants to leach into the groundwater, contribute to surface runoff, attract vectors, or create nuisance conditions and odors.