Guidelines for Land Treatment of Municipal Wastewater by Drip Irrigation

State of Georgia
Department of Natural Resources
Environmental Protection Division
Water Protection Branch
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1.0 INTRODUCTION

Slow rate spray irrigation and drip disposal facilities have been used and proven to effectively treat domestic and municipal wastewater. The number of subsurface land disposal systems continues to increase as sites are developed with conditions unsuitable for many other alternative wastewater treatment and disposal facilities. This document provides guidelines and criteria for the planning, design, and operation of slow rate land treatment systems in Georgia that utilize drip irrigation.

The term slow rate land treatment as used in this document refers to the treatment of wastewater by irrigation onto land with nutrients applied at agronomic rates to support vegetative growth. These systems are designed and operated so that there is no direct discharge of wastewater to surface waters. The irrigated wastewater transpires to the atmosphere and enters the groundwater through infiltration and percolation. Organic constituents in the wastewater are consumed or stabilized by soil bacteria. Organic and ammonia nitrogen is taken up by plants, nitrified by soil bacteria, lost to the atmosphere through denitrification, and leached into the groundwater or stored as soil nitrogen in the site biota. Phosphorus and many metal constituents are adsorbed into soil particles and 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.

The criteria in this document apply primarily to domestic wastewaters and to systems permitted to municipal governments or authorities. Wastewater irrigation systems for industrial and animal wastes will be evaluated on an individual basis because treatment requirements for those wastes may differ significantly from those for domestic wastewater. The irrigation or slow rate technology is based on maintaining aerobic conditions in the soil and therefore dosing and resting cycles must be established as part of the plan of operation and management. In order for the systems to maximize nitrogen removal and prevent nitrate nitrogen from contaminating the groundwater, installation of subsurface dripper lines should be within the root zone of the proposed cover crop. The actual facilities will consist of aerobic or anaerobic pretreatment systems followed by surface or subsurface distribution systems utilizing drip emitters to distribute a controlled flow. Drip irrigation systems must be capable of providing an equal flow distribution of wastewater effluent applied throughout the application fields at a predetermined application rate. The manufacturer of the drip system should have a history of usage of emitters with a wastewater application. All equipment proposed for use must be certified and warranted by the manufacturer that it has been tested for use with wastewater. It is imperative that all drip irrigation systems maintain uniform and accurate control of the effluent emission rates. Equipment must be provided that will identify and record any fluctuations in the wastewater flow through the system.

Site Inspections, Site Concurrence and the Environmental Information Document (EID) must meet the criteria as established in Section 2. The requirements for a Design Development Report (DDR) shall comply with the requirements in Table 2.2-2.

2.0 PROCEDURES FOR STATE REVIEW AND APPROVAL

2.1 PROPOSAL FOR LAND TREATMENT

The Georgia Water Quality Act and the Georgia Rules and Regulations for Water Quality Control govern procedures necessary to gain State of Georgia approval of slow rate land treatment systems. The steps outlined in Table 2.1-1 are in accordance with the Act and Rules. These steps are explained in the following sections. Projects funded under the State Revolving Loan Fund Program (SRF, Title VI of the Federal Clean Water Act) must meet certain federal requirements in addition to the steps listed in Table 2.1-1.

2.1.1 Site Inspection and Concurrence

The owner, his engineer or agent must submit to the Division a letter of intent to develop a wastewater treatment system. The letter should indicate the projected design flow for this system and proposed source(s) of project funding. The letter should also request a site inspection be performed by EPD. Accompanying the letter of intent should be a "Site Selection and Evaluation Report" as outlined in table 2.1-2. The report must identify potential land treatment sites and provide a preliminary environmental and soil evaluation of selected sites. Table 2.1-2 outlines information generally needed in the Site Selection and Evaluation Report. Additional information may be required as needed.

Upon receipt of the report, an EPD representative will inspect the selected site(s). A preliminary site concurrence or denial letter will be written based on an 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. A site concurrence for slow rate land treatment is valid for one year. The EPD may choose to reevaluate the project if detailed design has not been started within this period.

2.2 ENVIRONMENTAL INFORMATION DOCUMENT & DESIGN DEVELOPMENT REPORT

After a site has been selected by the owner and accepted by the EPD as suitable for slow rate land treatment, the owner must complete an "Environmental Information Document" (EID) and prepare a "Design Development Report" (DDR).

Table 2.1-1
STEPS FOR GEORGIA ENVIRONMENTAL
PROTECTION DIVISION (EPD) REVIEW AND
APPROVAL OF SLOW RATE LAND TREATMENT SYSTEMS

1.0 Letter of Intent and Site Selection and Evaluation Report submitted to EPD by owner or owner's representative.

- 1.1 EPD conducts site inspection
- 1.2 Site concurrence or denial issued by Division

2.0 Environmental Information Document

- 2.1 Owner holds public meeting
- 2.2 Submitted with DDR and minutes from public meeting

3.0 Design Development Report:

- 3.1 Submitted for EPD review
- 3.2 Geologic Survey reviews site (as necessary)
- 3.3 Accepted by EPD as the basis for facility design
- 3.4 Permit application sent to owner

4.0 Application for permit to apply treated wastewater to land:

- 4.1 Permit application completed and submitted to EPD
- 4.2 Application reviewed and checked against design development report and environmental information document

5.0 Land Application System (LAS) Permit drafted by Division.

- 5.1 Industrial pretreatment requirements included if necessary
- 5.2 Draft permit and monitoring requirements sent to owner for comment
- 5.3 Draft permit modified if necessary

6.0 Public Notice:

- 6.1 Public Notice drafted by EPD
- 6.2 One copy transmitted to owner for advertisement, one copy advertised by Division
- 6.3 Public comment period
- 6.4 Public Notice requirements completed
- 6.5 Trust Indenture executed for privately owned facilities

7.0 Final Land Application System (LAS) Permit issued.

- 7.1 Signed by Division Director
- 7.2 Sent to facility owner

8.0 Plans and Specifications:

- 8.1 Submitted for EPD review
- 8.2 Checked against accepted Design Development Report
- 8.3 Approved by Division for construction

9.0 Plan of Operation and Management:

- 9.1 Submitted by owner for EPD review
- 9.2 Approved by Division
- 9.3 Incorporated into final LAS Permit

10.0 Certification of Construction Completion:

- 10.1 Submitted to EPD by design engineer
- 10.2 EPD conducts facility inspection to verify compliance with approved plans and specifications

11.0 Authorization to commence operation at design flow

Table 2.1-2
SITE SELECTION AND EVALUATION REPORT
(REQUIRED INFORMATION FOR EACH SITE UNDER CONSIDERATION)

1.0 Site Description:

- 1.1 Location map
- 1.2 Topographic map
- 1.3 Soil survey map
- 1.4 Known cultural or historic resources (cemeteries, archaeological sites, etc.)

2.0 Site Soil Characteristics: [a]

- 2.1 United States Natural Resources Conservation Service soil series classifications
- 2.2 Narrative description for same including:
    - 2.2.1 Texture
    - 2.2.2 Permeability
    - 2.2.3 Slope
    - 2.2.4 Drainage
    - 2.2.5 Depth to seasonal high water table
    - 2.2.6 Soil wetness condition
    - 2.2.7 Depth to bedrock or saprolite
    - 2.2.8 Erodibility (if surface application)
    - 2.2.9 Soil fertility levels (from local Extension Service)

3.0 100 year flood elevation for site (if applicable)

4.0 Existing vegetative cover.

5.0 Existing land use.

6.0 Present land owner.

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[a] A detailed soil investigation report is required to be submitted with the Design Development Report (reference Tables 2.2-2 and 2.2-3).

The EID is to be developed prior to or concurrently with the DDR. The EID shall be a short and concise document that adequately discusses the environmental impact of the proposed project and is not expected to be a complete environmental impact study. The originator of the document should consider environmental impacts in the areas listed in Table 2.2-1. All areas, of course, may not be pertinent for each project and the degree of detail will vary depending on the project size and location. The DDR should include, but is not limited to, the information outlined in Tables 2.2-2 and 2.2-3.

When the EID and DDR are completed and before submitting them for EPD review, the owner must conduct a minimum of one public meeting. The purpose of the meeting is to present to the public the proposed project; its purpose, its design and its environmental impacts. The meeting date and time must be advertised at least 30 days in advance in local newspapers with circulation covering all areas upon which the project may impact. The Applicant should also make provisions to receive written comments.

Minutes of the public meeting, proof of advertisement, and any written comments derived from the meeting must be submitted to EPD with the Environmental Impact Document and the Design Development Report.

2.3 PERMITTING OF SLOW RATE LAND TREATMENT SYSTEMS

The EPD and the Department of Human Resources will issue approvals for slow rate drip irrigation systems. Those approved by EPD will incorporate an EPD approved Plan of Operation and Management prepared for the facility by the owner or owner's engineer. The Plan of Operation and Management must adhere to these guidelines. The DHR may utilize any or all of these guidelines in conjunction with their minimum standards for any project approved by the DHR. All facilities serving more than one dwelling will be required to obtain from EPD a permit for operation of a Land Application System.

Private (non-governmental) community systems with flows totaling less than 10,000 gallons per day may be permitted through the Department of Human Resources (DHR) through the local county health departments.

Table 2.2-1
ENVIRONMENTAL INFORMATION DOCUMENT
AREAS OF ENVIRONMENTAL CONSIDERATION

1. Compare with "No Action" Alternative
2. Cultural & Historic Resources
3. Archaeological Resources
4. Flood Plain Management
5. Wetlands Protection
6. Noise
7. Air Quality
8. Water Quality-Surface
9. Groundwater Quality
10. Solid Waste Disposal
11. Coastal Resources
12. Endangered Species
13. Farmland Protection
14. Recreation Potential
15. Wild & Scenic Rivers
16. Demographic Changes
17. Displacement of Individuals
18. Financial Impact to User
19. Conformance to Comprehensive Land Plans and Zoning
20. Erosion and Sedimentation Control
21. Hazards, Nuisances and Site Safety
22. Social and Economic Factors
23. Direct and Indirect Impacts
24. Present and Future Conditions
25. Primary and Secondary Impacts
26. Cumulative Impacts
27. Public Meeting

2.3.1 Trust Indenture

Owners of private, domestic wastewater irrigation systems are required to execute a trust indenture as required by Rule 391-3-6-.06(13). This Trust Indenture must be with a local governmental entity or other trustee approved by the Division. The trust indenture must guarantee operation and maintenance of the facility in the event of operational or financial default by the owner. This document must be executed before the EPD will issue the final land application system permit. A sample Trust Indenture is available upon request from the Division.

2.3.2 Public Notice, Draft and Final Land Application System (LAS) Permits

Upon EPD acceptance of the Design Development Report and Environmental Information Document, the owner of the proposed facility must submit a written request for a Georgia Land Application System (LAS) Permit. Upon receipt of a completed application for this permit, the EPD will prepare a draft LAS Permit and public notice for the project. One copy of the public notice will be transmitted to the owner for local advertisement and one copy will be published by the Division. The cost of the local advertisement is to be borne by the owner.

A 30 day comment period follows the publication date of each public notice. If no significant adverse public comments are received, a final LAS Permit will be issued for the slow rate land treatment system. **A condition of the final permit will require submission to and approval by the EPD of the Plan of Operation and Management for the facility prior to start-up and operation.**

2.3.3 Plan of Operation and Management

An outline for the scope of the Plan of Operation and Management required for the Georgia Land Application System Permit is presented in Appendix Section 9.1. The Plan is written by the owner or owner's engineer during construction of the slow rate land treatment system. Once accepted by the Division, this Plan becomes the operating and monitoring conditions for the facility. Therefore, the plan must address wastewater application rates, drip field cycling, monitoring requirements, harvesting schedules, soil and crop testing, maintenance schedules, and all other information necessary for successful operation.

Table 2.2-2
DESIGN DEVELOPMENT REPORT
REQUIRED INFORMATION

1.0 Site Description:

- 1.1 Location map
- 1.2 Climate
- 1.3 Geology (including subsurface hydrology)
- 1.4 Topography
- 1.5 Access
- 1.6 Water supply wells within 1,500 L.F. of facility

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

- 2.1 Preapplication treatment facilities
- 2.2 Storage facilities
- 2.3 Drip fields
- 2.4 Buffer zones
- 2.5 Hand auger, test pit and soil boring locations
- 2.6 Access roads and utilities
- 2.7 Watercourses
- 2.8 Drainage Structures
- 2.9 Flood elevations
- 2.10 Residences and habitable structures within or adjacent to site
- 2.11 Wells within 500 ft. of the site.

3.0 Design wastewater characteristics (influent to preapplication treatment and treated effluent to drip fields). If the project involves an existing facility, then actual, recent data should be used:

- 3.1 Average and peak daily flows
- 3.2 Biochemical Oxygen Demand [a]
- 3.3 Total Suspended Solids
- 3.4 Ammonia Nitrogen, Total Kjeldahl Nitrogen, Nitrate plus Nitrite
- 3.5 Total Phosphorus
- 3.6 Chloride
- 3.7 Sodium Adsorption Ratio [b]
- 3.8 Electrical Conductivity
- 3.9 Metals/Priority Pollutants [c]

4.0 Water Balance/determination of design wastewater loading rates for each drip field

5.0 Nitrogen Balance/selection of cover crop and management scheme

6.0 Background groundwater samples

7.0 Phosphorus and other constituent loading rates

8.0 Determination of wetted field area(s) and required storage volume

9.0 Process design for preapplication treatment facility

- 9.1 Schematic of pump stations and unit processes.
- 9.2 Basin volumes, loading rates, hydraulic detention times, etc. (aerobic or anaerobic).
- 9.3 Capacity of all pumps, blowers and other mechanical equipment. Pump curves and hydraulic calculations for the distribution system must accompany the DDR.

10.0 Detailed Soil Investigation Report (reference Table 2.2-3)

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[a] Chemical Oxygen Demand or Total Organic Carbon may be substituted for industrial wastewaters where appropriate.

[b] Sodium Adsorption Ratio = $\frac{Na^{+1}}{\sqrt{[(Ca^{+2} + Mg^{+2})/2]}}$

Where Na^{+1}, Ca^{+2} and Mg^{+2} in the wastewater are expressed in milliequivalents per liter (meq/l).

[c] Metal and priority pollutant analysis is required for all industrial wastewaters and municipal wastewater systems that receive industrial process wastes. Analyses required depend on the particular process wastewater being discharged and will be determined on a case-by-case basis. However, <u>in all cases the presence of industrial process wastewaters must be identified.</u>

Table 2.2-3
DETAILED SOIL INVESTIGATION REPORT
REQUIRED INFORMATION

1.0 Site description:

- 1.1 Location map
- 1.2 Topographic map
- 1.3 Soil Survey map
- 1.4 Hand auger, test pit and soil boring locations

2.0 Soil series descriptions (each soil series present)

- 2.1 Texture
- 2.2 Permeability
- 2.3 Slope
- 2.4 Drainage
- 2.5 Depth to seasonal high water table
- 2.6 Depth to bedrock
- 2.7 Erodibility

3.0 Soil characteristics (each soil series present):

- 3.1 Hand auger, test pit and soil boring logs:
  - 3.1.1 Soil horizons
  - 3.1.2 Depth to groundwater
  - 3.1.3 Depth to rock
- 3.2 Unified Soil Classification
- 3.3 Results from saturated hydraulic conductivity testing

Table 2.2-3(continued)

3.4 Results from soil chemistry testing:

3.4.1 pH
3.4.2 Cation Exchange Capacity
3.4.3 Percent Base Saturation
3.4.4 Sodium Exchange Potential
3.4.5 Phosphorus Absorption
3.4.6 Nutrients (N,P,K)
3.4.7 Agronomic trace elements (for cover crop proposed)
3.4.8 Mineralogy (clay)

3.5 Engineering properties of soils proposed for any potential pond construction.

3.5.1 Clay content
3.5.2 Permeability
3.5.3 Plasticity
3.5.4 Consistency

4.0 Identification of subsurface conditions adversely affecting vertical or lateral drainage of the land treatment site.

5.0 Delineation of soils and areas suitable and not suitable for wastewater drip irrigation.

6.0 Determination of design percolation for each soil type

2.4 ENGINEERING PLANS AND SPECIFICATIONS

2.4.1 Review

According to Georgia Law, all engineering design and specifications must be done by a professional engineer (P.E.) registered in the State of Georgia, or under the direct supervision of a P.E. registered in the State of Georgia. These guidelines are prepared by the Georgia Environmental Protection Division (EPD, Division) to assist the designer in preparation of design documents for approval through the Division.

After EPD acceptance of the Design Development Report, the owner can submit detailed construction plans and specifications. The plans and specifications should be completed in accordance with the rules and current policies of the Division. The plans and specifications will be reviewed for consistency with the Design Development Report and accepted engineering standards. Upon review of the plans and specifications and issuance of the final LAS Permit a letter approving the plans and specifications for construction will be written. This approval is valid for one year. If construction has not begun within this period, the project may require reevaluation.

IMPORTANT: No slow rate land treatment system can be approved for construction until a final LAS Permit for the facility has been issued. Detailed design work undertaken before the permit is issued is at the owner's risk. Approval for construction of privately owned, domestic wastewater irrigation systems is contingent upon execution of a trust indenture and issuance of the final permit (ref. Sec 2.3.1).

2.4.2 Construction

The Division may choose to make interim inspections of projects under construction to ascertain their progress and adherence to the approved plans and specifications. Upon project completion, the design engineer must certify, in writing, to the Division that the project was constructed according to the approved plans and specifications. Upon receipt of this certification along with a request from the owner, an EPD representative will inspect the completed facility. A letter authorizing initiation of operation under the facility's LAS Permit will be issued after the facility has been verified as being complete and operational. The facilities are not to begin operation until after authorization has been received from the Division. One copy of the as-built drawings must be submitted to EPD.

3.0 GUIDELINES AND CRITERIA FOR DESIGN

3.1 Suitability of Sites For Wastewater Drip Irrigation

3.1.1 Location

The use of subsurface drip irrigation systems is becoming more common in urban settings. Because of the subsurface application, aerosols are not produced and there is less potential for human exposure. Buffer zone requirements identified in Section 5.0 reflect the reduced health hazard potential. The dosing operation of the system also permits application into some areas that had previously been excluded from wastewater irrigation.

3.1.2 Topography

Maximum grades for wastewater drip fields should be limited to between 20 and 25%. Systems on slopes which exceed 25% may be approved by the Division on a case by case basis. Because subsoils may become saturated at times, lateral subsurface flows could potentially emerge on toe slopes or produce slides on unprotected slopes.

3.1.3 Soils

Drip irrigation systems subsurface emitters can produce low instantaneous application rates. In addition, the application period is usually of short duration. Therefore, soils with a wide range of USDA Natural Resources Conservation Service permeability classifications may be suitable for drip irrigation application. Soils with low permeabilities will be able to accommodate the low instantaneous loading rates and soils with higher permeabilities will not push wastewater rapidly through the soils allowing time for treatment within the soil column.

3.2 <u>SOIL INVESTIGATIONS</u>

3.2.1 General

Soil investigations for land treatment differ greatly from investigations for foundations, roads and other traditional 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 first 2 to 10 feet of the soil profile. It must verify or modify Natural Resources

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 that 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, EPD recommends that at least one sample be taken for every 5 to 10 acres of each soil series to confirm or modify the Natural Resources Conservation Service mapping and to provide a sufficient number of undisturbed soil samples. The specific information required for design is outlined in Table 2.2-3.

3.2.2 Saturated Hydraulic Conductivity Testing

Saturated vertical hydraulic conductivity testing is required for the most limiting horizon of each soil series present. The most limiting soil horizon should be determined from soil survey information. A minimum of three (3) tests for each soil series should be performed. **If the proposed site is to be clear cut, the permeability tests must be done following the clear-cutting and establishment of a vegetative cover.** Testing for saturated horizontal hydraulic conductivity is additionally required when subsurface drainage systems are planned or when lateral subsurface drainage is the predominant drainage mechanism for the land treatment site.

Acceptable methods for saturated hydraulic conductivity testing are listed in Table 3.2-1. Percolation tests as performed for septic tank drain fields are not acceptable.

3.2.3 Soil Chemical Testing

The pH, Cation Exchange Capacity, 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 soil series should be taken. Testing for soil nutrients (nitrogen, phosphorus and potassium) and agronomic trace elements may be included if appropriate for the vegetative management scheme.

Soil chemical testing should be performed according to the latest edition of Methods of Soil Analysis published by the American Society of Agronomy, Madison, Wisconsin.

3.3 PREAPPLICATION TREATMENT REQUIREMENTS

3.3.1 General

All wastewater, prior to drip application, must be biologically treated. Aerobically treated surface applications must be treated to a 5-Day Biochemical Oxygen Demand of no more than 50 mg/l at average design flow and 65 mg/l under peak loads. The total Suspended Solids are limited to 90 mg/l prior to passing through the drip system filters. Disinfection is generally not required. Applications utilizing surface distribution or without return piping will generally be considered for areas with Controlled Public Access. These above surface systems will be assessed on the merits of the site selected and actual use. The requirements of water reuse systems as outlined in Section 5.0 of our *Criteria For Slow Rate Land Treatment and Urban Water Reuse* must be met for other site classifications. <u>Subsurface applications with return piping shall be considered for use with Unlimited Public Access without having to meet the effluent requirements of water reuse systems as outlined in Section 5.0.</u> **Any surfacing of wastewater effluent will require the owner/operator to immediately control the access to the drip fields unless reuse requirements have been met.** The system will be reclassified for Controlled Public Access until repairs have been made which eliminate the potential for any future surfacing of wastewater effluent. Preapplication treatment requirements are the same as for other Land Application Systems (LAS). Preapplication treatment systems for subsurface drip systems should be similar to those of spray irrigation systems in that the pretreatment process should be designed and operated to minimize nitrification. The DDR should indicate the expected range of nitrogen removal in the preapplication system.

Subsurface systems utilizing emitters may be used in lieu of conventional or other alternative absorption fields in systems that follow anaerobic septic systems on a case by case basis. Approvals for small applications ($\leq$ 10,000 GPD) may be issued by the Department of Human Resources' local health department at their discretion.

Table 3.2-1
HYDRAULIC CONDUCTIVITY TEST METHODS
(Reference Section 3.2.2)

1.0	SATURATED VERTICAL HYDRAULIC CONDUCTIVITY [a]	
1.1	<u>Laboratory Tests</u>: [b]	
	Constant Head Method (coarse grained soils)	ASTM D 2434-68 AASTHO T 215-70 Bowles (1978), pp 97-104 Kezdi (1980), pp 96-102
	Falling Head Method [c] (cohesive soils)	Bowles (1978), pp 105-110 Kezdi (1980), pp 102-108
1.2	<u>Field Tests</u>:	
	Ring Permeameter Method	Boersma (1965) U.S. EPA (1981), pp 3-22 to 23
	Double Tube Method	Bouwer and Rice (1966) U.S. EPA (1981), pp 3-22 to 24
	Air-Entry Permeameter Method	Bouwer (1966) Reed and Crites (1984), pp 176 to 180 Topp and Binns (1976) U.S. EPA (1981), pp 3-22 to 27
2.0	SATURATED HORIZONTAL HYDRAULIC CONDUCTIVITY [d]	
2.1	<u>Field Tests</u>:	
	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)
3.0	Others	
	Constant Head Permeameter	Amoozegar (1989) Soil Sci. Soc. Am. J. 53:1356-1361

Table 3.2-1(continued)

[a] Other methods, properly documented, may be accepted by the EPD. However, "standard" percolation tests as performed for septic tank drain fields are <u>not</u> acceptable.

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

[c] Methods recommended by the EPD.

[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.

All anaerobically treated wastewater must be treated to best practical treatment technology. Individual septic tank interceptor units with a centralized distribution system are acceptable. A minimum 1,000 gallon tank should be provided. The EPD recommends that the tanks provide at least 48 hours detention time within the tank and suggests baffling to prevent short circuiting. For small residential districts, wastewater flows are commonly determined on the basis of population density and the average per capita contribution of wastewater. Where possible, flow rates should be based on actual flow from selected residential areas similar in social and economic makeup of the area being considered for development. When this is not possible, we recommend that a minimum of 100 gallons per capita per day be used. In sizing the tanks and distribution system, the assumption of 3.5 persons per household (3 bedroom home) should be used. Written verification of anticipated influent and effluent wastewater quality must be provided for all anaerobic treatment facilities proposed. The use of garbage grinders increases the solids (settleable and floatable) in wastewater and the rates at which they accumulate in the septic tank. This will require either more frequent pumping or a larger septic tank to keep the pumping frequency down. If garbage grinders are to be considered, the capacity of the septic tanks must be increased by 250 gallons. Notwithstanding, the Plan of Operation and Management must address the frequency and who maintains the responsibility for tank pumping and maintenance.

3.3.2 Nitrogen

Maximum nitrogen removal in slow rate land treatment occurs when nitrogen is 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 <u>not</u> produce a nitrified effluent.

For aerobic pretreatment, the EPD recommends that aerated or facultative wastewater stabilization ponds be used where possible. These systems generally produce a poorly nitrified effluent well suited for wastewater irrigation. When mechanical plants are employed for preapplication treatment, they should be designed and operated to limit nitrification.

The use of septic tanks or other anaerobic treatment methods are considered acceptable for specific applications.

The Design Development Report should 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 and may be found in the appropriate literature.

3.3.3 Treatment and Storage Ponds

Two treatment cells followed by a storage pond and irrigation pump station are required for all pond preapplication treatment systems. The treatment cells may be aerated, facultative or a combined aerated/facultative system. They may be separated by earthen dikes or floating baffles. However, the storage pond and irrigation pump station must be hydraulically separate from the treatment cells (i.e. pumping must not affect hydraulic detention time in these cells).

IMPORTANT: If initial flows are going to be significantly below design, EPD recommends that construction be phased. The storage pond should not be built for ultimate flow. Phasing is necessary to avoid erosion, odor, and liner failure problems that can occur in such circumstances.

The United States Environmental Protection Agency's October 1983 Design Manual: Municipal Wastewater Stabilization Ponds is recommended as a reference for design of preapplication treatment ponds.

Ponds used for **preapplication treatment** must have liners to prevent seepage from exceeding 1/8 inch per day. Either properly constructed clay or synthetic liners may be used. Facultative pond cells should have a length to width ratio of 4:1 (to minimize short circuiting) with a depth of between 3 and 5 feet. Sizing of complete and partially mixed aerated ponds should be based on first-order removal rate kinetic equations and the expected annual temperature variation. A 2 foot freeboard is required for all ponds less than or equal to six acres and a 3 foot freeboard is required for all ponds larger than six acres.

Ponds used for **storage** of treated wastewater must have liners to prevent seepage from exceeding 1/8 inch per day. Because storage ponds fluctuate greatly in water level, it is extremely difficult to maintain an effective clay liner due to drying, cracking, and erosion. EPD highly recommends synthetic liners for storage ponds. If clay liners are used, synthetic or concrete slope protection must be used on interior slopes from six (6) inches above the maximum operational water level to one (1) foot below the lowest operational water level. An appropriate water level must be maintained at all times in clay lined ponds.

Pond dikes must not exceed 3:1 for internal or external slopes. Any pond with a dike taller than 25 feet or which stores in excess of 100 acre feet at maximum depth must comply with the Safe Dam Regulations of the EPD.

3.4 SOIL AND COVER CROP COMPATIBILITY

Inorganic constituents of effluent from preapplication treatment should be compared with Table 3.4-1 to insure compatibility with land treatment site soils and cover crops. It is recommended that the Natural Resources Conservation Service or local county extension agent be contacted and a soils analysis be conducted to provide background soil nutrient values and cover crop requirements.

3.5 PROTECTION OF IRRIGATION EQUIPMENT

Before pumping to the irrigation field distribution system, the wastewater must be filtered to remove fibers, solids, algae, oil and grease that might clog distribution pipes or emitters. As a minimum, filters must be provided which will remove particles at least equal to one third the diameter of the smallest flow opening in the emitter system. The size and location of this opening must be included in the DDR. Filters should meet the manufacturer of emitters requirements (for size and quantity) to insure proper continuous operation of drip system.

Pressurized clean (i.e. filtered or potable) water for backwashing filters must also be provided. This backwash should be automated. When automated controls are used for backwashing, a discussion of the controls which initiate the backwash process (ie. differential pressure, total flow through filters, timers, etc.) must be included in the DDR. Manual backwash systems will be evaluated on a case by case basis only if an operator is on site during system operation. Filtered water used for backwash must be prefiltered to at least the same degree as the filtration equipment's filtration mesh size to ensure that the filtration equipment remains clean.

Filter backwash and maintenance requirements must be addressed in the Plan of Operation and Management prepared for the system. Backwash filtrate debris should be captured and removed from the site or returned to the pretreatment system for reprocessing. Arrangements should be made for periodic removal of solids buildup from the system. Final disposal of filtrate debris must be done according to all state and local ordinances and should be addressed in the Plan of Operation and Management.

Table 3.4-1
SUGGESTED VALUES FOR INORGANIC CONSTITUENTS
IN WASTEWATER APPLIED TO LAND
(Georgia DNR, 1978; U.S. EPA, 1976 & 1981)

Potential Problem and Constituent	No Problem	Increasing Problem	Severe
pH (std. units)	6.5 - 8.4		< 5.0 > 9.0
Permeability			
Electrical Conductivity (μmho/cm)	< 1.0	> 2.0	> 5.0
Sodium Adsorption Ratio [a]	< 5.0	5.0 - 9.0	> 9.0
Salinity			
Electrical Conductivity (μmho/cm)	< 0.75	0.75 - 3.0	> 3.0
Specific Ion			
Anions:			
Bicarbonate (meq/l)	< 1.5	1.5 - 8.5	> 8.5
(mg/l as $CaCo_3$)	< 150	150 - 850	> 850
Chloride (meq/l)	< 3.0	> 3.0	> 10
(mg/l)	< 100	> 100	> 350
Fluoride (mg/l)	< 1.8		

Table 3.4-1 (continued)

Potential Problem and Constituent	No Problem	Increasing Problem	Severe
Cations:			
Ammonia (mg/l as N)	< 5.0	5.0 - 30	> 30
Sodium (meq/l)	< 3.0	> 3.0	> 9.0
(mg/l)	< 70	> 70	
Total Dissolved Solids (TDS)	<100		>1,000
Specific Ion (cont)			
Trace Metals (mg/l):			
Aluminum	< 10.0		
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	< 10.0		
Lead	< 10.0		
Lithium	< 2.5		
Manganese	< 0.4		
Molybdenum	< 0.02		
Nickel	< 0.4		
Selenium	< 0.04		
Zinc	< 4.0		

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

Where Na^{+1}, Ca^{+2} and Mg^{+2} in the wastewater are expressed in milliequivalents per liter (meq/l).

3.6 DETERMINATION OF DESIGN PERCOLATION RATE(S)

3.6.1 General

When evaluating surface irrigation systems one must consider that the maximum conductivity will not be achieved until the soil is saturated. In properly designed subsurface drip irrigation systems, saturation will occur over time without runoff concerns. The U.S. Environmental Protection Agency recommends using only 4 - 10 % of the hydraulic conductivity for a surface application rate. With the subsurface drip irrigation applications, 10 - 15 % would be reasonable with 12 % being used here.

One of the first steps in the design of a slow rate land treatment system is to develop a "design percolation rate." This value is used in water balance calculations to determine design wastewater loading(s) and thus drip irrigation field area requirements. The percolation rate is a function of soil permeability <u>and</u> drainage. Because different soil types may have different limiting percolation rates and because the soil types may vary from field to field, it may be necessary for a system to have different design percolation rates for each field.

3.6.2 Design Values

The most limiting layer, i.e. A, B, or C horizon, of <u>each</u> 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 bedrock, a high water table, aquitards, and extremely anisotropic soil permeability. Values of saturated vertical hydraulic conductivity from soil testing are used to develop the design percolation rate.

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 the soil series, the rooting habits of the vegetation, the soil reaeration factors, and the long-term changes in soil permeability due to wastewater application. The EPD recommends that the design percolation rate at land treatment sites with seasonal high groundwater at depths greater than 5 feet should be no more than 12 percent (12%) of the mean saturated vertical hydraulic conductivity of the most limiting layer within the first five feet from the surface. Design percolation rates for treatment sites with seasonal high groundwater or impermeable layers between two and one half (2½) feet and five (5) feet shall be no more than 10 percent (10%) of the mean saturated vertical hydraulic conductivity of the most limiting layer within the first five feet from the surface.

Sites with seasonal high groundwater or impermeable layers between one and one half (1½) and two and one half (2½) feet from the surface may not be suitable for drip disposal systems and may be permitted for surface disposal on a case by case basis. With the slow instantaneous application rate of wastewater in the drip systems, underdrains are not recommended to be used in conjunction with subsurface disposal. Sites with seasonal high groundwater or impermeable layers within one and one half (1½) feet from the surface are not suitable for installation of drip disposal systems and will not be permitted. Areas prone to flooding or within the 25 year flood zone should be differentiated from the application site area during site selection and eliminated from the dripper zones.

3.7 DETERMINATION OF DESIGN WASTEWATER LOADING(S)

3.7.1 General

The design wastewater loading is a function of:

a. Precipitation.

b. Evapotranspiration.

c. Design percolation rate.

d. Nitrogen loading limitations.

e. Other constituent loading limitations.

f. Groundwater and drainage conditions.

g. Average and peak design wastewater flows.

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. This loading is then compared to nitrogen and other constituent loading limitations (reference Section 3.8). If the initial value exceeds these limitations, the design wastewater loading is reduced and the process is repeated.

The EPD limits design wastewater loadings for non-reuse systems to a maximum of 2.8 inches/week and instantaneous wastewater application rates to 0.30 inches/hour. Requests for higher loadings may 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 climatic and drainage limitations. Also, because a given site may include several different soil types with significant variation in their permeabilities, it is possible for there to be different application rates for different areas of the site. EPD recommends that when this is the case, the fields be laid out to separate the soils with different permeabilities. However, if this is not done and a field includes more than one soil type, the application rate will be limited to the most restrictive soil permeability.

Considerations must be made for the depth of the dripper line and the storage capacity of the soil above the dripper. The available storage capacity should be calculated for each soil series. Thirty five percent (35%) or less of this value should be used to determine the hourly rate of the emitter. This should verify that the saturated hydraulic conductivity of the soil used (12%) is adequate for the instantaneous application rate proposed. The depth to emitters may be adjusted to insure adequate storage is provided in the soil above the line. A minimum dripper burial depth of 8-inches is recommended.

3.7.2 Water Balance

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

$$D(allowed) = (Evap + Perc) - Precip \qquad \textbf{eq. 3.7.2}$$

Where,	*D(allowed)*	=	Maximum allowable hydraulic wastewater loading (in/month). This value cannot exceed 0.36 x no. of days in the month.
	Evap	=	Potential Evapotranspiration (in/month)
	Perc	=	Design percolation rate (in/month); reference Section 3.6
	Precip	=	Design precipitation (in/month)

3.7.3 Potential Evapotranspiration

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. For row and forage cover crops, the EPD recommends use of either the modified Penman or the Blaney-Criddle Method calibrated for local conditions. For forested systems or when data for other methods is not available, the Thornthwaite equation adjusted for sunlight duration and latitude can be used. **The Thornthwaite equation and adjustment factors for Georgia are presented in Appendix Section 9.2.**

The method used to estimate average monthly potential evapotranspiration for water balance calculations <u>must</u> be referenced in the Design Development Report. In addition, these values must be based on a record of 30 years of historical climatic data.

3.7.4 Five-Year Return Monthly Precipitation

The EPD 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:

$$Precip(avg) + (0.85 \times std.dev.) \qquad \textbf{eq. 3.7.4}$$

Where, *Precip(avg)* = Average monthly precipitation from 30 or more year historic record

std.dev. = Standard deviation for same

The most recent thirty year records of both monthly precipitation and temperature are available for all of Georgia from the National Climatological Center of the National Oceanic and Atmospheric Administration in Asheville, North Carolina. The source of precipitation data used for design <u>must</u> be referenced in the Design Development Report.

3.8 <u>NITROGEN BALANCE/COVER CROP SELECTION AND MANAGEMENT</u>

3.8.1 General

Nitrate concentration in percolate from wastewater irrigation systems must not produce a groundwater nitrate nitrogen concentration leaving the site which exceeds 10 mg/l. Percolate nitrate nitrogen 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. The proposed wastewater percolate combined with background nitrate nitrogen concentrations cannot exceed 10 mg/l. If this occurs for the selected cover crop and management scheme, either the loading rate must be reduced or a cover crop with a higher nitrogen uptake must be integrated. It is recommended that the maximum nitrate nitrogen applied be ≤ 10 mg/l.

3.8.2 Nitrogen Balance

Percolate nitrate concentrations are estimated from an annual nitrogen balance based on the average design wastewater loading, proposed cover crop, and cover crop management scheme. **In no case will a percolate which exceeds drinking water standards for nitrate (10 mg/l) be allowed.**

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. Assumed losses to ammonia volatilization should not exceed 5 percent of the total ammonia applied. Soil storage of nitrogen should be assumed to be zero. The EPD 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. Those tables are reprinted here as Tables 3.8-1 and 3.8-2 for your convenience. In all cases, the source of the plant nitrogen uptake rate used for design must be referenced in the Design Development Report.

3.8.3 Cover Crop Selection and Management

Row crops may be irrigated with wastewater only when not intended for direct human consumption. Forage crops irrigated with wastewater should be harvested and dried before feeding to livestock. Some crop management plans may call for silage that would not require drying. We recommend that contact be made with the local county extension agent. Nitrate levels should be measured to prevent nitrate poisoning as with all hay crops. Unmanaged, volunteer vegetation (i.e. weeds) is not an acceptable drip field cover crop. Disturbed areas in forest systems must be initially grassed and replanted for succession to forest.

Drip field cover crops require management and periodic harvesting to maintain optimum growth conditions assumed in design. Forage crops should be harvested and removed 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. Some may be harvested even sooner. It is recommended that whole tree harvesting be considered to maximize nutrient removal. However, wastewater loadings following the harvesting of forest systems must be reduced until the hydraulic capacity of the site is restored. Drip field area to allow for harvesting and the regeneration cycle <u>must be addressed in design</u>.

While high in nitrogen and phosphorus, domestic and municipal wastewaters are usually deficient in potassium and trace elements needed for vigorous agronomic cover crop growth. High growth rate forage crops such as Alfalfa and Coastal Bermuda will require supplemental nutrient addition to maintain nitrogen uptake rates assumed in design. At least annually the soils should be evaluated by the local extension office to determine if soil supplements are needed. Industrial wastewaters considered for irrigation should be carefully evaluated for their plant nutrient value. Surface applications are presumed to pass through the root zone when percolating into the soil.

When burying dripper lines it is important that the lines be placed at a depth considered **within the root zone** of the prospective cover crop. Contact with the local extension office should be made to insure the depth of the cover crop root zone is consistent with the dripper line burial depth specified.

3.9 <u>SOIL STORAGE CAPACITY</u>

It is important to consider the available water storage capacity in the soil column above the dripper lines. All of the permeability calculations used are based on a saturated condition. A properly operated drip system will maintain aerobic conditions and therefore tend to not be saturated most of the time. Potential problems with specific application rates include surfacing of wastewater within the drip fields. In an effort to prevent the potential for this type of malfunction, we have recommended a minimum burial depth of 8-inches. In addition, the soil storage capacity should be calculated to ensure that the minimum is adequate. The needed volume is approximately equal to one hour of flow for intermittent applications. Additional volume may be required for extended application periods.

In an effort to analyze the soil storage capacity some definitions must first be outlined. They are:

Vp = Pore volume	*Vs = Solids Volume*	*Va = Air Volume*
Vw = Water volume	*Vt = Total Volume*	*Ms = Solids Mass*
Mw = Water Mass	*Mt = Total Mass*	

Bulk density (Pb),	$Pb = Ms/Vt$
Particle Density (Pp),	$Pp = Ms/Vs = 2.65\ gm/cm^3$ *(Relatively Constant)*
Saturation Ratio (S),	$S = Vw/Vp$ *(degree of saturation = S x 100, expressed as a %)*
Volumetric Water Constant (Θ),	$\Theta = Vw/Vt$
Porosity(n),	$n = Vp/Vt = (1-Pb/Pp) = e/(1+e)$

Effective Porosity for Storage (ne), $ne = Va/Vt = n \times (1-S)$

Effective Porosity for Flow (nef), $nef = F \times ne = F \times n \times (1 - S)$

Void Ratio (e), $e = Vp/Vs = n \times (1-n)$

The required depth can be calculated as follows:

Soil Storage Capacity (Φ), $\Phi = Va/Vt = n \times (1-S) = n - \Theta$

$$D = G\ (gal/hr) \div 7.48\ gal/ft^3 \div [F \times (1 - Pb/Pp) \times (1 - S)]\ ft^3/ft^3 \div (L \times W)\ ft^2 \times 12 \quad \text{eqn 3.9.1}$$

Where ***D*** is the minimum soil depth required to store the wastewater applied in one hour without wastewater surfacing. The equation can be rewritten as follows:

Where ***L x W*** equals the spacing of the drip emitters and dripper lines, ***F*** is a fraction less than one and G is the drip emitter discharge rate. The soil is a very tortuous medium far from containing a neat network of continuous, interconnected voids. To account for this tortuosity, the porosity must be reduced by a factor ***F*** to estimate the effective porosity flow or dynamic porosity. Two soils may have different *nef* depending clay content and degree of aggregation. F is established as a maximum of 35% in section 3.7.1.

This provides the depth required per hour of application. For intermittent operations, one hour is considered a minimum. If a surface application is selected, loadings should be the same as other surface irrigation systems to prevent runoff.

3.10 STORAGE VOLUME

3.10.1 GENERAL

The total storage volume required for the subsurface drip systems will differ rom typical LAS systems and the surface drip systems. Operational storage for cutting and harvesting is essentially eliminated for subsurface installations and wet weather storage, because of subsurface applications, is not a major factor. However, water balance storage and emergency storage are required. For automated systems, operations may occur for 24 hours per day, seven days per week. Some manual systems may only operate 5 days per week. Operational storage will be required to get surface drip installations and manually operated systems through the entire week. Emergency storage may be required to supplement for equipment malfunctioning. Wet weather storage requirements may result from severe weather causing completely saturated conditions. The Georgia EPD has established minimum requirements for wet weather and emergency storage to ensure the reliability of the treatment system. The volume provided for wet weather and emergency storage must be the greater of 3 days average design flow volume or as calculated in equation 3.10.1 of these guidelines. Water balance storage must be calculated in accordance with Section 3.10.2 of these guidelines. These minimum storage requirements may be increased based on the crop cover, water balance and reliability provided. For subsurface application, minimum emergency storage requirements are established at three (3) days unless 100% back-up reliability is provided including standby power. Under no circumstances will less than 24 hours be provided.

Surface application minimum storage requirements are five (5) days. This minimum volume is necessary to ensure system reliability and provide wet weather and emergency storage. Water balance storage must also be determined. Surface drip systems should not be operated during rainfall events that produce run-off from the site. A water balance must be prepared to determine storage requirements as identified in Section 3.7 of these guidelines. Elements of the water balance include: allowable hydraulic loading, potential evapotranspiration, design percolation, and design precipitation. Storage requirements must be based on anticipated wet weather flows. Stormwater infiltration and inflow (I&I) must be included in the storage calculations.

3.10.2 Operational Storage

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 with surface applications which harvest cover crops on a frequent basis may stop irrigation to allow drying of these fields. Wastewater storage volume is required during these periods.

3.10.3 Wet Weather and Emergency Storage

Wet weather and emergency storage provides for periods of excess rainfall, saturated soil, and equipment failure when wastewater cannot be applied. The Georgia EPD has minimum requirements for wet weather and emergency storage. These are necessary to insure reliability of the slow rate land treatment system.

The volume provided for wet weather and emergency storage must be the greater of that required for the system (5 days surface, 3 days subsurface) days average design flow volume or

$$\frac{\text{Delta } P \text{ x } (30.4 \text{ days/month}}{D(\text{allowed}) \text{ crit}} \qquad \textit{eq. 3.10.1}$$

Where, *Delta P* = 20 year variation from 5-year return monthly design precipitation (in).

D (allowed) crit = Maximum allowable hydraulic loading in most critical water balance month.

Weather flow storage shall be based on a peak flow of ADF plus 25% ADF to account for I&I. Any sewer studies which have been performed for the community may be used to document actual anticipated wetweather flows.

Table 3.8-1 (EPA TABLE 4-11)
NUTRIENT UPTAKE RATES FOR SELECTED CROPS
LB/ACRE·YEAR

	Nitrogen[b]	Phosphorous	Potassium
Forage Crops			
Alfalfa[a]	201-482	20-31	156-200
Brome Grass	116-201	36-49	219
Coastal Bermuda Grass	357-602	31-40	201
Kentucky Blue Grass	178-241	40	178
Quack Grass	210-250	27-40	245
Reed Canary Grass	299-401	36-40	281
Ryegrass	178-250	54-76	241-290
Sweet Clover	156	18	89
Tall Fescue	133-290	27	268
Orchard Grass	223-312	18-45	201-281
Field Crops			
Barley	112	13	18
Corn	156-178	18-27	98
Cotton	67-98	13	36
Grain Sorghum	120	13	62
Potatoes	205	18	219-290
Soybeans[a]	223	9-18	27-49
Wheat	143	13	18-40

[a] Legumes will also take nitrogen from the atmosphere.
[b] Site specific yields based upon potential crop yields may require additional nitrogen applications. Pounds of nitrogen per crop ton or pound per crop bushel may require specific loadings to vary (increase).

Source: United States EPA 1981 Process Design Manual, *Land Treatment of Municipal Wastewater*

Table 3.8-2 (EPA TABLE 4-12)
ESTIMATED NET ANNUAL NITROGEN UPTAKE IN THE OVERSTORY AND UNDERSTORY VEGETATION OF FULLY STOCKED AND VIGOROUSLY GROWING FOREST ECOSYSTEMS IN SELECTED REGIONS OF THE UNITED STATES

	Tree Age (Years)	Average Annual Nitrogen Uptake (lb/acre/year)
Eastern Forest		
Mixed Hardwoods	40-60	196
Red Pine	25	98
Old Field With White Spruce Plantation	15	250
Pioneer Succession	5-15	250
Southern Forests		
Mixed Hardwoods	40-60	303
Southern Pine With Understory[a]	20	196
Southern Pine With No Understory[a]	20	286
Hybrid Poplar[b]		
	5	138

[a] Principal southern pine included in these estimates is loblolly pine.

[b] Short-term rotation with harvesting at 4-5 years; represents first growth cycle from planted seedlings.

Source: United States EPA 1981 Process Design Manual, *Land Treatment of Municipal Wastewater*

3.10.4 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/week, 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:

$$WBS = D(\text{potential}) - D(\text{allowed}) \qquad \textbf{eq. 3.10.2}$$

Where,

WBS = Required water balance storage (in/month)

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

$D(allowed)$ = Maximum allowable hydraulic wastewater loading (in/month); Reference eq. 3.7.2

4.0 DETERMINATION OF WETTED FIELD AREA

The total wetted field area required for the drip irrigation system will be broken down into individual application fields which must be capable of being isolated and monitored. Effluent may be applied intermittently to any of the fields in any sequence that has been approved in the Plan of Operation and Management for the project. The soils within the application site must remain aerobic at all times. The wetted field area is sized to adequately treat a combination of three volumes of water - seven days of the design average flow, emergency storage, and water balance storage. Since storage in the drip systems is minimal, sufficient area must be provided so that the flows stored can be eliminated within a 30-day period. If 20 or more days of total storage are provided, storage can be eliminated within a 90-day period. <u>If less than three days of storage are provided, the flows stored must be eliminated within 7 days.</u>

The wetted field area must be sized to adequately treat the storage volumes discussed and seven days of average daily design flow. In equation form this relationship is represented as:

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

Where,

$A(wetted)$	=	Required total 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
$A(WW/E)$	=	area (acres) necessary to treat the wet weather/emergency storage.
$A(WBS)$	=	area (acres) necessary to treat the water balance storage

Sufficient area must be provided so that all of the storage can be eliminated within a seven (7) or thirty (30) day period depending on storage provided as discussed above. The necessary areas for treating storage volume is calculated as follows:

$$A(ADF) = \frac{7\ days}{1\ week} \times ADF\frac{gal}{day} \times \frac{1\ cf}{7.48\ gal} \times \frac{1\ acre}{43{,}560\ sf} \times \frac{12\ in}{1\ ft} \times \frac{1\ week}{WLR,in} \quad eq.\ 4.1$$

Drip field area necessary for the treating/storage associated with the facility operating less than seven days per week is included in the A(ADF) calculation. The total storage (sto.) required consists of operational, wet weather/emergency and water balance storage which are all calculated as follows:

For 7 days depletion:

$$A(sto.) = \frac{gal(sto)}{7\ days} \times \frac{7\ days}{1\ week} \times \frac{1\ cf}{7.48\ gal} \times \frac{1\ acre}{43{,}560\ sf} \times \frac{12\ in}{1\ ft} \times \frac{1\ week}{WLR,in} \quad eq.\ 4.2$$

For 30 days depletion:

$$A(sto.) = \frac{gal(sto)}{30\ days} \times \frac{7\ days}{1\ week} \times \frac{1\ cf}{7.48\ gal} \times \frac{1\ acre}{43{,}560\ sf} \times \frac{12\ in}{1\ ft} \times \frac{1\ week}{WLR,in} \quad eq.\ 4.3$$

Therefore, this calculation must be performed at least three times to find the total area required to eliminate the wastewater generated. One for Operational Storage, A(OP), one for wet weather/emergency storage, A(WW/E), and one for water balance storage, A(WB). The total wetted land area is calculated as previously shown.

5.0 BUFFER ZONES, PUBLIC ACCESS & PROTECTION OF WATER SUPPLY WELLS

Buffer zones are required to provide adequate access to buried drip lines and to ensure that no wastewater leaves the site. The following minimum buffer zones must be provided for all systems:

a. A 25 foot buffer must be maintained between the edge of the subsurface piping and the property line. A minimum 50 foot buffer must be maintained between the edge of the surface piping and the property line. This requirement is subject to change as a result of site topography and the flushing system provided.

b. A 25 foot undisturbed natural vegetative buffer is required between the drip piping and the edge of any perennial lake, stream, or channelized intermittent watercourse. If application of wastewater causes an intermittent watercourse to become perennial, a 25 foot buffer requirement will apply. All buffer requirements for trout streams and sedimentation and erosion control will also apply. Any local ordinances or requirements more stringent will govern.

c. A 300 foot buffer must be maintained between any habitable structure and any part of the onsite pretreatment and storage facility. This requirement does not apply to the underground septic tank interceptor tanks. Septic tanks must be installed in accordance with the local health department requirements.

d. Requirements for buffer areas in relation to potable water wells will be determined on a case by case basis. The buffer will be determined after reviewing groundwater pollution susceptibility and groundwater recharge maps or by contacting the Georgia Geologic Survey Branch of EPD. In no case shall a community wastewater application system be located within 300 feet of a drinking water well. Wellhead Protection requirements may increase the buffer distances as necessary.

In order to protect the drinking water aquifers, abandoned water supply wells within the treatment site must be identified along with all public water supply wells within 1,500 linear feet of any community land treatment site and all private water supply wells within 500 linear feet of any community land treatment site. Shallow wells within 500 feet of a community land treatment system will require monitoring along with all other monitoring wells. Poorly constructed wells within 500 feet of a community land treatment system will require abandonment and sealing.

6.0 SURFACE DRAINAGE AND RUN-OFF CONTROL

Drainage of storm run-off should be considered in the design of drip irrigation systems. All land application fields must be protected against flooding, ponding and erosion. Run-off from upgradient areas should be redirected around the irrigation site. If properly designed and constructed, drip irrigation systems will not produce any runoff if surface applied or any surface flow of wastewater if subsurface applied. All areas that acquire a wet surface should have the hydraulic loading rate reduced to prevent the situation from recurring. Areas exhibiting a wet surface on a regular basis must be eliminated from future applications unless the surface wetting can be corrected. A reassessment of the design should be performed to determine if reconstruction or repair of the failing area would correct the deficiency. Any areas taken out of service because of failure will subsequently cause a reduction in the permitted system capacity.

Indirect runoff as a result of underflow, changes in slope, and shallow restrictive soil layers can be anticipated at some slow rate land treatment sites. Indirect runoff may be acceptable if it is dispersed over a wide area. However, monitoring of streams affected by such indirect runoff will be required.

Water resulting from line flushing must be dispersed over a wide area. No flush waters shall be permitted to flow off the site onto adjoining property. Direct discharge of these flows into any water course is prohibited. Effluent from line flushing should be absorbed by the surrounding area within a few minutes of line flushing. Line flushing should not be performed during any rain event.

7.0 DISTRIBUTION SYSTEMS, MAINTENANCE AND CONSTRUCTION

Hydraulic calculations for the pump and distribution system must be submitted with the DDR. Field pressure and flow variation due to friction loss and changes in static head should not exceed plus or minus 10% of the design emitter pressure or flow. If this criterion cannot be met, revisions to field layout, emitter output, or any other viable option should be used to comply with this requirement. The system will not be allowed to initiate operations if the total flow or pressure variation is in excess of 10% of the design. The 10% difference should be the difference between any two emitters in the entire system.

Fields should be laid out so that the irrigation lines follow the contour of the site. The DDR should contain the proposed line layout so that flushing flows and static head calculations can be addressed on a field by field basis. Each field should define total flow (gpm) proposed, total length of emitter piping, emitter spacing, line spacing, total number of lines and total number of lines to be included per flushing. This layout information should be shown on a topographic map. All proposed main line sizes and lengths along with individual irrigation line lengths should be shown. All return piping sizes and lengths should also be shown and should not exceed manufacturers' specifications to insure equal distribution to each emitter. Emitter and line spacing should be in accordance with manufacturers recommendations.

System should be self draining to prevent freezing during the winter months. The Plan of Operation and Management should address disinfection and flushing of emitter lines to prevent solids buildup. Flushing of lines should be performed according to the manufacturers' recommendations but at minimum on a bi-monthly basis. **Velocities must be a minimum of 2 feet per second at the end of each irrigation or return line during the flushing operation.** Calculations supporting the 2 feet per second should be included in the DDR.

Satisfactory operation of the drip irrigation system is necessary to safeguard the health of the public and to insure that the wastewater effluent is disposed of in an environmentally sound manner. Emitter manufacturers must supply documentation that placing the emitter in the root zone of the cover crop will not interfere with the emitter performance. Emitters should be buried no less than 8 inches nor more than 12 inches from the surface for optimum nutrient uptake. Variance from this depth of burial will be evaluated on a case by case basis if supported by manufacturers' recommendations. All systems must be equipped with audible and visual alarms to signal system malfunctions. Telemetry systems should also be installed where the facility is not manned during normal working hours. Monitoring equipment must be provided to detect a 5% change in flow rate to any given field. If a change is detected which shows a 10% variance, evaluations must be performed to determine if it is a result of clogging filters, forcemain breaks, emitter clogging, leaks in field lines, a flush valve failure, etc. The Plan of Operation and Management should address what actions are required to correct any such problem should it occur. Pumping equipment must be provided with pressure and flow sensitive controls which will disengage pumps if a main breaks or clogs.

8.0 MONITORING

A system is required for monitoring the groundwater influenced by the land treatment system in accordance with the LAS permit issued. Groundwater leaving the site boundaries must meet drinking water standards. Subsurface geology and the direction of groundwater flow determine the placement and depth of monitoring wells. For a total wetted field area in excess of 10 acres, a minimum of four (4) wells are required as follows:

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

b. One well within the wetted field area. Additional wells will be required for <u>each</u> major drainage basin intersected by the land treatment site.

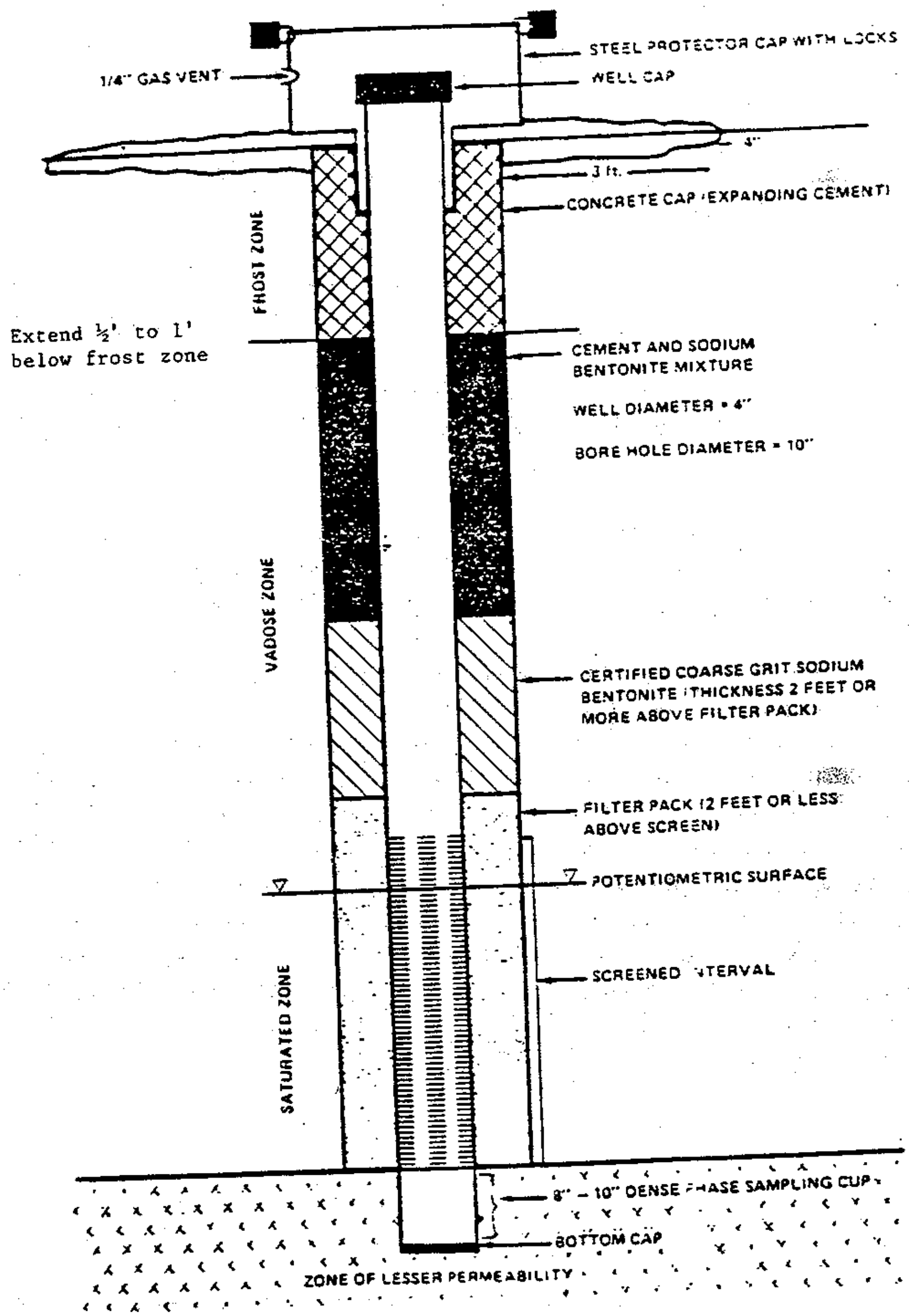
c. Two wells down gradient of the wetted field area. Additional wells will be required for <u>each</u> major drainage basin intersected by the land treatment site.

On a system with a total wetted field area less than ten (10) acres, a minimum of two monitoring wells will be required. The actual number of wells required for the specific application proposed will however be determined on a case by case basis.

All monitoring wells must be constructed to conform with the <u>Manual for Groundwater Monitoring</u> (May, 1987) which was developed as a reference for the design and construction of groundwater monitoring wells at land treatment systems. All monitoring wells must extend to sufficient depth to sample seasonal fluctuations of the unconfined water table. Monitoring wells failing to access water within twenty (20) feet of the surface may require deepening or replacement. Casings and screens must be provided for all monitoring wells. The casing must be backfilled and sealed to prevent the entry of surface water. This seal should include a concrete apron surrounding the well at the surface. Care should be taken to avoid contamination of monitoring wells both during and after construction. **All monitoring wells must be numbered <u>and</u> locked.** Details for the monitoring well must be included with the treatment system plans and specifications.

FIGURE 8.0-1

General Monitoring Well - Cross Section



9.0 APPENDICES

9.1 PLAN OF OPERATION AND MANAGEMENT FOR SLOW RATE LAND TREATMENT SYSTEMS

This plan should include but not be limited to the following:

9.1.1 Introduction

A. System Description:

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

2. A map of the land treatment facility showing the preapplication treatment system(s), storage (pond(s)or tanks), drip fields, buffer zones, roads, streams, drainage system discharges, monitoring wells, return piping, etc.

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

4. A schematic and plan of the preapplication treatment system(s) interceptor septic tanks and storage (pond(s)or tanks) identifying all pumps, valves and process control points.

5. A schematic and plan of the irrigation distribution system identifying all filters, pumps, valves, gauges, emitters, sensors, etc.

6. A plan for managing the residuals generated in the preapplication treatment process.

B. Discuss the design life of the facility and factors that may shorten its useful life. Include procedures or precautions which will compensate for these limitations.

C. A copy of facility's Georgia Land Application System (LAS) Permit.

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

9.1.2 Management and Staffing

A. Discuss management's responsibilities and duties.

B. Discuss staffing requirements and duties:

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

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

9.1.3 Facility Operation and Management

A. Preapplication Treatment System:

1. Describe how the system is to be operated.

2. Discuss process control.

3. Discuss maintenance schedules and procedures.

4. Discuss residuals management.

B. Irrigation System Management:

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

a. Wastewater loading rate (inches/week)
b. Wastewater application rate (inches/hour)
c. Drip field application cycles
d. Organic, nitrogen and phosphorus loadings (lbs/acre per month, etc.)

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

a. Storage pond(s)
b. Irrigation pump station(s) and filtration system

c. Drip field force main(s) and laterals
d. Line flushing intervals and chlorination

3. Discuss start-up and shut-down procedures.

4. Discuss system maintenance.

a. Equipment inspection schedules
b. Equipment maintenance schedules

5. Discuss operating procedures for adverse conditions.

a. Wet weather
b. Freezing weather
c. Saturated soil
d. Electrical and mechanical malfunctions

6. Provide troubleshooting procedures for common or expected problems.

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

8. Discuss any contractual agreements with management firms and any telemetry systems which may be incorporated into the system.

C. Vegetation Management:

1. Discuss how the selected cover crop is to be established, monitored and maintained.

2. Discuss cover crop cultivation procedures, harvesting schedules and uses. Also discuss the supplemental nutrient requirements of the crop and soil testing procedures and intervals.

3. Discuss buffer zone vegetative cover and its maintenance.

9.1.4 Monitoring Program

A. Discuss sampling procedures, frequency, location and parameters for:

1. Preapplication treatment system.

2. Irrigation System:

   a. Storage (pond(s)or tanks)
   b. Groundwater monitoring wells
   c. Flushing system discharges (if applicable)
   d. Surface water (if applicable)

B. Discuss soil sampling and testing.

C. Discuss ambient conditions monitoring:

1. Rainfall.

2. Wind speed.

3. Soil moisture.

D. Discuss the interpretation of monitoring results and facility operation:

1. Preapplication treatment system.

2. Drip fields.

3. Groundwater.

4. Soils.

9.1.5 Records and Reports

A. Discuss maintenance records:

1. Preventive.

2. Corrective.

B. Monitoring reports and/or records should include:

1. Preapplication treatment system and storage (pond(s)or tanks).

   a. Influent flow
   b. Influent and effluent wastewater characteristics

2. Irrigation System.

   a. Wastewater volume applied to drip fields
   b. Drip field scheduling
   c. Loading rates

3. Groundwater Depth and quality

4. Surface water parameters (if applicable).

5. Soils data.

6. Vegetation, quantity and quality

7. Rainfall and climatic data.

9.2 THORNTHWAITE POTENTIAL EVAPOTRANSPIRATION

The Thornthwaite Potential Evapotranspiration (P.E.T.) is defined as "the amount of water which will be lost from the 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). The Thornthwaite method is applicable to slow rate land treatment systems in the southeast United States including Georgia. It is not applicable to arid and semi-arid regions west of the Mississippi River.

The Thornthwaite equation is outlined below. Note that the results are expressed in centimeters (cm) for a 30 day month. The P.E.T. results must be modified by the actual number of days in each month. Finally, for water balance calculations as described in Section 3.7, a 30 year record of historical climatic data (referred to as the climatological normal) is required to determine monthly temperature normals used in the Thornthwaite equation.

$$P.E.T. = 1.6 \times Ld \times [(10 \times T)/I]^{A} \qquad \textbf{eq. 9.2.1}$$

Where,

P.E.T. = 30 day Thornthwaite Potential Evapotranspiration (cm)

Ld	=	Daylight hours in units of 12 hours (reference Table 9.2-1)
T	=	Mean (normal) monthly air temperature in degrees Celsius
I	=	Annual heat index obtained by summing the 12 monthly heat indexes, i where: $i = (T/5)^{1.514}$
A	=	Power term derived from annual heat index, I where: $A = 0.000000675(I)^3 - 0.0000771(I)^2 + 0.01792(I) + 0.49239$

Table 9.2-1
MONTHLY AVERAGE DAYLIGHT HOURS AS A FUNCTION OF LATITUDE

Latitude	Daylight Hours (x 12 hours)[a] 30 degrees	35 degrees
January	0.90	0.87
February	0.87	0.85
March	1.03	1.03
April	1.08	1.09
May	1.18	1.21
June	1.17	1.21
July	1.20	1.23
August	1.14	1.16
September	1.03	1.03
October	0.98	0.97
November	0.89	0.86
December	0.88	0.85

[a] Values for sites between 30 and 35 degrees latitude should be interpolated.

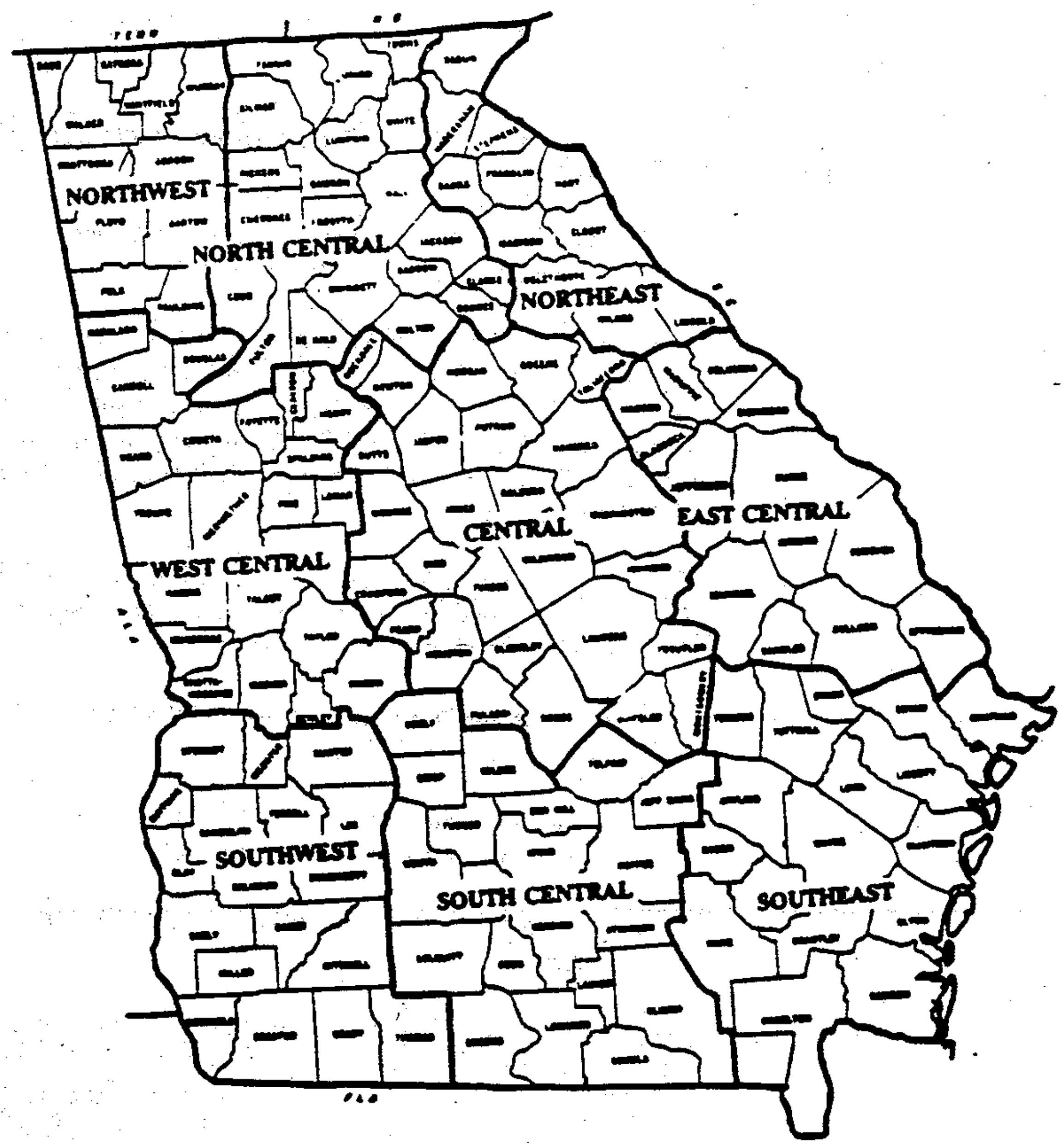
9.3 DELTA P VALUES FOR GEORGIA CLIMATIC DIVISIONS

Table 9.3-1
DELTA P VALUES FOR GEORGIA CLIMATIC DIVISIONS
(Reference Figure 9.3-1)

Georgia Climatic Division	Delta P[a] (inches)
Northwest	2.0
North Central	2.5
Northeast	3.0
West Central	2.5
Central	2.0
East Central	2.0
Southwest	2.5
South Central	3.0
Southeast	2.5

[a] 20 year variation from 5-year return monthly precipitation. Derived from National Oceanic and Atmospheric Administration historical rainfall data for Georgia.

Figure 9.3-1
GEORGIA CLIMATIC DIVISIONS



9.4 EXAMPLE CALCULATIONS

9.4.1 Introduction and Assumptions.

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 half (0.5) MGD facility in the Coastal area of Georgia. They illustrate the basic computations required and the relationship between variables.

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

a. The average design flow is one half (0.5) MGD with a daily peak factor of 2 and a weekly peak factor of 1.25.

b. The land treatment site is moderately well drained with seasonal high groundwater 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 of 0.000106 cm/s corresponding to 0.150 inches/hour.

c. The annual average precipitation is 89 inches. Evapotranspiration occurs at the potential evapotranspiration as computed by the Thornthwaite equation.

d. Nitrogen concentrations in effluent from the preapplication treatment system are as follows:

Total Nitrogen as N	20 mg/L
Ammonia Nitrogen as N	15 mg/L

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

f. Maximum loss to ammonia volatilization is 0 percent of the total ammonia applied for this subsurface application. Maximum loss to denitrification for pine forest is 25 percent of the total nitrogen applied. Maximum loss to denitrification for Coastal Bermuda grass is 15 percent of the total nitrogen applied.

g. Net uptake and removal of nitrogen in pine forest with understory growth is 75 lbs/acre-year. Nitrogen uptake and removal for Coastal Bermuda grass is 300 lbs/acre-year.

h. Delta P from Table 9.3-1 is assumed to be 2.5 inches.

9.4.2 Design Percolation

As stated in Section 9.4.1, the average permeability of the most limiting soil layer is 0.150 inches/hour. As this limiting layer occurs at a depth less than 5 feet, 12 percent of this value will be used for design (reference Section 3.6.2). The design percolation rate becomes:

$$0.12 \times (0.150 \text{ in/hr}) \times (24 \text{ hr/day}) = 0.432 \text{ in/day}$$

9.4.3 Water Balance

Water balance calculations for the hypothetical one half (.5) MGD wastewater irrigation system are presented in Table 9.4-1. This table makes use of eq. 3.7.2 to determine maximum allowable monthly hydraulic wastewater loadings.

Thornthwaite potential evapotranspiration and 5-year return monthly precipitation values for Coastal Georgia are used in Table 9.4-1. The table indicates that for the assumed site conditions, the most critical water balance month is January with a maximum allowable wastewater loading of 4.7 inches, corresponding to 1.1 inches/week. Therefore, a design wastewater loading greater than 1.1 inches/week will require water balance storage. Conversely, no water balance storage will be required for a design wastewater loading less than 1.1 inches/week (reference Section 3.9.3).

9.4.4 Nitrogen Balance

The nitrogen balance is used to evaluate the range of wastewater loadings possible under different cover crop and management schemes. Tables 9.4-2 and 9.4-3 present nitrogen balances for cover crop alternatives of pine forest and Coastal Bermuda grass. To meet a percolate total nitrogen limit of 10 mg/l, Table 9.4-2 indicates a pine forest cover crop will allow a design wastewater loading up to the maximum of 2.8 inches/week. Table 9.4-3 indicates Coastal Bermuda grass will also allow a design wastewater loading up to the maximum of 2.8 inches/week. The final cover crop selected is an economic decision balancing wetted area and storage requirements against operating costs.

Table 9.4-1
WATER BALANCE CALCULATIONS

Month	Evap[a] (in)	Perc[b] (in)	Precip[c] (in)	D(allowed) (in)	(in/week)
(1)	(2)	(3)	(4)	(5)[d]	(6)[e]
October	0.9	13.4[f]	7.2	7.10	1.6
November	0.5	13.0[i]	6.5	7.00[j]	1.6[k]
December	0.4	13.4	7.3	6.50	1.5
January	0.5	13.4	9.2	4.70	1.1[l]
February	1.1	12.1	7.4	5.80	1.5
March	1.9	13.4	8.7	6.60	1.5
April	2.8	13.0	8.0	7.80	1.8
May	3.4	13.4	9.6	7.20	1.6
June	3.8	13.0	5.3	11.50	2.7
July	3.5	13.4	4.4	12.50[g]	2.8[h]
August	2.7	13.4	6.0	10.10	2.3
September	1.7	13.0	9.2	5.50	1.3
Total	23.20	157.90	88.80	92.30	1.78

[a] Thornthwaite average monthly evapotranspiration.
[b] Based on the (number of days per month) x (a saturated vertical hydraulic conductivity of 0.000106 cm/s or 0.150 in/hr) x (a design safety factor of 12 percent) x 24 hr/day.
[c] Five-year return, monthly precipitation.
[d] The maximum allowable hydraulic wastewater loading rate for each month in in/month. Column 5 = Column (2 + 3 - 4).
[e] The maximum allowable hydraulic rate for each month in in/wk.
[f] 31 days x 0.150 in/hr x 24 hr/day x 0.12 safety factor = 13.4 in.
[g] The maximum allowable hydraulic wastewater loading rate is 13.4 in/month. This (13.4 in/month) is the maximum value that can be used. No values in column 5 may exceed this value.
[h] 12.5 in/month ÷ 4.42 weeks per month = 2.82 in/wk. Since 2.82 exceeds the maximum allowable hydraulic wastewater loading of 2.8 in/wk, 2.8 in/wk should be used.
[i] 30 days x 0.150 in/hr x 24 hr/day x 0.12 safety factor = 12.96 in.
[j] 0.5 + 13.0 - 6.5 = 7.0 in./month.
[k] 7.0 in/month ÷ 4.28 weeks per month = 1.64 in/wk
[l] 1.1 in/wk is the lowest value in column 6. In this example the month of January is the most critical water balance month.

Table 9.4-2
NITROGEN BALANCE, PINE FOREST
(Surface Application)

1.	Average Daily Flow ADF (mgd)	.5	.5[a]	.5	.5
2.	Average Design Wastewater Loading (in/week)	1.25	1.50[b]	1.75	2.50
3.	ADF Wetted Area (acres)	103.1	85.9[c]	73.7	51.6
4.	Nitrogen Input from Wastewater (lbs/acre-year)	295	354[d]	413	590
5.	Nitrogen Input from Rainfall and Fixation (lbs/acre-year)	5	5[e]	5	5
6.	Total Nitrogen Input (lbs/acre-year)	300	359[f]	418	595
7.	Ammonia Volatilization @ 5% of Ammonia Applied (lbs/acre-year)	11	13[g]	15	22
8.	Denitrification, @ 15% of Total Nitrogen applied (lbs/acre-year)	75	90[h]	105	149
9.	Net Plant Uptake and Storage (lbs/acre-year)	75	75[i]	75	75
10.	Nitrogen Leached by Percolate (lbs/acre-year)	139	181[j]	223	349
11.	Precipitation (in/year)	88.8	88.8[k]	88.8	88.8
12.	Wastewater Applied (in/year)	65	78[l]	91	130
13.	Potential Evapotranspiration (in/year)	23	23[m]	23	23
14.	Percolate (in/year)	131	144[n]	157	196
15.	Estimated Percolate Total Nitrogen (mg/l)	4.70	5.57[o]	6.29	7.88

[a] Given value, 0.5 mgd
[b] Selected design loading, 1.50 in/wk

c $\frac{\text{7 days/week x 500,000 gal/day x 12 in/ft}}{\text{7.48 gal/cf x 43,560 sf/acre x 1.50 in/wk}}$

d Given Total Nitrogen value = 20 mg/l

$\frac{\text{20 mg/l x 8.34 lb/gal x 0.5 mgd x 365 day/year}}{\text{Line 3 value}}$

e Constant from atmosphere, 5 lbs/acre-year

f Line 4 value + Line 5 value

g Given Ammonia Nitrogen value = 15 mg/l

$\frac{\text{15 mg/l x 0.5 mgd x 8.34 lbs/gal x 365 day/year x 5\%}}{\text{Line 3 value}}$

h Line 6 value x 25%

i Constant

j Line 6 value - Line 7 value - Line 8 value - Line 9 value

k Given

l Line 2 value x 52 wks/year

m Given

n Line 11 value + Line 12 value -Line 13 value

o $\frac{\text{Line 10 value x 4.41}}{\text{Line 14 value}}$

Table 9.4-3
NITROGEN BALANCE, COASTAL BERMUDA GRASS
(Subsurface)

Average Daily Flow ADF (mgd)	0.5	0.5	0.5	0.5
Average Design Wastewater Loading (in/week)	1.25[a]	1.50	1.75	2.50
ADF Wetted Area (acres)	103.1	85.9	73.7	51.6
Nitrogen Input from Wastewater (lbs/acre-year)	295	354	413	590
Nitrogen Input from Rainfall and Fixation (lbs/acre-year)	5	5	5	5
Total Nitrogen Input (lbs/acre-year)	300	359	418	595
Ammonia Volatilization @ 0% of Ammonia Applied (lbs/acre-year)	0	0[b]	0	0
Denitrification, @ 15% of Total Nitrogen applied (lbs/acre-year)	45	54	63	89
Net Plant Uptake and Storage (lbs/acre-year)	300	300	300	300
Nitrogen Leached by Percolate (lbs/acre-year)	0	5	55	206
Precipitation (in/year)	88.8	88.8	88.8	88.8
Wastewater Applied (in/year)	65	78	91	130
Potential Evapotranspiration (in/year)	23	23	23	23
Percolate (in/year)	131	144	157	196
Estimated Percolate Total Nitrogen (mg/l)	0.0	0.17	1.56	4.65

[a] This loading exceeds the maximum loading of 1.1 in/week without water balance storage. Additional acreage will be required to eliminate the stored volume for this and all flows greater than 1.1 in/week.
[b] No ammonia volatilization is anticipated with subsurface distribution.

9.4.5 Operating Scheme

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

a. The average initial design wastewater loading will be 1.50 inches/week. The actual loading rate will be somewhat less than 1.50 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.

b. The maximum allowable instantaneous application rate is 0.150 in/hr (ref. 7.4.1b). For this example an instantaneous application rate of 0.30 in/hr has been used. This equates to drippers producing 0.75 gal/hr on 2 ft. centers with lines spaced at 2 ft. intervals. (Note that the application rate exceeds permeability. This is only possible with subsurface applications and short periods of operation. If application rates exceed one hour, the soil permeability is the maximum instantaneous application rate allowed.)

c. The soil permeability is 0.15 in/hr. The particle density is 1.5 g/cm^3. A check of the potential soil storage capacity (eq 3.9.1) is needed to determine if the minimum dripper line depth of 8 inches is adequate. Assuming that 35% of the voids are available and that the soil is at 70% saturation, the burial depth is:

$$D = [.75 \div 7.48 \div .35 \times [(1-1.5/2.65) \times (1-0.7)] \div (2 \times 2)] \times 12$$
$$= 6.6 \text{ inches (adequate)}$$

d. The cover crop will be Coastal Bermuda grass. The grass will be harvested and sold.

e. Normal operation will be five (5) days per week. The flow from the other two days will be stored. (If the system is automated, this storage may not be necessary.) Since the system will normally be operated five days per week, the wastewater volume applied each day is:

$$[\ (7 \text{ days/week})/(5 \text{ days/week})\ ] \times 0.5 \text{ MGD} = 0.7 \text{ MGD}$$

f. Normal application will be to apply for 15 minute intervals allowing 15 minute rest periods between applications.

9.4.6 Storage Volume Requirements

As discussed in Section 3.10, the required storage volume consists of three (3) <u>separate</u> storage components.

a. Operational Storage

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

(7 days - 5 days) x 0.5 MGD = 1.0 Mgal

For 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.

b. Wet Weather and Emergency Storage

Minimum requirements for wet weather and emergency storage are discussed in Section 3.10.1. These are the <u>greater</u> of 3 days flow or the results of eq. 3.10.1. NOTE: Exception for storage Section 3.10.1.

For the hypothetical facility, Delta P from Table 9.3-1 is assumed to be 2.5 inches. However, the actual application rate selected is 1.50 inches per week. The maximum allowable hydraulic wastewater loading in the most critical water balance month (January) from Table 9.4-1 is 4.7 inches/month. By eq. 3.10.1:

$$\frac{2.5 \text{ in} \times 365 \text{ days/yr}}{12 \text{ mo/yr} \times 4.7 \text{ in/month}} = 16.2 \text{ days}$$

16.2 days is greater than the 3 day minimum storage requirement. Therefore, the required wet weather and emergency storage is:

16.2 days x 0.5 MGD = 8.1 Mgal

However, the actual application rate selected is 1.50 inches per week. Therefore, by eq. 3.10.1:

$$\frac{1.5 \text{ in} \times 365 \text{ days/yr}}{12 \text{ months/yr} \times 4.7 \text{ in/month}} = 9.7 \text{ days}$$

9.7 days is greater than the 3 day minimum storage requirement. Therefore, the required wet weather and emergency storage is:

$$9.7 \text{ days} \times 0.5 \text{ MGD} = 4.85 \text{ Mgal}$$

Note that for an actual subsurface installation wet weather storage is not required. Emergency storage is always required.

c. Water Balance Storage

As discussed in section 3.10.4, the water balance storage is a function of hydraulic loading rate 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.

9.4.7 Wetted Field Area Determination

The area required for the site is the total of four separate components, as discussed in Section 3.10.

$$A(\text{wetted}) = A(\text{ADF}) + A(\text{OP}) + A(\text{WW/E}) + A(\text{WBS})$$

Substituting the appropriate loading rates and the appropriate volumes into equations 3.10.1 and 3.10.3 results in the following wetted area requirements:

$$A(\text{ADF}) = \frac{7 \text{ days/wk operation} \times 500{,}000 \text{ gpd} \times 12 \text{ in/ft}}{7.48 \text{ gal/cf} \times 43{,}560 \text{ sf/acre} \times 1.50^{a} \text{ in/wk}}$$

[a] 1.50 in/wk is the maximum allowable wastewater loading as selected

$$A(\text{ADF}) = 85.9 \text{ acres}$$

$$A(WW/E) = \frac{9.6 \text{ days storage x } 500{,}000 \text{ gpd x } 7 \text{ days/wk x } 12 \text{ in/ft}}{7.48 \text{ gal/cf x } 43{,}560 \text{ sf/acre x } 90 \text{ days x } 1.1^{b} \text{ in/wk}}$$

[b] 1.1 in/wk is the most critical water balance month wastewater loading

$$A(WW/E) = 9.2 \text{ acres}$$

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

$$A(OP) = \frac{2.0 \text{ days storage x } 500{,}000 \text{ gpd x } 7 \text{ days/wk x } 12 \text{ in/ft}}{7.48 \text{ gal/cf x } 43{,}560 \text{ sf/acre x } 30 \text{ days x } 1.5 \text{ in/wk}}$$

$$A(OP) = 5.7 \text{ acres}$$

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

The wastewater loading rate (WLR) is:

$$WLR = \frac{7 \text{ days/wk x } 500{,}000 \text{ gpd x } 12 \text{ in/ft}}{7.48 \text{ gal/cf x } 43{,}560 \text{ sf/acre x } 100.8^{c} \text{ acres}}$$

[c] A(ADF) 85.9 acres + A(WW/E) 9.2 acres + A(OP) 5.7 acres = 100.8 acres

$$WLR = 1.28 \text{ in/wk}$$

Table 9.4-4 combines eq. 3.7.2 and 3.10.2 to determine the required water balance storage (WBS) for the loading rate of 1.28 in/wk. The table indicates a total water balance storage of 0.923 inches over the wetted area of 100.8 acres. Storage for the most critical month (January) is:

$$\frac{0.92 \text{ in. x } 100.8 \text{ acres x } 7.48 \text{ gal/cf x } 43{,}560 \text{ sf/acre}}{12 \text{ inches}} = 2{,}518{,}000 \text{ gal}$$

Substituting the appropriate values into eq. 3.10.4:

$$A(WBS) = \frac{2{,}518{,}000 \text{ gal x } 7 \text{ days/wk x } 12 \text{ in/ft}}{90 \text{ days x } 7.48 \text{ gal/cf x } 43{,}560 \text{ sf/acre x } 1.28 \text{ in/wk}}$$

$$A(WBS) = 5.7 \text{ acres}$$

Table 9.4-4
WATER BALANCE STORAGE

Month	D(potential)[a]	D(allowed)[b]	WBS[c]	Sum WBS[d]
October	5.66[e]	7.08	0.0	0.0[f]
November	5.48	6.94	0.0	0.0
December	5.66	6.50	0.0	0.0
January	5.66	4.74	0.92	0.92[g]
February	5.11	5.83	0.0	0.22[h]
March	5.66	6.56	0.03	0.0[i]
April	5.48	7.72	0.0	0.0
May	5.66	7.17	0.0	0.0
June	5.48	11.44	0.0	0.0
July	5.66	12.52	0.0	0.0
August	5.66	10.10	0.0	0.0
September	5.48	5.45	0.0	0.03

a Based on the number of days per month and the actual wastewater loading of 1.28 in/week, assumes all influent wastewater is applied to drip fields.

b Values from Table 9.4-1.

c WBS = Water balance storage, reference eq. 3.10.4.

d A positive WBS value indicates that no WBS is required for that month. A negative WBS value indicates that WBS is required for that month.

e $\frac{\text{31 days/month}}{\text{7 days/week}}$ = 4.42 weeks/month

4.42 wk/month x 1.28 in/wk = 5.66 inches

f 5.66 in. - 7.08 in. = 1.42 in., the value is positive which indicates that no WBS is required for this month.

g 4.74 in. - 5.66 in. = -0.92 in., the value is negative which indicates that WBS is required for this month.

h 5.83 in. - 5.11 in. = 0.72 in., the value is positive but must be added to the previous WBS value. -0.92 in. + 0.72 in. = -0.20 in. The value is negative which indicates that WBS is required.

i 6.56 in. - 5.66 in. = 0.90 in., the value is positive but must be added to the previous WBS value. -0.20 in. + 0.90 in. = 0.70 in. The value is positive which indicates that no WBS is required.

The total area necessary for this land treatment system is:

A(ADF)	85.9 acres
A(OP)	5.7
A(WW/E)	9.2
A(WBS)	5.7
A(TOTAL)	106.5 acres

Applying 0.7 Mgal each day for five days per week, the wetted field area will be divided into five 21.3 acre sections. For normal flows each field will be loaded at a rate of:

$$\frac{0.7 \times 10^6 \text{ gal/day} \times (12 \text{ in/ft})}{7.48 \text{ gal/cf} \times 43{,}560 \text{ sf/acre} \times 21.3 \text{ acres}} = 1.21 \text{ in/wk}$$

*The average wastewater irrigation period will be:

(1.21 in/week)/[(1 day/week) x (0.30 in/hr)] = 4.03 hr/day

*The maximum wastewater irrigation period will be:

(2.80 in/week)/[(1 day/week) x (0.30 in/hr)] = 9.3 hr/day

* Note that the 0.30 in/hr exceeds the actual permeability of the soil. This example assumes 24 hour per day operation with the irrigation periods broken down throughout the total 24 hour period. Actual system operation must be adjusted to the variable seasonal conditions when maximum application rates (instantaneous or maximum) are used.

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