Guidelines for the Design, Construction, Operation, and Maintenance of Small Wastewater Treatment Facilities with Land Disposal

Commonwealth of Massachusetts
Department of Environmental Protection
Division of Watershed Permitting
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Massachusetts Department of Environmental Protection

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INTRODUCTION

The field of environmental engineering has advanced significantly since the Department developed the "Guidelines for the Design, Construction, Operation and Maintenance of Small Sewage Treatment Facilities with Land Disposal – Second Draft: January 1988". This document needs a substantial updating to reflect improvements in existing technology as well as advances in new technology since 1988. Our understanding of groundwater flow dynamics and the potential for impacts on downstream resources has grown. There are also a number of new Department policies and initiatives which directly impact the groundwater program. Lastly, our experience in reviewing the design and operation of wastewater treatment facilities over the years has given us a keen insight into what is necessary to construct, operate, and maintain a modern facility.

This guidance is intended to serve as a technical guide for individuals involved in the design, construction, and use of small wastewater treatment facilities in the Commonwealth of Massachusetts. It outlines the current regulations, policies, and standards of the Department as they relate to facilities that discharge to the ground. For the purposes of this document, small treatment facilities are defined as those with a sewage flow of between 10,000 and 150,000 gallons per day (gpd).

It is the Department's intent that this guidance be used as a supplement to the standards and design criteria found in the document published by the New England Interstate Water Pollution Control Commission titled " TR-16: Guides for the Design of Wastewater Treatment Works – 1998 Edition". TR-16 is and will continue to remain as the primary design reference for Department use. This additional guidance is not intended to replace TR-16, but rather to provide further information and standards, where necessary, given the particular problems that we face in Massachusetts in the design and construction of land-based systems. It should be emphasized that while this guidance is intended primarily for small systems, many of the principles and design criteria are also applicable to larger systems. The larger systems (> 150,000 gpd) present a different set of issues that have to be evaluated in a separate manner. As an example, such topics include flow derivation, size of effluent disposal reserve area and/or redundancy, and level of hydrogeologic evaluation. Whenever possible, differences in approach will be noted in the text.

In addition to TR-16, other documents used in the development of this guidance and to be read in conjunction with include:

- Wastewater Engineering: Treatment, Disposal, and Reuse – 3rd Edition Metcalf & Eddy

- Biological Wastewater Treatment – 2nd Edition – Grady, Daigger, & Lim

- Wastewater Treatment Plant Design: Manual of Practice (MOP 8) – Water Environment Federation

- Process Design Manual: Land Treatment of Municipal Wastewater– United States Environmental Protection Agency (EPA 625/1-81-013)

- Process Design Manual: Land Treatment of Municipal Wastewater – Supplement on Rapid Infiltration and Overland Flow – United States Environmental Protection Agency (EPA 625/1-81-013a)

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I. LAWS AND REGULATIONS

There are several laws and regulations implemented by federal, state and local governmental agencies that apply to the planning, installation, operation and maintenance of small sewage treatment facilities. This section presents a brief explanation of the major regulatory programs with jurisdiction over small sewage treatment facilities. It also contains a table listing possible regulatory requirements applicable to any particular project. Copies of other laws and regulations may be obtained as follows:

(1) for state laws and regulations, visit the Department of Environmental Protection (Department) website at www.state.ma.us/dep or the State House Bookstore, Room 116, State House, Boston, MA 02133, telephone (617) 727-2834;

(2) for local bylaws, ordinances and regulations the Town Clerk at the Town Hall for the municipality in which the facility is to be located; and

(3) for federal laws and regulations, visit the Federal Bookstore website at http://bookstore.gpo.gov or telephone (866) 512-1800.

A. STATE

The primary statutory authority for regulation of small sewage treatment facilities is contained in the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26-53. This state law established a Division of Water Pollution Control within the Department. The responsibilities of the Division of Water Pollution Control have since been transferred to the Department's Division of Watershed Management (Division). The Division's duties and responsibilities include enhancing the quality and value of water resources and establishing a program for the prevention, control, and abatement of water pollution. The Division is specifically authorized by the Act to establish programs and adopt regulations that include:

1. standards of minimum water quality applicable to the various waters of the Commonwealth;

2. a permit program establishing effluent limits and procedures applicable to the management and disposal of pollutants including, where appropriate, prohibition of discharges;

3. requirements for dischargers to establish monitoring, sampling, record keeping and reporting procedures and facilities, and to submit data gathered to the Division;

4. regulations requiring proper operation and maintenance of wastewater treatment facilities;

5. rules and regulations needed to properly administer laws regarding water pollution control and protect the quality and value of water resources; and

6. requirements for the Division to approve reports and plans of wastewater treatment facilities, or any part thereof, and to inspect the construction of such facilities to determine compliance with the approved plans.

Additionally, M.G.L. c. 111, §17 requires towns, districts and other persons to submit their proposed system for the disposal of drainage and sewage to the Department for its approval.

The Code of Massachusetts Regulations (CMR) is a compilation of state agency regulations. Agency regulations implement statutes passed by the state legislature. The state laws are referred to as the Massachusetts General Laws (M.G.L.).

The Department of Environmental Protection regulates discharges of pollutants below ground surface through the Ground Water Discharge Permit Program regulations at 314 CMR 5.00 requiring potential dischargers to seek plan approval and obtain a discharge permit. The groundwater discharge permits impose limitations on the amount and type of pollutants allowed to be discharged to assure that the receiving waters meet minimum water quality standards established by the Ground Water Quality Standards, 314 CMR 6.00 and the Surface Water Quality Standards, 314 CMR 4.00.

Each ground water discharge permit also contains monitoring and reporting requirements to verify compliance with permit limitations and conditions, including a requirement for the installation of monitoring wells. Detailed plans for a minimum of three ground water monitoring wells must be submitted to the Program as part of a completed permit application. The plans must specify the type of wells, their locations, depth, screen selection and method of construction, development and sampling. The applicant must also submit, for review and approval by the Program, detailed plans and specifications for all new collection, treatment and disposal facilities.

Procedures for plan approval and permit issuance specified in the Permit Procedure regulations at 314 CMR 2.00. Generally, the project proponent submits a completed discharge permit application, along with an engineering report and hydrogeologic assessment, to the Department. The project proponent must submit a copy of the application and accompanying documents to both the Boston office and the appropriate regional office of the Department.

A project proponent must submit sufficient engineering and hydrogeologic information to explain the public health and environmental impacts of the proposed project to the Department. After receiving sufficient information, the Department prepares a draft permit and a fact sheet detailing the significant factual, legal, methodological and policy questions considered by the Department during its review of the project. The draft permit and fact sheet are sent to the applicant, the applicant's consultants and the local Board of Health for review and comment.

Following this informal review, the Department makes a tentative determination to either issue or deny the permit and begins the formal public comment process. Notice of the tentative determination is published in at least one newspaper of general circulation in the area of the proposed discharge, as well as in the Massachusetts Central Register and sent to the applicant and, as a courtesy, the local Board of Health. Publication of the notice begins a thirty-day public comment period on the tentative permit determination to the Department. If the applicant or permittee requests a public hearing, or if the Department decides that a public hearing is in the public interest, the Department schedules and conducts the hearing in a community within the area affected by the facility or discharge. If a public hearing is deemed necessary, the permit issuance or denial is postponed until all issues raised during the hearing have been evaluated and the Department has prepared a final response summary and determination.

At the conclusion of the thirty-day public comment period, the Department issues the permit or a final determination to deny it. If no comments objecting to the permit's issuance or terms were received during the public comment period, the permit becomes effective on the date of issuance. If comments objecting to the permit's issuance or terms were received during the thirty-day comment period, the permit becomes effective thirty days after its issuance. Any person aggrieved by the permit's issuance, terms, or the Department's determination to deny the permit may file a request for an adjudicatory hearing with the Department's Office of Administrative Appeals within the thirty-day period following permit issuance.

The Department's Operation And Maintenance and Pretreatment Standards For Wastewater Treatment Works and Indirect Dischargers regulations at 314 CMR 12.00 require permittees to submit an Operation and Maintenance manual and a Staffing Plan to the Department after permit issuance and prior to facility start-up. In addition, the Certification of Operators of Wastewater Treatment Facilities regulations at 257 CMR 2.00 require that a certified wastewater treatment plant operator must be employed by the permittee to operate and maintain the treatment facilities. The Department's Sewer System Extension and Connection Permit Program regulations at 314 CMR 7.00 require that any additional connections to the sewage treatment facilities or extension of the collection system made after the original permits and approvals are issued must be reviewed, approved and permitted by the Department.

The project may require a filing under 301 CMR 11.00, the Massachusetts Environmental Policy Act (MEPA). These regulations establish review thresholds at 310 CMR 11.03 that determine whether MEPA review is required.

B. LOCAL

At the local level, primary regulatory authority over the design, construction and use of small sewage treatment facilities that discharge less than 10,000 gallons per day is vested in the Board of Health. Title 5 of the State Environmental Code at 310 CMR 15.003 requires the Board of Health to issue a disposal system construction permit prior to the construction of any subsurface sewage disposal system, in most instances. M.G.L. c. 111, §31 authorizes Boards of Health to adopt reasonable health regulations. Many Boards have used this authority to promulgate bylaws, ordinances or regulations more stringent than the Department's Title 5 regulations.

The primary regulatory authority for facilities greater than 10,000 gallons per day is vested in the Department. Unlike Title 5, there is no fomal local review process or local jurisdiction over 10,000 gallons per day, but the applicant should check with the Board of Health to determine if any additional requirements beyond those imposed by state laws and regulations apply to the proposed project.

C. FEDERAL

The Department, not the federal government, has jurisdiction over the groundwater discharge permit program.

The Underground Water Source Protection Program also known as the Underground Injection Control Program (UIC) is a federal program designed to protect underground sources of drinking water from pollution. The United States Environmental Protection Agency (EPA) pursuant to the Federal Safe Drinking Water Act, 42 U.S.C.A §§300f to 300j-26, administers this program. The EPA divides injection practices into five classes. Class I includes deep disposal wells for industrial and municipal waste. Class II covers all injection wells related to oil and gas production including wells used to store hydrocarbons, which are liquid at standard temperature and pressure. Class III includes wells, which inject liquids for the in situ extraction of minerals or energy. Class IV includes the injection of hazardous and high level radioactive wastes into and above usable ground water. Class V covers all other injection wells including those used to discharge treated sewage.

In Massachusetts, the EPA has delegated the UIC Program to the Department of Environmental Protection. The Department has promulgated and is amending its regulations at 310 CMR 27.00 to implement the State's UIC Program in accordance with the federal requirements. For purposes of the UIC Program, a well is defined as a "bored, drilled, or driven shaft, a dug hole, or seepage pit whose depth is greater than the largest surface dimension; or, an improved sinkhole; or, a soil absorption system.

LIST OF ACRONYMS USED ON SUMMARY TABLES

CFR- Code of Federal Regulations

CMR- Code of Massachusetts Regulations

DEP- Massachusetts Department of Environmental Protection

DPS- Massachusetts Department of Public Safety

EOEA- Massachusetts Executive Office of Environmental Affairs

EPA- Federal Environmental Protection Agency

FWPCA- Federal Water Pollution Control Act

MEPA- Massachusetts Environmental Policy Act

M.G.L.- Massachusetts General Laws

NPDES- National Pollution Discharge Elimination System

O&M- Operation and Maintenance

U.S.C.- United States Code

WWTF- Wastewater Treatment Facilities

TABLE 1

REGULATORY SUMMARY

Program Name	Component or Activity Regulated	Application or Filing Required	Statutory Authority	Regulatory Reference	Implementing Agency
Permit Procedures			M.G.L. c. 2l, §27	314 CMR 2.00	State DEP
Surface Water Discharge Permit	Treatment Plant	Application/Plans	M.G.L. c. 21, §27	314 CMR 3.00	State DEP
Surface Water Quality Standards		'	M.G.L. c. 2l, §27	314 CMR 4.00	State DEP
Ground Water Discharge Permit	Treatment Plant and Discharge	Application/Plans	M.G.L. c. 21, §27	314 CMR 5.00	State DEP
Ground Water Quality Standards			M.G.L. c. 21, §27	314 CMR 6.00	State DEP
Sewer System Extensions and Connections	Collection System	Application/Plans	M.G.L. c. 21, §27	314 CMR 7.00	State DEP
Operation & Maintenance of Treatment Facilities	Treatment Plants/Sewers	O&M Manual and Staffing Plan	M.G.L. c.21, §27	314 CMR 12.00	State DEP
Administrative Penalty Regulations	Violations of State Laws and Regulations		M.G.L. c. 21A, §16	310 CMR 5.00	State DEP
Wetland Protection	Construction within 100 ft. of Wetland or 200 ft. of a Riverfront Area	Notice of Intent	M.G.L. c. 131, §40	310 CMR 10.00	Local Conservation Commission/DEP
Water Quality Certification	Activity Requiring Federal Permit	Plans	33 U.S.C. §1341; M.G.L. c. 21, §27	314 CMR 9.00	State DEP
Cross Connections	Water Supply	Plans for Backflow Preventor	M.G.L. c. lll, §160A	310 CMR 22.00	State DEP

TABLE 1 CONTINUED

REGULATORY SUMMARY

Program Name	Component or Activity Regulated	Application or Filing Required	Statutory Authority	Regulatory Reference	Implementing Agency
Underground Injection Control	Discharge into Wells	Registration Form	M.G.L. c. 21, §27	310 CMR 27.00	State DEP
Wastewater Treatment Plant Operation Certification	Operator	Application/ Exam	M.G.L. c. 21, §34A & 34B	257 CMR 2.00	State Board of Certification of Operators of WWTF's
Environmental Code General Application & Administration	Environmental		M.G.L. c. 21A, §13	310 CMR 11.00	State DEP
Massachusetts Environmental Policy Act	Issuance of State Permit	Environmental Notification Form	M.G.L. c.30, §§61-62H	301 CMR 11.00	State MEPA Office/EOEA
Waterways License	Waterways		M.G.L. c. 91, §l-63	310 CMR 9.00	State DEP
Engineer Registration	Design Engineer	Application/ Exam	M.G.L. c. 112, §81 D-T	250 CMR 1:00-6.00	State Board of Registration of Professional Engineers and Land Surveyors
Air Pollution Regulations	Diesel Generator	Plans	M.G.L. c. lll, §142 A-E	310 CMR 7.00	State DEP

TABLE 1 CONTINUED

REGULATORY SUMMARY

	Component or Activity Regulated	Application or Filing Required	Statutory Authority	Regulatory Reference	Implementing Agency
Ambient Air Quality			M.G.L. c. lll, §142 A-E	310 CMR 6.00	State DEP
Disposal Works Construction Permit	Subsurface Disposal System	Application/ Plans	M.G.L c. 2lA, §13	310 CMR 15.000	Local Board Health/DEP
Building Permit	Building	Application/ Plans	M.G.L. c. 143	780 CMR	Local Building Inspector/DEP
Plumbing Permit	Plumbing	Application	M.G.L. c. 143, §13	248 CMR 2.00	Local Plumbing Inspector/DPS
Electric Permit	Wiring	Application	M.G.L. c. 143, §3L	527 CMR 12.00	Local Wiring Inspector/DPS
Flammable Liquid Storage	Storage tanks	Application/ Plans	M.G.L. c. 148, §1-59	527 CMR 14.00	Local Fire Chief/DPS
Zoning By-Laws	Subdivision Plan	Plans	M.G.L. c. 40A	310 CMR 15.000	Local Planning Board/Zoning Board
Hauler's Permit	Transportation & Disposal of Sludge	Application	M.G.L. c.21A, §13	310 CMR 15.000	Local Board of Health
FWPCA §404 Dredge and Fill Permit	Construction in Navigable Water	Application	33 U.S.C. §1344	40 CFR Parts 220-232	Federal Army Corps of Engineers
NPDES Permit	Discharge to Surface Waters	Application	33 U.S.C. §1342	40 CFR Parts 122-125	Federal EPA

II. FILING FOR A GROUNDWATER DISCHARGE PERMIT

Owners of a facility, which has a design flow of 10,000 gallons per day or greater must possess a valid discharge permit from DEP if they intend to discharge to the ground.[1] Typically, the requirement to obtain a groundwater discharge permit entails the obligation to construct a wastewater treatment facility (WWTF). Once issued, such permits are valid for a term of up to five years, unless modified or revoked by DEP. Applications for renewal of permits must be submitted 180 days prior to the permits expiration date.

Permit applications for new WWTF's or modified WWTF's no longer require that engineering plans and specifications for the new or modified facility, with the exception of those documents associated with the effluent disposal facilities, be submitted with the application. Instead, an expanded engineering report accompanied by a certification statement from a Massachusetts Registered Professional Engineer stating that the plans and specifications have been prepared in accordance with applicable standards are required. Whether submitted to the Department or not, these plans must be stamped, signed and dated by a Massachusetts Registered Professional Engineer. The plans and specifications must describe in detail the collection, treatment and disposal components of the WWTF. Permit applications must also include hydro geologic studies of the WWTF disposal site and its surroundings and a ground water monitoring plan. Specifics regarding these submittals are contained in the permit application packages and in the hydrogeologic section of these guidelines. Application packages are available from the DEP Internet web site at:

www.state.ma.us/dep

Application packages are also available from the DEP Regional Office Service Centers noted below:

DEP Boston

One Winter Street

Boston, MA 02108

1-800-462-0444

DEP Northeast Region

One Winter Street

Boston, MA 02108

[1] WWTF's may be allowed for flows less than 10,000 gpd provided it is demonstrated, to the satisfaction of the Department, that the financial burden associated with the operation, maintenance and replacement of such a facility can be borne by the users of the system without posing an undue hardship on any individual within the user group.

617-654-6500

DEP Southeast Region

20 Riverside Drive

Lakeville, MA 02347

508-946-2714

DEP Central Region

627 Main Street

Worcester, MA 01608

508-792-7650

And

DEP Western Region

436 Dwight Street

Suite 402

Springfield, MA

413-755-2214

Once received, applications are reviewed for Administrative completeness (30 days) and Technical completeness (120-200 days depending on application category). Administrative review is done to insure proper forms are submitted and completed (transmittal form, application form, permit fee paid if applicable) and proper attachments are included (plans and specifications as required, hydrogeologic studies). Technical reviews evaluate the technical submittals (plans and specifications, certification statement, hydrogeologic studies, monitoring well plans, ownership documentation if required). If, during either review, deficiencies are noted in the application DEP sends written notice to the applicant defining such deficiencies and setting a time limit for the submittal of additional information to address those deficiencies. Any additional information submitted is reviewed under new time periods as noted above.

At the completion of the technical review, a public notice at the applicant's expense is published in a newspaper of general circulation located in the area of the proposed WWTF, proposing to issue or deny a permit for the WWTF. This is a one-day advertisement with a 30-day public comment period. At the end of the comment period DEP reviews any comments received regarding the permit and determines whether the permit can be issued, should be modified, should be denied or must go to a public hearing. Generally, no permit can be issued until final plans and specifications, in accordance with applicable requirements, are approved for the WWTF. No construction of any WWTF can occur until a permit is issued and effective. Within 30 days following the issuance of the permit, any person aggrieved by the issuance of a permit or final determination may request an adjudicatory hearing. The regulations at 314 CMR 2.08 outline the requirements.

Issued discharge permits contain effluent discharge limitations, monitoring requirements and operational conditions for the approved WWTF. Each permit issued is unique to the facility it is issued to. Permits also contain requirements for the regular monitoring of ground water up gradient and down gradient of the proposed discharge in approved monitoring wells. Some permits require financial assurance documents/plans to insure the proper operation, maintenance and eventual replacement of the WWTF.

Progression of DEP Permitting Actions/Requirements

- Applicant submits proper permit application (forms, technical documents)
    - New permit/ Major and Minor Discharges[2]
        - Application #BRP WP 06/08
    - Renewal of Permit with or without modification
        - Application #BRP WP 11/12

- DEP Reviews Application
    - Administrative Review – 30 Days

      Technical Review –

      200 Days for new permits

[2] The definition of major and minor discharges is contained in the "Instructions and Supporting Materials" document that accompanies the permit application forms.

120 Days for permit renewals

If technical problems, omissions, and/or deficiencies are noted by the Department, applicant is notified and has 180 Days, under BRP WP 11/12 or 200 Days under BRP WP 06/08 to correct applications. Once corrected, the Department has an additional technical review period equivalent to the first review period.

- DEP Approves Plans and Reports

- Applicant Provides 30 Day Public Notice Period

  No Comments on Permit – Issue or Deny Permit

  Adverse Comments on Permit Issue – Issue or Deny Permit Issued Permit Effective 30 Days from Permit Issuance Date

- Applicant May Proceed With Construction and Operation of an Approved WWTF

III. REQUIRED SUBMITTALS

All reports, plans and specifications, permit applications and supporting documents shall be submitted to the local Board of Health, the appropriate DEP Regional Office and the Boston Office of DEP's Division of Watershed Permitting at least 180 days prior to the date upon which an action by the Department is desired. The documents submitted for formal approval shall include an engineering report, a hydrogeologic report, a completed discharge permit application, final plans and specifications as required, certification statement on final plans and specifications, an operation and maintenance plan, a staffing plan, documentation of ownership and financial resources and contracts for operational services.

The engineering report and the plans and specifications shall be stamped, dated and signed by a qualified professional engineer registered to practice in the Commonwealth of Massachusetts. If the engineer's discipline is not noted on the stamp, then the discipline shall be printed below the imprint.

No construction shall take place until the final plans and specifications have been approved by the Department and the discharge permit has been issued.

A. ENGINEERING REPORT

An engineering report shall be submitted for all projects involving sewage collection, treatment and disposal systems. The purpose of this report is to present in clear, concise form a description of the project, the results of site evaluations, solutions examined, the basis of design for the recommended systems, and the associated environmental and public health impacts. The report shall be written for easy public understanding, and serve as a permanent summary of the principle information needed by the Department for conceptual approval of the project. Data on structural, mechanical, electrical and HVAC designs may be excluded at this point of project development except that reference to such elements shall be made as necessary to understand the functional operation of the proposed systems.

The engineering report shall include, at a minimum, the following items:

- a detailed description of the project including all phasing of development which is expected over a 20 year planning period;
- all pertinent data concerning relevant local, state and federal permits, approvals, orders of conditions and variances;
- a description of the geographic location and setting of the project including a locus map and preliminary site plan at an appropriate scale;
- a description of the geology, hydrology and topography with an appropriate plan showing key features, surface drainage and contours of the project site;
- a listing of the current and projected population both resident and nonresident involved in the proposed project;
- the location of all public and private water supply wells, springs, surface reservoirs including tributaries, and other features of public health significance within a half mile of the project site;
- the amount and source of water supply for the proposed project;

- a delineation of all wetlands resource areas (as defined in 310 CMR 10.00) within the project boundaries and/or within 100 feet of any proposed construction activity;
- a description of the proposed sewage collection system for the project with a reference to the overall site plan;
- a description of the probable future expansion of the collection system together with information on how these areas will be served;
- an explanation of the relationship between the point of generation of sewage to the proposed treatment facility, including rough elevations and locations where pump stations may be necessary;
- a description of the various locations within the project site available for wastewater treatment and disposal and the reasons for choosing the one recommended;
- an identification of the proximity of residences or developed areas to the treatment and disposal areas;
- a discussion of the type of treatment and disposal processes studied, including water reclamation alternatives, and the reasons for choosing the recommended alternative;
- a description of how the proposed plan fits into the municipal wastewater management plan, including, where appropriate the potential for future transfer of ownership to the city, town, or district, and the possibility of including capacity for sewage flows from neighboring properties;
- identification of any local standards for wastewater treatment plant design and operation and how those local standards will be met;
- a complete description of the basis of design of the collection, treatment and disposal systems including design population (resident and nonresident), as well as flow contributing common facilities (recreational hall, laundries, health clubs, restaurants, etc.) strength of sewage, total daily sewage flow (including infiltration allowances where appropriate), and daily peak, monthly average and maximum hour flow;
- a description of all pumps, including type, number, and operating range;
- a description of all major unit processes giving capacity, equipment type, and operation factors under varying conditions (i.e. seasonal flow variations or project phasing), redundancy requirements and method of operation;
- a discussion of the degree and type of treatment and adequacy for present and future needs;
- a hydraulic profile showing water surface elevations at average, maximum, and minimum flow conditions;
- a general layout and flow diagram, including return lines, chemical feed lines, and sampling points shall be provided;
- the results of all site testing and evaluations including the location and log for all soil borings, deep observation holes, and percolation tests; and
- Design calculations for each unit process.
- List of chemicals used in each process

B. HYDROGEOLOGIC REPORT

The proponent shall submit to the Department for approval a hydrogeologic report assessing the site characteristics and the fate and effects of the treatment plant discharge. A qualified geologist or engineer must prepare this report.

The Long-Term Acceptance Rate (LTAR) shall be determined through percolation testing and/or infiltration rate testing. In all cases the soil must be tested under saturated conditions (soaked) as described in Title 5 or in documentation relative to the infiltrometer testing.

The appropriateness of the methods is determined by the size of the facility and the accepting soil characteristics. If the design discharge is less than 20,000 gpd, a percolation test is the preferred method. The exception to this would be for a small system, which may be in tight (Class III) soils where an infiltration rate would yield the most reliable data.

For systems greater than 20,000 gpd an infiltration test shall be performed. It shall be performed according to acceptable engineering practice or the technical reliability demonstrated to the satisfaction of the Department. However, if the soils are Class I, then a percolation test may still is the preferred method. The Department should be contacted on this instance to determine the appropriate testing method.

The report shall minimally include (for primary and reserve area(s)):

- An analysis of the ability of site to accept and disperse flow at the proposed discharge rate. (Maximum Monthly flow)
- Evaluation of the mounding potential, presence of confining layers, thickness and estimated aerial extent of unsaturated receiving formation. Mounding calculations or modeling to be evaluated for maximum monthly flow for a duration of 90 days. Maximum daily flow may be higher, but the sum of the daily flows for the months over the 90 days shall not exceed the maximum monthly flow for the 90-day period evaluation of the site.
- Evaluation must include (if applicable) the effect of impermeable or semi-permeable barriers within the potential groundwater mound. These would include but not limited to foundations and retaining walls.
- proposed appropriate monitoring well locations based upon known or inferred groundwater flow direction under various seasonal conditions and geology. (Minimum of One Upgradient and two down gradient locations. The Department may require more based upon site complexity, proximity to sensitive areas or design of the system.)
- evaluation of likely impacts on current and potential down gradient and cross gradient receptors. The list includes wells with in 1 mile (public and private), wastewater discharges (such as septic systems), subsurface construction and infrastructure (basements and pipelines), water supply protection areas (Zone I, Zone II, Zone A), Outstanding resource water.

- hydraulic conductivity and infiltration rate
- determine ambient water quality (groundwater and if present nearby surface water)
- a summary of all soil borings and geotechnical evaluations.
- Test pits and Infiltration test data performed by a Certified Soil Evaluator, (or engineer or geologist with Department approval). Data forms to be included in the report.
- If within Zone II or well head protection area evaluate time of travel from discharge to water supply.
- Location of other wastewater disposal systems, which are near the proposed site. Indicate whether or not the mounds will interfere.
- location (Lat, Long to nearest second), surveys to use the most recent standard datum. Currently it is a geographic coordinate reference system based on the NAD83 horizontal datum and NAVD88 vertical datum. The datum utilized shall be clearly stated.
- Proximity to the nearest wetlands and surface water bodies.

C. PLANS AND SPECIFICATIONS[3]

The Department no longer requires that engineering plans and specifications for new or modified WWTF's be submitted for approval with the permit application, with the exception of those documents associated with the effluent disposal facilities or if the Division of Municipal Services finances the project. Instead, a certification statement from a Massachusetts Registered Professional Engineer stating that the plans and specifications have been prepared in accordance with applicable standards is now required. Regardless of whether the documents are submitted to the Department, all plans and specifications must satisfy the requirements outlined below.

All plans shall bear a suitable title showing the name and location of the project and shall show the scale in feet, a directional arrow indicating north, date, the name, address and telephone number of the engineer and the imprint of his registration seal.

The plans shall be clear and legible. They shall be drawn to a scale that will permit all necessary information to be plainly shown. The size of the plans shall be 24" x 36". The datum used and its relation to mean sea level datum (USC&GS) should be indicated. Locations and logs of all test borings, percolation tests and deep observation holes shall be shown on the plans.

Detailed plans shall consist of plan views, elevations, sections and supplementary views that, together with the specifications and general layouts, provide the working information for the contract and construction of the various processes. The plans shall include dimensions and relative elevations of all structures, the location and outline form of equipment location and size of piping, ground water levels, ground elevations (existing and finish grades) and

[3] The permittee should also check with the BWP air permitting section in the appropriate regional office to determine whether the project would trigger any of the air regulation thresholds.

hydraulic profiles. Plans shall include a profile (to scale) of the soil absorption system (SAS), which depicts the mounded, and high groundwater elevation below the SAS.

Complete technical specifications for the construction of sewers, pumping stations, treatment and disposal systems including all appurtenances shall accompany the plans. The specifications accompanying the construction drawings shall include, but not be limited to, all construction information not shown on the drawings which is necessary to inform the contractor in detail of the design requirements as to the quality of materials, workmanship and fabrication of the project. They shall include: the type, size, strength, operating characteristics and rating of equipment, allowable infiltration including allowable methods of measuring infiltration; the complete requirements for all mechanical and electrical apparatus; wiring and meters; laboratory fixtures and equipment; operating tools; construction materials, special materials such as stone, sand or gravel; installation specifications; miscellaneous appurtenances; chemicals when used; instructions for testing materials and equipment as necessary to meet design standards; and operating tests for the completed works and component units.

The plans and specifications shall include civil, sanitary, structural, electrical, mechanical, HVAC and land surveying components of the sewage collection, treatment and disposal systems in sufficient detail for approval by the Department.

When required, a minimum of five sets of final design plans and specifications shall be submitted to the appropriate DEP regional office. Upon approval, these five copies will be imprinted with the Department's approval stamp. One set of stamped approved plans will be kept on file in the Regional Office, one set to be sent to the Board of Health, and three sets of stamped approved plans will be returned to the consulting engineer. One of the returned sets must be kept on site at all times during construction.

All construction shall be in strict accordance with the approved plans and no changes to the plans shall be made without the prior written approval of the Department. The design engineer shall be present at the site at all important phases of construction to verify and certify that all construction of the treatment plant processes conform to the approvals. For all projects, at the completion of construction the design engineer shall submit two sets of "as-built" record drawings to the DEP Regional Office showing final elevations and dimensions and which include any modifications that have been approved by the Department.

D. OPERATION AND MAINTENANCE PLAN

An individual operation and maintenance (O&M) manual shall be prepared and kept current for all small sewage treatment facilities. The O&M manual shall contain all information necessary for the plant operator to properly operate and maintain the collection, treatment and disposal systems in accordance with all applicable laws and regulations. The regulations at 314 CMR 12.04 include a listing of requirements. A copy of the approved O&M manual shall be maintained at the treatment plant at all times. See

Section X for further details. The WWTF cannot begin operation until the O&M Manual has been reviewed and approved by the Department.

E. DOCUMENTATION OF OWNERSHIP AND FINANCES

General: The Department will only approve the use of small sewage treatment facilities where it is demonstrated that the following objectives have been met, consistent with the Willis Hill Decision[4]:

Objective #1: to ensure that a single entity, fundamentally identical to the user of the facility, is fully responsible for the operation, maintenance, repair and replacement of the facility;

Objective #2: to ensure that all users share the financial and operational responsibilities the above obligations entail, that record notice of these responsibilities is given to all prospective purchasers of the dwellings to be served by the facility, and no prospective user can avoid these responsibilities;

Objective #3: to ensure that the entity has the authority both to institute a user-charge system sufficient to generate adequate revenues and to enforce such assessments against users in a manner equivalent to municipal fee, tax and betterment assessments;

Objective #4: to ensure that the entity maintains a source of immediate funding available for any emergency repair and replacement of the facility and a capital reserve account adequate to fund the prompt replacement of the facility at the end of its useful life;

Objective #5: to ensure that no change in the entity's organizational arrangements that would affect the attainment of these other objectives can take place without the written approval of the Department;

Objective #6: to ensure that the entity owns the land on which the sewage treatment and disposal facilities are situated and either owns or is allowed through valid easements access to the land above and for ten feet on either side of all sewer lines and appurtenances.

For further information, please see the following policies: "Private Sewage Treatment Facilities For Multiple Lot Residential Subdivisions" and " Financial Security Provisions For Groundwater Discharge Permits".

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[4] In 1988 the Department denied a groundwater discharge permit to the Willis Hill trust for a wastewater treatment plant serving a multiple lot subdivision. The decision identified the six objectives that should be met by every ownership entity requesting the construction of a PSTF ("Private Sewage Treatment Facility"). A GEIR completed in 1990, for which the Secretary of EOEA issued a Certificate on November 25, 1990, validated the six objectives listed in the decision and considered how various ownership and financial arrangements could meet these objectives.

Documentation of Ownership: For owners of small sewage treatment facilities, other than public agencies, this demonstration shall be made by submitting to the Department, along with an application for a Ground Water Discharge Permit, suitable documentation of ownership and financial arrangements. Documentation of ownership shall be made by submitting a copy of the property deed(s) for the land on which the sewage collection, treatment and disposal facilities are to be located. In addition, if the owner is other than an individual, organizational documents that specify the owner's legal authority shall be included in the submittal. This documentation shall include, at a minimum, the following items:

(1) for a private corporation or authority, the articles of incorporation;
(2) for a partnership or a limited partnership, the partnership agreement;
(3) for a condominium association, the master deed;
(4) for a trust, the declaration of trust; and
(5) for a residential homeowners association or cooperative, the cooperative agreement.

User Charge: The owner of small sewage treatment facilities which service multiple System users shall establish, and submit to the Department as part of the discharge permit application, a system of assessments for all expenses and charges related to the operation, maintenance, repair, replacement and financing of the sewage treatment facilities. These expenses shall include all permit and inspection fees, and any fines or penalties that may be assessed by the Department as a result of violations of any applicable statute, regulation or permit condition. The system of assessments shall also be adequate to generate revenues sufficient to fund the proper operation, maintenance and repair of the sewage treatment facilities, and to fund a capital reserve account to provide for the complete replacement of the sewage treatment plant within twenty years of the date of its initial operation.

Financial Security Requirements[5]

> **Emergency Repair Account**: Prior to the commencement of operation of any privately owned treatment facilities (including clear water hydraulic testing), the owner may be required to provide adequate security to serve as a source of funding for the immediate repair and replacement of the sewage treatment facilities. The security amount shall be determined by the Department and shall be based upon such factors as the design flow and construction costs. Such security shall be provided by the owner in a form satisfactory to the Department, including but not limited to, by means of an interest bearing bank escrow account, bank loan agreement or letter of credit. The owner shall maintain such security throughout the useful life of the sewage treatment facilities, replenishing the amount set forth by the Department within ninety days of any disbursements.

[5] Please review the current Department policy on Financial Security Provisions for further details on applicability and determining the cost basis.

Capital Reserve Account: The owner of small sewage treatment facilities may be required to establish, and submit evidence thereof to the Department prior to commencement of operation of the facilities (including clear water hydraulic testing), an interest bearing capital reserve account(s). Such account(s) shall be maintained at financial institutions that provide insurance for the full amount on deposit. It is suggested that the capital reserve account be dedicated to sewage treatment facilities replacement.

Operation & Maintenance: The owner of small sewage treatment facilities which service multiple users shall establish and maintain throughout the useful life of the facilities adequate accounts from which all expenditures for operation, maintenance and repairs of the facilities can be made. The owner shall maintain records of deposits to and disbursements from such accounts for at least seven years from the date of the transaction.

Annual Financial Report: The owner of small sewage treatment facilities which service multiple users shall submit to the Department an annual financial report concerning the sewage treatment facilities. The report shall be due by May 1 of each year and shall contain all financial transactions for the previous calendar year. The report shall include, at a minimum, the following information:

(1) the aggregate balance of the security funds maintained in the "Emergency Repair Account";
(2) a listing of all disbursements from the "Emergency Repair Account". together with a description of the means by which the account will be replenished;
(3) the initial and current balances in the "Capital Reserve Account";
(4) a summary of expenses for operation, maintenance and repair of the sewage treatment facilities; and
(5) a determination of assessments to the individual users for the current year.

Rules & Regulations: The owners of small sewage treatment facilities which service multiple users shall establish and submit to the Department for approval prior to the commencement of the facilities operation (including clear water hydraulic testing) a copy of the "Rules And Regulations Regarding The Use Of Common Sanitary Sewers". Said rules and regulations shall be contained within tenantry use, in the lease or rental agreements. The rules and regulations shall contain, at a minimum, the following restrictions:

(1) no person shall discharge or cause to be discharged any stormwater, surface water, groundwater, roof runoff or subsurface drainage, to any sanitary sewer;
(2) no person shall discharge or cause to be discharged any of the following described waters or wastes to any sewers:

   (a) any gasoline, kerosene, benzene, naphtha, fuel oil, or other flammable or explosive liquid, solid, or gas;
   (b) any non-latex paints, paint thinners, paint removers, or strippers;

(c) any organic solvent or any liquid containing any organic solvent including the following:

Acetone
Benzene
Bromodichloromethane
Bromoform
Bromomethane
Carbon tetrachloride
Chlorobenzene
Chloroethane
2-Chloroethylvinyl ether
Chloroform
Chloromethane
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethane
trans-1,2-Dichloroethene
cis-1,3-Diclorpropene
trans-1,3-Diclorpropene
Ethyl benzene
Methylene chloride
1,1,2,2-Tetrachloroethane
Tetrachloroethene
Toluene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethane
Trichloroflouromethane
Vinyl chloride

(d) any lubricating or hydraulic fluids including waste crankcase oil, brake fluid, transmission fluid, and lithium grease;
(e) any photographic fluids including waste developer, fixer and rinsewater;
(f) any pesticide including insecticides, fungicides, rodenticides and herbicides of any sort;
(g) any waters or wastes containing toxic or poisonous solids, liquids, or gases in sufficient quantity, either singly or by interaction with other wastes, to injure or interfere with any sewage treatment process, constitute a hazard to humans or animals, create a public nuisance, or create any hazard in the receiving waters of the sewage treatment plant;

(h) any waters or wastes having a pH higher than 9.5 or lower than 5.5, or having any other corrosive property capable of causing damage or hazard to structures, equipment, and personnel of the sewage works; and
(i) solid or viscous substances in quantities or of such size capable of causing obstruction to the flow in sewers, or other interference with the proper operation of the sewage works such as, but not limited to, ash, ashes, cinders, sand, mud, straw, shavings, metal, glass, rags, feathers, tar, plastics, wood, unground garbage, whole blood, paunch manure, hair and fleshings, entrails and paper dishes, cups, milk containers, etc. either whole or in parts.

(3) No person shall discharge or cause to be discharged the following described substances, materials, waters, or wastes if it appears likely in the opinion of the owners or their agent that such wastes can harm either the sewers, sewage treatment process, or equipment, have an adverse effect on the receiving waters, or can otherwise endanger life, limb, public property, or constitute a nuisance. In forming the opinion as to the acceptability of these wastes, the owners or their agent will give consideration to such factors as the quantities of subject wastes in relation to flows and velocities in the sewers, materials of construction of the sewers, nature of the sewage treatment process, capacity of the sewage treatment plant, degree of treatability of wastes in the sewage treatment plant, and other pertinent factors. The substances prohibited are:

(a) any liquid or vapor having a temperature higher than 150 °F (65 °C);
(b) any water or waste containing fats, wax, grease, or oils, whether emulsified or not, in excess of 100 mg/l or containing substances which may solidify or become viscous at temperatures between 32 and 150°F (0 and 65°C);
(c) any garbage that has not been properly shredded. The installation and operation of any garbage grinder equipped with a motor of three-fourths (3/4) horsepower (0.76 hp metric) or greater shall be subject to the review and approval of the owners or their designated agent; and
(d) waters or wastes containing substances which are not amenable to treatment or reduction by the sewage treatment process employed, or are amenable to treatment only to such degree that the sewage treatment plant effluent cannot meet the requirements of other agencies having jurisdiction over discharge to the receiving waters.

(4) No unauthorized person shall maliciously, willfully, or negligently break, damage, destroy, uncover, deface, or tamper with any structure, appurtenance, or equipment which is a part of the sewage works. Any person violating this provision shall be subject to immediate arrest under charge of disorderly conduct.

F. <u>CONTRACT SERVICES</u>

Contracts for the following services shall be submitted to and be approved by the Department at least 14 days prior to scheduling a clear water hydraulic test.

- Certified Wastewater Treatment Plant Operator;

- Professional Engineer Operational Consultant;
- Licensed Septage Hauler; and
- Approved Sludge Treatment and Disposal Facility.
- Approved Laboratory

Proof of employment and resume of qualified members of the owner's staff may be submitted as partial fulfillment of the above obligations.

Certified Wastewater Treatment Plant Operator

General: A certified operator shall be retained by the owner of all small sewage treatment facilities in accordance with the requirements of the Board of Certification of Operators of Wastewater Treatment Facilities. The operator shall be responsible for daily operation and routine maintenance of the collection, treatment and disposal systems.

Plant Coverage: The certified operator shall spend a minimum of two hours per day, five days each week at the facilities. Additional time shall be allotted when conditions warrant. Treatment Plants rated by the Board of Certification of Operators of Wastewater Treatment Facilities as Grade 4 and above shall have a certified operator present at least 3 hours a day during the working week and at least one hour a day on weekends and holidays. Note that as facilities increase in size and complexity that the required plant coverage will increase.

On Call Requirements: The operator or an assistant, each of whom must be certified at least to the grade level of the plant, shall be on call 24 hours a day, 7 days a week to respond to plant malfunctions. On-call personnel shall be equipped with an appropriate paging device and shall be capable of responding to emergencies within one hour of alarm activation.

Reporting: The certified operator shall report any plant malfunction that has the potential to endanger public health or the environment to the Department and the local Board of Health. Initial notification shall be provided orally within 24 hours from the time the operator becomes aware of the circumstances. A written report shall also be provided within 5 days of the time the operator becomes aware of the circumstances. The written submission shall contain a description of the event, including exact dates and time, steps taken or planned to eliminate the problem and to prevent its reoccurrence.

Operational Training: The certified operator shall be responsible for all process control testing including free chlorine residual; influent, effluent and intermediate BOD, Suspended Solids, and Settleable Solids; pH and dissolved oxygen. The operator shall also be responsible for maintaining flow charts and recording the daily flow.

Record Keeping: The certified operator shall maintain all testing records and flow chart at the plant for inspection and shall submit copies of the results to the Department and the local Board of Health as required by the discharge permit.

Professional Engineer Operational Consultant

General: The owner of all small sewage treatment facilities shall engage the services of a Massachusetts Registered Professional Civil or Sanitary Engineer experienced in sewage treatment plant operation.

Contract Period: The initial contract for engineering operational services shall be for a period of not less than two years. The contract shall be renewed thereafter, on a yearly basis or a new contract with another qualified engineer shall be submitted. Failure to have a valid contract shall be grounds for revocation of the facility's discharge permit.

Start-Up Services: The consultant engineer shall be present at the initial clear water hydraulic test of the treatment facilities. Inspection of the operation of the treatment facilities shall continue on a once per week basis for the first two months to explain procedures to the operator and assist in the actual operation of the plant. A complete sampling shall be conducted every two weeks during the first two months of operation. Inspection of the operation of the treatment facilities shall continue once every two weeks for the next four months to check the operation and discuss operating procedures with the operator. A complete sampling shall be conducted at least once each month during this four-month period.

Monthly Inspection: Inspections of the operations of the treatment facilities by the consultant engineer shall be required at least once a month to check the operation and consult with the operator. Monthly visits shall include a complete sampling in accordance with the facility's discharge permit. Additional visits shall be made as necessary to assist the plant operator as requested by the owner or the Department.

Compliance Monitoring: The consultant engineer shall, promptly following each inspection, submit a written report indicating the condition of the facilities, results of sampling, flow figures, and recommendations for modifications to the owner with copies to the Department and the local Board of Health. The report shall state whether established protocol was followed during sample collection, storage and transport to the approved laboratory.

Licensed Septage Hauler

General: The owner of all small sewage treatment facilities, not equipped with sludge processing equipment, shall engage the services of a qualified individual or firm for the removal and transport of waste sludge to an appropriate off-site sludge treatment and disposal facility.

License: the person so engaged shall be properly licensed by the Board of Health of the municipality in which the small sewage treatment facility is located and by the Massachusetts Department of Public Utilities.

Disposal Location: Waste sludge shall only be disposed of at an approved treatment and disposal facility. The location and method of disposal and appropriate restrictions shall be included in the contract.

Pump-Out Records: Copies of all receipts for sludge pump outs along with a certification that volume of sludge has been received at the approved disposal facility shall be submitted to the Department and the local Board of Health. Such receipts shall indicate the date of pump-out, volumes pumped and the date and location of disposal.

Approved Sludge Treatment and Disposal Facility

General: The owners of all small sewage treatment facilities, not approved for on-site sludge disposal, shall obtain the written approval of a fully approved and permitted facility for the disposal of waste sludge.

Approval Required: No small sewage treatment facility shall be placed into operation until the primary and backup sludge disposal facilities have been approved in writing by the Department.

Approved Laboratory

General: an approved laboratory shall perform all analyses for compliance monitoring at small sewage treatment facilities. All monitoring and sampling shall be conducted in accordance with the procedures contained in the latest edition of "Standard Methods For The Examination Of Water And Wastewater".

Certification*:* Any laboratory used for water or wastewater analysis shall be certified by the Department pursuant to the Safe Drinking Water Act.

QA/QC: The laboratory shall have a Quality Control - Quality Assurance Program approved by the Department.

IV. CALCULATION OF WASTEWATER FLOW

The wastewater design flow is used to determine whether the project is subject to the requirements of the State Environmental Code (Title 5) – 310 CMR 15.000 or the Groundwater Discharge Permit Program – 314 CMR 5.00. The design criteria outlined in 310 CMR 15.203 are used. The estimated maximum contributory population for the entire development should be used. In the case of phased projects the existing as well as all planned future phases shall be included. If the calculated flows are less than 10,000 gallons per day (gpd), the system can be designed in accordance with Title 5. If the flows are greater than 10,000 gpd, then the requirements of the groundwater discharge permit program govern.[1]

If the project is subject to the requirements of the groundwater discharge permit program, there are several different methods that may be used to evaluate wastewater flows for designing treatment unit processes, as follows:

1. **State Environmental Code (Title 5):** This is the standard method for calculating the design flow. The wastewater treatment plant design and the disposal area must be based upon the estimated flows as contained in 310 CMR 15.203. This value is equivalent to the estimated flow for the proposed use plus a factor representing flow variation. It represents the maximum volume of wastewater that the treatment plant and disposal area will receive on any given day.

2. **Metered Flows:** The actual metered flows from known similar establishments would be used as the basis for determining wastewater treatment plant design and disposal area. This method would be most applicable for, but not necessarily limited to, commercial facilities and office parks. In this manner, a flow value, such as X gallons per 1000 square feet for an office park or Y gallons per seat for a restaurant would be established. All proposed flow values must be fully documented by the project proponent. When this method is utilized, the design of the wastewater treatment plant and disposal area shall be based on 200 percent of the average daily meter readings (during periods of peak use) to simulate maximum daily flows.

3. **Per Capita Flows:** This method should be utilized when dealing with municipal facilities that tend to be larger, have more diverse flow sources, and have variable flow rates For residences, per capita rates will be based on water use records. If such records are not available, a reasonable assumption is 70 gallons per capita per day (gpcd). For commercial, industrial, recreational and institutional sources, flow rates will be based either on actual use or similar facilities. An allowance for infiltration will be added. The summation of these

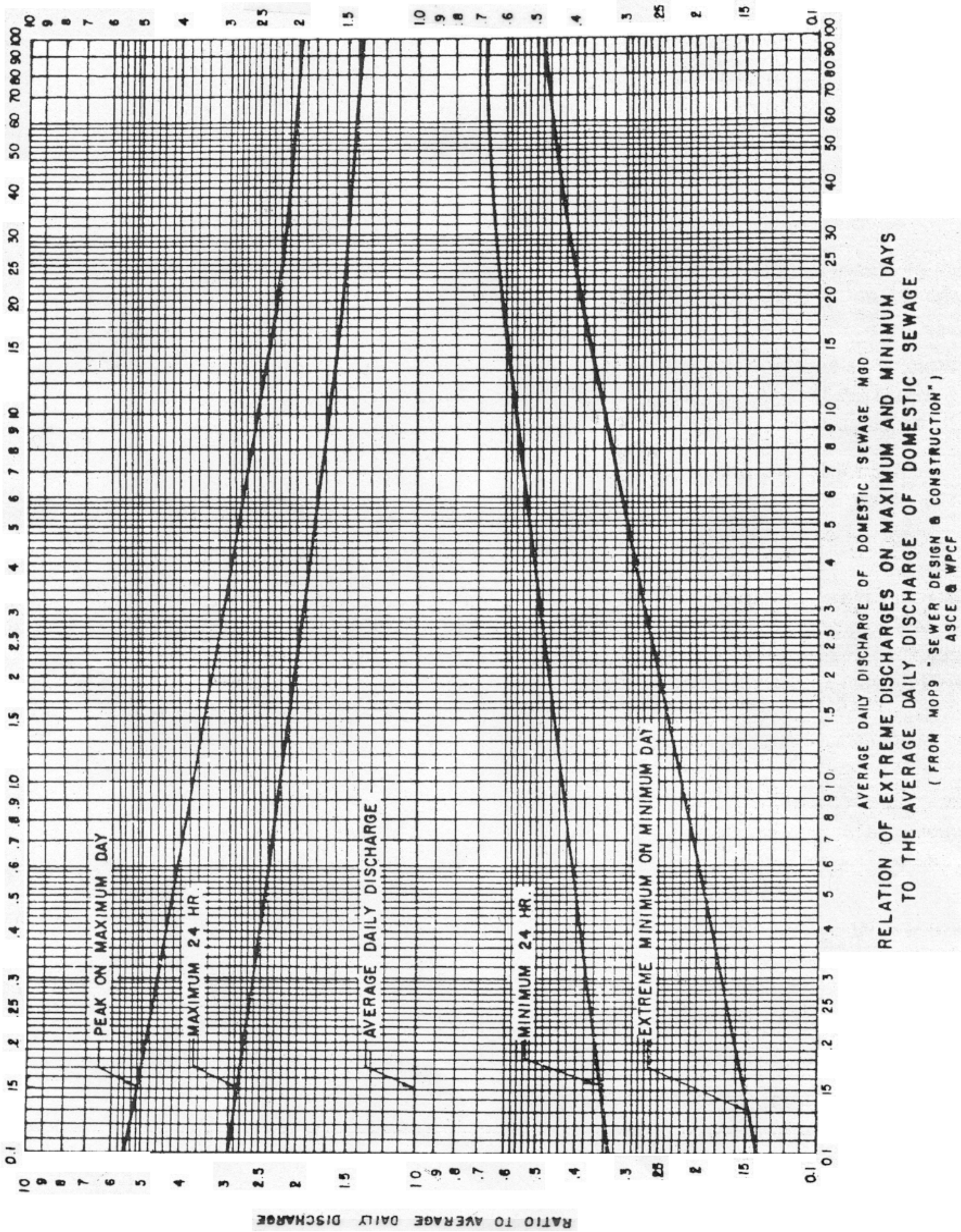
[1] WWTF's may be allowed for flows less than 10,000 gpd provided it is demonstrated, to the satisfaction of the Department, that the financial burden associated with the operation, maintenance and replacement of such a facility can be borne by the users of the system without posing an undue hardship on any individual within the user group.

flows will yield the average daily flow. Maximum daily flows will be calculated in accordance with Figure1. (Note: This is the Merrimack Curve contained in TR-16). The wastewater treatment plant will be designed to handle both the average and maximum day hydraulic flow and maximum organic loading/wastewater strength, since in this instance certain unit operations/processes may be more sensitive either to the average or maximum day flow or high strength wastes. The disposal area will be evaluated and sized for both the average daily and maximum month flows, since the concern is whether the site can adequately accept variable flows.

When developing the groundwater discharge permit, the manner in which the flow limits are described will vary with the method used to develop flows. Most permits are written with a "not to exceed" flow limit. That language is generally appropriate when the flows are derived using either the Title 5 or metered flows method since we have only a single value that accounts for all flow variations. When the per capita method is used, the permit will contain two flow limits, one for the average and one for the maximum day flow. Depending on the particular situation, the average limit could represent an annual average value, or, such as the case where the system experiences significant infiltration during high groundwater periods, it could be the average flow during the maximum month.

FIGURE 1

MERRIMACK CURVE



V. INFILTRATION/INFLOW & SEWER SYSTEM MANAGEMENT

Infiltration/Inflow (I/I) is extraneous water entering the wastewater collection system through a variety of sources. Infiltration is groundwater that enters the collection system through physical defects such as cracked pipe/manholes and deteriorated joints. Typically, many sewer pipes are below the surrounding groundwater table, therefore leakage into the sewer (infiltration) is a broad problem that is difficult and expensive to identify and remove. The rate of infiltration is generally higher in the spring when groundwater levels are at the maximum. Inflow is extraneous flow entering the collection system through point sources. It may be directly related to stormwater runoff from sources such as roof leaders, yard and area drains, sump pumps, manhole covers, and cross connections from storm drains or catch basins. Other potential sources include non-storm related point sources such as leaking tide gates, cooling-water discharges, or drains from springs or swampy areas. Because inflow enters a collection system through point sources, it is generally easier and more cost-effective to identify and remove than infiltration.

High levels of I/I reduce treatment and pipeline capacity that would otherwise be available for sanitary flow. The result, during extreme storm events, could be sewer surcharging, back-up of sewage into homes and businesses; local overflows of untreated sewage, treatment plant bypasses, and inadequate treatment of sewage. I/I also results in the transport of groundwater and surface water out of the natural watershed, which may adversely impact groundwater and surface water resource areas.

The Department has wide authority over sewage collection and treatment facilities, including regulatory responsibility for sewer surcharging and overflows caused by I/I. These powers include the ability to issue enforcement orders to reduce I/I, including specific schedules and corrective measures to reduce I/I quantities. Additionally, many groundwater discharge permits will contain a special permit condition relating to the management of Infiltration/Inflow. For communities, the standards for performing I/I reduction projects are incorporated into Department guidance most recently issued in 1993. The Division of Municipal Services can be contacted for copies of the latest guidance.

In order to minimize the impacts of I/I, there are 7 overall goals that should be followed:

1. Eliminate all sewer system backups
2. Minimize, with a long-term goal of eliminating, health and environmental impacts of sewer system overflows related to I/I
3. Remove all (and prevent new) inflow sources from separate sanitary systems
4. Minimize system-wide infiltration
5. Educate and involve the public
6. Develop an Operation & Maintenance (O&M) program
7. Improve funding mechanisms for identifying and removing I/I

For the purposes of this document, special attention should be paid to the development of a proper O&M program. The need for a preventative maintenance program cannot be overemphasized. Such steps include, but are not limited to: record keeping, frequent inspection at chronic problem sites, periodic sewer system inspection, system cleaning, maintenance of pump stations and ancillary facilities, and establishing a sufficient spare parts inventory. In this manner, many problems can be resolved before they occur.

CMOM PROGRAM[6]

Capacity, management, operation and maintenance (CMOM) Program is applicable to publicly owned treatment facilities and has 6 major components:

1. General performance standards

The CMOM program requires that permittees meet **general standards** for management of sewage systems. Permittees must manage and maintain their facilities, provide adequate capacity to process base and peak flows, take all feasible steps to stop Sanitary Sewer Overflows (SSOs), and inform the public when SSOs occur.

2. Management program

Permittees must develop and implement their own CMOM **management program** to comply with CMOM general standards provisions. CMOM management includes goal setting and organizing personnel to implement CMOM. CMOM also requires the permittees to use their legal authority to maintain sewers and reduce I&I. Permittees should also maintain a map of the sewage collection system and keep an inventory of system equipment and spare parts. Permittees should eliminate sewage overflows into sensitive waters. Other important provisions include monitoring the effectiveness of the CMOM management program and making appropriate system changes in response to monitoring results.

3. Overflow emergency response plan

Permittees must also have an **overflow emergency response plan** to protect public health, inform public health authorities, and investigate the cause of SSOs.

4. System evaluation and capacity assurance plan

System evaluation and **capacity assurance** plans are necessary to address hydraulic deficiencies and estimate system capacity during peak flows.

5. Program audits

CMOM program audits are probably the most important part of the CMOM provisions. Permittees carry out self-audits to identify maintenance and capital improvements needs.

6. Communication

The CMOM provisions outline the need for permittees to establish lines of **communication** with various interested parties concerning the CMOM program and to allow comment from outside parties.

[6] Further information can be found on the EPA website: www.epa.gov

VI. SITE EVALUATION & SITING CRITERIA

The site investigation shall minimally include:

- Installation and development of monitoring wells (according to Standard Methods for Monitoring Wells, WSC 310-91); submit well completion form to DEM, photocopy to be provided to Department. Provide soil boring information, Standard Penetration Test and other relevant data. Wells are recommended to be installed with 15-foot screens with approximately 5' above and 10' below the adjusted high groundwater level. This construction may be modified based upon specific site conditions such as suspected seasonal high water level fluctuations. Wells must be able to be secured and constructed so as not to allow infiltration of surface water or runoff. The ability of the proponent to install or demonstrate that wells can be installed in the future to monitor the reserve area shall be required should the need to expand into that area be needed.
- Test pits to at least 5 feet below the bottom of the proposed disposal system. If bedrock rock is encountered, characterize the bedrock surface. The extent of the characterization shall be based upon observations of the field personnel such as but not limited to the degree of weathering, fracturing, and type of rock. Note if redoxymorphic features or water appear to be at or near this surface at the time of observation. Provide Certified Soil Evaluator (CSE) logs. Test pits shall be 1 per each 500 sqft, with a minimum of 2 per proposed contiguous disposal area. Test pits shall be dug at the furthest ends of the propose study area. If the soil profile is consistent across the proposed disposal area, then the number of test pits may be reduced to 1 per 1000 sqft, with a minimum of 4 pits. Reserve areas shall be assessed on the same frequency. If the reserve area is within the primary disposal area (such as between laterals), then there should be a minimum of 3 test pits per contiguous disposal area.
- Percolation, infiltration and other testing for the purpose of determining the infiltration rate of the proposed disposal system shall be in the most restrictive layer encountered during the exploration of the test pit by the Certified Soil Evaluator. If the final design of the system will result in the removal of the restrictive material, the testing mentioned may be conducted in the most restrictive material to remain as the receiving soil. All percolation tests shall be performed in accordance with the methodology stated in Title 5 – 310 CMR 15.000.
- Mapping of all surface water, vernal pools (certified or potential) and wetlands.
- Locate seeps, springs or other areas of groundwater reaching the surface.
- Locate public (if discharge is in a Zone II or IWPA or surface water protection zone or within 1 mile) and private water supplies (within ½ mile).
- Locate bedrock at or known to be near the surface. Include a description.
- Perform Infiltration testing by qualified professional (see Appendix)
- Record initial water levels.
- Survey location and elevation of wells.
- Initial background water quality sampling.
- Hydraulic conductivity testing of wells

- Ground water mound calculations shall be performed based upon the starting groundwater elevation of the 80th percentile of the highest estimated groundwater level. A simple desktop calculation or analytical model should utilize data collected from the site investigations.

Based upon site complexity, sensitive receptors or design, the Department may require, the following items for the site evaluation:

- Additional wells
- Surface water sample collection and analysis
- Split spoon logs from borings. At a minimum, the deepest boring shall have a continuous split spoon log.
- Assessment of potential impacts of nutrients (i.e. Nitrogen, Phosphorus)
- Sieve analysis of split spoon samples and/or test pit samples. The results shall include an estimate of the infiltration rate.
- Geophysical investigation methods.
- Scale loading tests.
- Mounding of system to provide adequate separation between estimated high water and the bottom of the distribution system or bed. Characterization of difference between the mounding material and the native material must be done to account for difference in infiltration rate and preferential flow direction.
- A more sophisticated model may be required based upon sensitive receptor or mound height issues. This would usually require additional fieldwork to provide the additional input data. Usually a greater coverage of data is also necessary then is required for desktop or analytic mounding analysis.
- Evaluation of travel time or other issues of wastewater to water supplies.
- Other information as deemed appropriate and necessary by the Department.

Plans & Specifications

Submit with locus map (Topographic Map) and site map (such as plot plan). Show neighboring properties. If not on plan provide notes or figure that shows new structures or important changes.

Sampling and Analysis

A list of all monitoring points (operational and compliance) and the analysis required along with the regulatory limits and methodology shall be submitted. QA/QC plan must be presented in the plan. The complete plan shall be submitted to the Department for approval.

Adjustments to observed ground water levels:

The presence of soil mottles (redoxymorphic features) may be utilized if observed in test pit by a qualified individual (CSE, Soil Scientist, P.E., C.E., geologist or Hydrogeologist). The general use of these features shall be based upon commonly

acceptable practice. This includes the declaration of high water by frequency of occurrence of these features at specific depth. The absence of these features in certain soil types (such as sand) may not indicate the absence of a seasonally high water table as some soils do not have the capability of producing observable redoxymorphic features. The use of Town and/or U.S. Geological Survey published observation well data according to the methodology set forth in the following publications:
Frimpter, M.H. 1981, Probable High Ground-Water Levels in Massachusetts: U.S. Geological Survey Water Resources Investigations Open File Report 80-1205.
Frimpter, M.H. and Fisher, M.N, 1983, Estimating Highest Ground-Water Levels for Construction and Land Use Planning – A Cape Cod Massachusetts Example: U.S. Geological Survey Water Resources Investigation Report 83-4112.

Repairs and replacement systems:

The data requirements shall be the same as the above with the opportunity for the proponent to demonstrate with existing data the requirements above. If infiltration testing data does not exist or utilizes an unacceptable or superceded method or was not witnessed by the Department or designee the testing must be performed as for a new system. If loading rates and monitoring data is available, mounding calculations may utilize this data. Reasons for the repair shall be stated and considered should additional data be needed to mitigate the reason for the failure.

Preferred testing method:

Soil Description (To be most restrictive encountered and left in place at proposed site)	**Classification**	**Hydraulic Conductivity (Gal/Ft^2/Day)**	**Testing Method**
Clean Gravel	Gravel	10^5 to 10^4	Percolation Test (Likely to be less than 2 Min./In. See Table 3)
Clean Sand and Sand & Gravel	Sand	10^3 to 10^2	Percolation Test (Probably less than 2 Min./In.) (See Table 3)
Fine Sand	Fine Sand	10^1 to 10^{-1}	Percolation test or Infiltration test method
Sand with Silt & or Clay	Sandy Loam	10^{-1} to 10^{-3}	Infiltration test method (Possibly greater than 20 Min./In.) (See Table 3)
Sand with Significant Silt or Clay	Loamy Sand or Silt	10^{-3} to 10^{-4}	Infiltration test method (Greater than 20 Min./In.) (See Table 3)

Distances - No sewage collection, treatment or disposal system shall be closer than the distances stated to the components listed in Table 2. Please note that these are minimum setbacks and that site-specific conditions may warrant additional distance.

TABLE 2

MINIMUM ACCEPTABLE SEPARATION DISTANCES

(FEET)

Component	Treatment Plant Bldg.	Pump Station	Subsurface Tank	Leaching Facility	Sewer or Force Main
Well					
Public	400	400	400	400	400
Private	50	50	50	100	50
Water Supply Line	-	10	10	25	10*
Dwelling Unit	50	25	10	25	10
Subsurface Drain	-	25	25	25	5
Property Boundary	50	25	10	25	10
Surface Waters	100	50	50	100	50
Downhill Slope greater than one vertical to three horizontal	10	10	10	50	--

* See design criteria for collection systems.

VII. EFFLUENT DISPOSAL

General - Final effluent disposal shall be by means of properly designed open sand beds, leaching pits, leaching chambers, leaching trenches, or other approved subsurface methods. The use of reclaimed water consistent with Department policies is encouraged. Other methods of discharge may be allowed on a case-by-case basis provided adequate documentation is presented to the Department, which demonstrates the expected impact on the environment and hazard to public health resulting from such alternate system. This documentation shall include either the results of a properly monitored pilot test performed with Departmental approval at the proposed discharge site or the results of tests and/or actual experience at other similar locations.

Reserve Area - A reserve area tested and shown to be sufficient to replace the capacity of the original leaching area shall be provided. Although it is preferred that a 100% reserve area be provided whenever possible, particularly for smaller facilities ($\leq$40,000gpd), there are instances where this requirement can be modified. For open sand beds, the construction of a minimum of four (4) basins of approximate equal size can be provided. In this manner, the loading cycle can be adjusted so that one bed is being loaded as the others are drying, while at the same time one of the beds can be taken out of service for required maintenance. For subsurface facilities, the combination of a proven treatment process providing a high level of treatment and permeable soils may reduce the need for a reserve area. Another example is where effluent disposal is accomplished by means of a number of small subsurface leaching facilities that are not interconnected. In this instance, a reserve area equivalent to one field being off-line is possible.

Open Sand Beds

Leaching Area - The leaching area required shall be determined in accordance with the provisions of Table 3. The effective leaching area shall include only the bottom area, not the sidewall.

Groundwater - The maximum ground water elevation including mounding shall be no less than 4 feet (1.22 m) below the bottom of the sand bed.

Number - The sand bed shall be divided into at least two sections or at least two separate beds of approximate equal size shall be provided. Sections shall be alternately dosed.

Construction - All top soils and subsoils shall be removed from the bed area. At least 2.0 feet (0.61 m) of clean sand shall be placed within the beds. Material for the sand beds shall be placed without compaction of the subgrade or the sand itself. Sand shall conform to the following grading limitations, as determined by AASHO -T11 and T27:

Percent by Weight		
Size of Sieve (Square Openings)	**Passing Through Minimum/Maximum**	
1/2 inch	100	---
3/8 inch	85	100
#4	60	100
#16	35	80
#50	10	55
#100	2	10

Impervious Materials - Excavations into or fill upon impervious material shall not be allowed. Excavation through impervious material may be allowed if at least 4 feet (1.22 m) of naturally occurring pervious material (as determined by performing a percolation test in the most restrictive pervious layer), remains beneath the lowest point of excavation. All construction after excavation through impervious material shall be in accordance with 310 CMR 15.02(17).

Surface Drainage - The grade adjacent to the sand bed shall slope away from the bed at least 2 percent to prevent the accumulation of surface water.

Excavation - Excavation may be made by machinery provided that the soil at the bottom of the disposal system is not compacted. The bottom of each bed shall be level.

Frozen Conditions - Sand beds shall not be constructed in frozen soil.

Downhill Slope - Sand beds shall not be located closer than 50 feet from downhill slopes steeper than one vertical to three horizontal.

Berms - A berm of at least 2 feet in height shall be provided around the perimeter of the sand beds.

Splash Pads - Suitable splash pads of washed stone, concrete or other appropriate material shall be installed in each bed beneath the outlet pipe to prevent scouring of the bed surface.

Fencing - Open sand beds shall be enclosed within a fence of at least 5 feet in height. The fence shall be provided with a locking gate.

Piping - All distribution pipe shall be SDR-35 PVC and shall be self-draining to prevent freezing.

Disinfection – Must be provided at all times for facility discharges utilizing open sand beds.

Maintenance Plan – All open sand beds must have a maintenance plan to ensure that the beds are free of weed and plant growth.

All Other Leaching Facilities

General - The criteria listed in 310 CMR 15.251, 15.252, and 15.253 (Title 5) shall be used to design leaching pits, leaching chambers and leaching trenches respectively for use at small sewage treatment facilities, with the following revisions:

- leaching area requirements shall be determined in accordance with the provisions of Table 3;
- maximum ground water, including mounding, must be at least 4 feet (1.22 m) below the bottom of the excavation;
- at least 4 feet (1.22 m) of naturally occurring pervious material is required below the lowest point of excavation; and
- the area between the leaching facilities is allowed to be used as the reserve area.

Percolation Test vs. Infiltration Test – The rate of movement of water into the soil is called the infiltration rate. A dry sol may have a very high initial infiltration rate, but as the soil pores become filled with water (saturated) the infiltration rate decreases sharply. In a saturated soil, the infiltration rate is equal to the rate at which water moves through the soil profile which is the percolation rate. The infiltration rate and percolation rate are critical physical properties of the soil that must be considered when designing and operating a subsurface disposal system. Both of these properties determine the rate at which water can be effectively applied to a soil. A percolation test involves a pre-soak which is intended to saturate the soils, while the infiltration test uses a confining ring which allows constant saturation of the soil being tested. The infiltration test provides a higher degree of control and is preferable in most situations. The results are relatively comparable, but will vary due to the accuracy of the method used. Since infiltration tests provide a more accurate analysis of the saturated acceptance ability than percolation tests, a higher loading rate (with the exception of less than 2 min/in) will be available in Table 3 for sites where infiltration testing has been performed. Examples of infiltration tests include: Double-ring infiltrometer; Guelph Permeameter: and loading tests. Please refer to the Appendix for further discussion of infiltration testing methods.

Ventilation – Adequate ventilation is necessary for the proper operation of the facilities. If the facilities are constructed beneath a parking lot then ventilation is required.

Cover – Depth of cover over leaching facilities shall be no greater than 3 feet. The facilities can be located below parking lots, if properly vented, or athletic fields as long as there is nothing penetrating the field.

Disinfection – Must be provided at all times for new facility discharges utilizing subsurface disposal. The Department may waive this requirement on a case-by-case basis. For existing facilities utilizing subsurface disposal, the need for disinfection will be evaluated on a case-by-case basis.

Maintenance Plan – A maintenance plan is required to ensure that the area over the leaching facilities is free of tree and shrub growth.

TABLE 3

DESIGN LOADING RATE – GALLONS PER DAY PER SQ. FOOT (GPD/SF)

(Using Percolation Testing)

Percolation Rate	Less than 2 Min/In	2 to 5 Min/In	5 to 10 Min/In	10 to 20 Min/In	Greater than 20 Min/In[1]
Open Sand Bed	5.0	5.0	4.0	2.0	0.3 (w/regular maintenance
Leaching Pit	3.0	3.0	2.5	1.5	0.2
Leaching Chamber	3.0	3.0	2.5	1.5	0.2
Leaching Trench	2.5	2.5	1.5	1.0	0.2[2]

(Using Infiltration Testing)

Percolation Rate	Less than 2 Min/In	2 to 5 Min/In	5 to 10 Min/In	10 to 20 Min/In	Greater than 20 Min/In[1]
Open Sand Bed	5.0	5.0	4.5	3.0	0.4 (w/regular maintenance
Leaching Pit	4.0	3.5	3.0	2.0	0.3
Leaching Chamber	4.0	3.5	3.0	2.0	0.3
Leaching Trench	3.0	2.75	2.0	1.5	0.25[2]

[1] A maximum percolation test rate of 60 min/in shall be imposed. The Department based upon test data and system design may impose lower loading rates.
[2] Leaching trenches may require additional restrictions and a significantly lower rate. More stringent treatment standards may be required if this method is selected.

VIII. GENERAL REQUIREMENTS FOR TREATMENT PLANTS

A. TREATMENT REQUIREMENTS

All groundwater discharge permits will be issued a set of effluent limitations that are specific to the particular site. As a general rule, the Department shall apply the more stringent of either the water quality based effluent limitations under 314 CMR 5.10(3) or the technology based effluent limitations under 314 CMR 5.10(4). However, please be aware there are circumstances where even more stringent limitations may be required. Knowledge of downgradient uses and impacts is critical to making the proper decision on treatment requirements. Such situations include, but are not limited to, discharges that will impact a Zone II or IWPA, projects incorporating wastewater reuse, and nutrient (nitrogen and/or phosphorus) sensitive areas. These and other conditions will be discussed further below.

1. **Standard Groundwater Permit Limitations:** Unless otherwise stated, all groundwater discharge permits will include limitations and conditions necessary to insure the maintenance of Class I and II groundwater standards as contained in 314 CMR 6.00, and any such limitations shall apply to the end of the pipe or outlet. Although the discharge is required to meet all the Class I and II standards, the effluent limitations contained in the permit do not have to include the complete list of pollutants, but typically will consist of the following: BOD_5, suspended solids, pH, oil and grease, total nitrogen and nitrate nitrogen. Other pollutants may be included on a project specific basis. The Class I and II nitrogen limits of 10 mg/l for both total and nitrate nitrogen will also be required for facilities with design flows less than 150,000 gpd if, in the opinion of the Department, it is necessary to protect downgradient ground and surface water uses.

2. **Disinfection:** The standard permit limitation is 200 fecal coliform per 100 ml. This limitation may be more stringent on a case-by case basis, such as for wastewater reuse. As an example, the most stringent fecal coliform limit for certain categories of reuse is a median of no detectable colonies per 100 ml over continuous, running 7-day sampling periods, not to exceed 14 colonies per 100 ml.

3. **Enhanced Nitrogen Removal:** In order to maintain Class I and II standards, the end-of-pipe effluent limit for both total and nitrate nitrogen is <10 mg/l. While in most instances this limit is sufficient, there may be instances where a more stringent standard may be necessary to protect sensitive receptors such as aquifer systems and estuaries. In particular, nitrogen is the growth-limiting nutrient in marine environments. Once the hydrogeologic study has determined the area impacted by the discharge, the sensitive receptors within that impact area will be identified and evaluated.

4. **Phosphorus Removal:** The groundwater quality standards do not contain a limit for phosphorus. As opposed to nitrogen, phosphorus is not mobile and frequently adsorbs to soil particles due to chemical and electrostatic bonding. Consequently, phosphorus has not generally been regulated in groundwater discharge permits. However, it is the limiting nutrient for unwanted aquatic growth in inland

waterways. There has been substantial recent evidence that, under certain conditions, the ability of the soil to adsorb phosphorus is finite and that it could migrate and reach sensitive receptors. The Department is presently developing guidance detailing under what circumstances and to what levels phosphorus should be controlled in a groundwater discharge. Until such guidance is finalized, the location of sensitive receptors within the plume area shall be identified and the potential impact of phosphorus will be evaluated on a case-by-case basis. If phosphorus removal is necessary, the Department in consultation with the permittee will determine the required effluent limit.

5. **Wastewater Reuse:** The Department has developed interim guidance describing how the use of reclaimed water will initially be regulated in Massachusetts. The document is entitled "Interim Guidelines on Reclaimed Water (Revised)" and a copy can be obtained from the DEP Regional Office. The most current version can also be found on the Department's website at http://www.state.ma.us/dep/brp/wwm/files/reuse.pdf. At this time, the following uses are allowable; irrigation of golf courses and nurseries, toilet reuse, and indirect aquifer recharge[7]. Additional approved uses may be added in the future. Please check with the Department whether a proposed use is allowable. Specifically, Appendix A of the guidance outlines the specific effluent limitations for each type of reclaimed water project, particularly the coliform standards.

6. **Zone II:** Discharges into a Zone II (or IWPA) are referenced in the Reclaimed Water guidance The treatment plant reliability requirements are described in Section A.2 of the guidance, and require that EPA Class I Reliability be met, although plants designed to treat less than 40,000 gpd may be waived from the Class I requirements. The guidance also lists when the Department's NO_3 loading model, or equivalent, must be run. Finally, all discharges into an aquifer recharge area must be disinfected to the standards listed in Appendix A of the guidance.

7. **Nutrient Loading Approach:** The Department has developed an interim policy entitled "Nutrient Loading Approach to Wastewater Permitting and Disposal". This voluntary approach allows a mixture of treatment technologies to achieve a site-wide nutrient loading limit, rather than simply a single wastewater treatment plant with a nitrate and total nitrogen end-of pipe effluent limit $\leq$10 mg/l. Under certain circumstances, the use of this approach is mandatory for projects subject to the requirements of the interim policy entitled "Private Sewage Treatment Facilities For Multiple Lot Residential Developments". Please review that policy for applicability.

[7] Highly treated reclaimed wastewater introduced to a groundwater system ("Zone II") that is ultimately used as a potable water supply

B. GENERAL WWTF REQUIREMENTS

1. **Building Requirements** – A building shall be constructed at the site of all wastewater treatment facilities. Some buildings will contain the entire treatment system, minus outside tankage such as pretreatment and flow equalization tanks. Other buildings will house only pumps, blowers, chemical feed equipment and electrical controls.

2. **Interior Construction** – The structure shall provide heat, water and protection from the elements. Floor drains in the building shall discharge to the pretreatment tank with a U vent. The building shall be constructed of moisture proof materials.

3. **Siting** – The treatment plant building shall be located as far as possible from built-up areas to prevent nuisance odors and noise. The site shall be located outside the 100-year flood level. The treatment plant should provide for uninterrupted operation of all units under flood conditions of a 25-year frequency and should be placed above or protected against structural and equipment damage from the 100-year flood level. All first floors, tank walls, and structural openings should be higher than the 100-year flood level. Provide flood proofing (e.g. stoplogs at garage entrances, raised motor drives and pumps, and adequate structural strength to buildings) to above the 100-year flood level. All facilities should be constructed outside of coastal velocity flood zones. A paved and accessible roadway shall be provided. The chemical storage area shall have a paved access way and accessible in the winter.

4. **Electrical** – All electrical controls shall be located in a separate room from the process treatment units to prevent malfunction due to contact with moisture or corrosive gases. Electrical fixtures shall be non-corrosive and moisture-proof. The use of PVC electrical conduits is strongly suggested. Electrical equipment in enclosed places, where gas may accumulate, shall comply with the National Electrical Code requirements for Class I, Group D, Division I locations.

5. **Ventilation** – Ventilation shall be provided for all treatment buildings. If the building contains process treatment units, ventilation in the process area shall be sized to handle up to twelve complete air changes per hour. An automatic timer with light switch override shall be provided. Ventilation for the office/laboratory, electrical control room, generator room and restroom shall be sized on the basis of at least five air changes per hour. Heating is required and dehumidification is suggested. Air vents from underground sludge or holding tanks shall all be separate and located in an area to minimize dispersal of odors. Fresh air intakes should be located away from processes or equipment that may generate hazardous gases.

6. **Chemical Storage** – There shall be spill containment under or around the barrels or drums containing the chemical. The containment shall be designed to handle 125% of the chemical kept at the facility. A Material Data Safety Sheet (MSDS) shall be posted on the wall near the chemical and at a central location remote from all hazards. Hazardous chemicals (i.e. gaseous chlorine or methanol) shall be stored in enclosed rooms with access from the exterior of the building only. Doors for the chemical storage area shall open outward and shall be equipped with panic bar openers. All methanol drums shall be grounded.

7. **Potable Water** – All buildings, whether they contain process treatment units or not, shall contain a potable water source. An approved backflow prevention device in accordance with 310 CMR 22.00 shall protect the potable water supply to the treatment plant. Hose bibs and floor drains are recommended for cleaning. At a minimum, a sink and eye wash station shall be present. An emergency shower is recommended, particularly if hazardous chemicals are present. If chemicals are stored in the building, heat is recommended (may not be necessary for dry chemicals and certain acids – review with design engineer).

8. **Safety Equipment** – In addition to the eye wash and shower required with the potable water, all buildings shall also be provided with a first aid kit and fire extinguisher, emergency lighting, and smoke and fire detectors. All necessary personal protective equipment (safety harness, life rings, safety glasses, gas monitors, etc.) shall be provided.

9. **Spacing** – Pumps, blowers, and other component parts of the treatment plant shall have adequate spacing around the units to provide the operator with ample room for maintenance and repair. A minimum aisle width of thirty-six (36) inches shall be provided. All drains, valves, cleanouts and sampling ports shall be readily accessible to the plant operator. UV disinfection bulbs that require a lateral removal shall have ample room to remove the bulbs.

10. **Equipment Removal** – Provisions should be made for removing all equipment from the building. Access openings, hatches, and/or skylights should be sized accordingly. Portable or permanent hoisting devices should be provided as necessary.

11. **Ladders** – Any treatment plant unit that requires a ladder to access the top of a unit for repair or maintenance (i.e. the tops of clarifiers and sand filters) shall have an inclined ladder with handrails or flat catwalk from nearby units. If a vertical ladder is proposed, then it should be in accordance with OSHA standards.

12. **Alarms** – Alarms shall be provided for all equipment to signify pump failures, power outages and other process malfunctions. There shall be a visual light

alarm on the outside of the operations building. Please see the chapter on Instrumentation Guidance for additional detail.

13. **Flow Measurement** – The facility shall contain a flow meter that records the effluent discharging to the ground on a daily basis. The flow meter shall have a recording device so flow measurement can be taken on weekends when operators are typically not present

14. **Alternate Power Source** – All treatment units shall be equipped with an alternate electrical supply or a permanently installed standby generator sized to operate all electrical components including, where feasible, remote pumping stations. The secondary electrical source must be equipped with a transfer switch that will automatically activate upon a prolonged interruption of the primary electrical supply. Equipment start-up after power interruption shall be sequenced. Generators must be provided with fuel sufficient for at least three days of operation. Portable generators and gas-powered pumps are not acceptable substitutes, with the exception for small pumping stations.

15. **Spare Parts** – An inventory of high wear parts such as bearings, belts, gears, links, relays and starters shall be maintained at the treatment facility.

16. **Redundancy** – Multiple treatment units shall be provided whenever the average daily flow exceeds 40,000 gpd and shall include the biological processes and clarifiers. Each unit shall be designed for equal proportions of the design flow. The treatment plant shall be capable of operating at 100 percent of the design flow without violating its discharge limits with any one unit out of service. In no case shall the organic or hydraulic loading to remaining units exceed the peak rates specified in the following sections of this document. Redundancy shall also be required for flows less than 40,000 gpd if during a portion of the year a large fraction of the flow will not be discharging (i.e. schools – see Section N). This could involve sizing tankage and mechanical equipment for the extreme flow variations over the course of the year. Redundancy may also be required on a case-by-case basis for facilities under 40,000 gpd if located within a Zone II or IWPA.

17. **Flexibility** – When treatment facilities are designed with parallel process trains or multiple alternating components, designs shall also include interconnected piping to provide flexibility between all units (as example, modifying flow from parallel mode to series). Flexibility shall also be provided with the ability to recycle flows and add chemicals to different units.

18. **Duplicate Pumps** – Duplicate pumps shall be installed wherever pumping is required. Pumping systems shall be capable of handling the peak daily flow with the largest unit out of service. Particular care should be taken to insure that the pumps are capable of pumping the low flows during initial facility start-up.

19. **Unit Drains** – Unit drains shall be provided for all processes to facilitate cleaning, repairing, or replacing treatment processes.

20. **Floor Drains** – All buildings shall contain floor drains. The floor shall be sloped approximately ¼ inch per foot to a floor drain. The drain shall discharge to a pretreatment tank or treatment unit. Drains shall have U traps to prevent the escape of odors from the pretreatment tank to the building.

21. **Odor Control** – If the facility is located in close proximity to a residential development or high use or populated area, all necessary design standards shall be taken to minimize nuisance odor conditions.

22. **Lighting** – Lighting shall be included in all treatment buildings. Emergency lights for power outages shall also be provided. Lights shall be located in an area that is easily accessible to replace bulbs.

23. **Security** – All treatment facility buildings shall have locks and outside units be protected from vandalism or fenced in.

24. **Sampling Locations** – the design should include easily accessible sampling locations for influent and effluent samples. These locations shall allow for representative 24-hour composite samples. Every process unit shall be equipped with its own sampling ports and/or electronic monitoring equipment so as not to rely on measurements obtained from any other component.

25. **As-Built Plans/O&M Manual** – All facilities shall have a copy of the as-built drawings, including the disposal area, pump stations, and transmission system, and an up-to-date copy of the Operation & Maintenance Manual.

26. **Flow Equalization Tanks** – The purpose of the Flow Equalization Tanks (FET) is to provide uniform hydraulic and organic loading to downstream process components. Sizing of FET pumps must be capable of handling the maximum daily flows but at the same time not exceed hourly loading rates of downstream components served. FET pumps must be operated off timers. Float switches are appropriate only for use as a low-level pump shut-off or high level alarm.

27. **Deep Tanks** – if flow equalization or final dosing tanks are deep in the ground, manhole covers shall be large enough and possibly have a shelf so that operators can access the pumps for maintenance and repair.

28. **Buoyancy Calculations** – Buoyancy calculations must be done for all in-ground units that are located at or near the water table.

29. **Effluent Tank Covers** – Tanks used for the storage of effluent prior to disposal should be covered to prevent the growth of algae.

IX. DESIGN CRITERIA

A. COLLECTION SYSTEM

The following standards apply to conventional collection systems consisting of gravity sewers with standard pump or lift stations. The use of low-pressure sewers may be allowed as an alternative on a case-by-case basis.

Inflow - No new sewage collection systems will be approved by the Department, which allow for the introduction of rainwater, surface drainage, sump pump discharges, non-contact cooling water or any other source of inflow.

Overflows - Overflows from sewage collection systems shall not be permitted.

Design Flows - New sewage collection systems at small-scale installations shall be designed on the basis of the sewage flow estimates previously developed. An appropriate allowance for infiltration shall be added to this flow when sewers are installed in areas of high ground water. An allowance of 200-500 gpd/inch diam/mile of sewer is suggested under these circumstances.

Minimum Diameter - No gravity sewer shall be less than six inches (15 cm) in diameter. No building sewer shall be less than 4 inches (10 cm) in diameter. Gravity sewers within a municipally owned right-of-way shall be a minimum of 8 inches (20 cm) in diameter.

Depth of Cover - Sewers should be designed to be deep enough to drain basement fixtures (where feasible) and to prevent freezing. Insulation may be required for sewers that cannot be placed at depths greater than 4 feet (1.22 m).

Minimum Velocities - All sewers shall be designed and constructed to yield a velocity when flowing full of not less than 2.0 feet per second (0.61 m/s) based on "Manning's" formula. An "n" value of 0.013 constant with depth shall be used for all pipes constructed of materials other than PVC. An "n" value of 0.011 shall be used for PVC pipe. The following minimum slopes shall be used:

Sewer size		Minimum slope (ft/100ft)
6 inches	15 cm	0.005
8	20	0.004
10	25	0.0028
12	30	0.0022
14	36	0.0017
15	38	0.0015
16	41	0.0014
18	46	0.0012
21	53	0.0010
24	61	0.0008

Maximum Velocities - Velocities greater than 12 feet per second (3.7 m/s) shall not be allowed under any flow conditions.

Alignment - Sewers shall be laid with uniform slope and straight alignment between manholes. When a sewer joins one of a larger diameter, the connection shall be made at a manhole. The invert of the larger sewer shall be lowered sufficiently to maintain the same energy gradient. An approximate method for securing this result is to place the 0.8 depth point of both sewers at the same elevation.

Pipe Materials - Sewers shall be constructed of SDR - 35 PVC, ductile iron, reinforced concrete or other material approved by the Department. All sewers shall be designed to prevent damage from superimposed loads. All sewer piping located beneath any street, roadway, driveway or passageway upon which vehicular traffic could occur, should be designed for H-20 Loading.

Material Strength - Proper allowance for loads on the sewer shall be made based upon the width and depth of trench. When standard strength sewer pipe is not sufficient, the additional strength needed shall be obtained using extra strength pipe appropriate bedding or encasement. Sewers greater than 20 feet in depth shall be constructed of SDR – 80 PVC or Schedule 40 ductile iron pipe or equivalent.

Leakage Testing - The method of joining pipes and the materials used shall be included in the specifications. Sewer joints shall be designed to minimize leakage and to prevent the entrance of roots. Allowable infiltration or exfiltration shall not exceed 200 gpd/inch diam/mile of sewer (0.19 m^3/day/cm diam/km). Leakage tests shall be specified in the specifications and may include water or low pressure air testing. Such tests shall be performed with a minimum positive head of 2 feet (0.61 m) above the water table.

Manholes - Manholes shall be installed at the end of each line. Locations at all changes in grade, size or alignment, at all intersections, and a distance not greater than 400 feet (122 m).

Drop Manholes - A drop pipe shall be provided for a sewer entering a manhole at an elevation of 24 inches (61 cm) or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than 24 inches (61 cm), the invert shall be filleted to prevent solids deposition.

Minimum Manhole Diameter - The minimum diameter of manholes shall be 48 inches (122 cm). A minimum access diameter of 24 inches (61cm) shall be provided. Larger openings shall be provided for manholes that house equipment.

Flow Channel - The flow channel through manholes shall be made to conform in shape and slope to that of the sewers entering and leaving the manholes. The top of the flow channel shall be constructed so that under peak design conditions the flow will remain in the channel. The channel shall be at least full pipe depth. When curved flow channels are required, increase minimum slopes to maintain acceptable velocities. Provide a minimum 0.1-foot drop through the manholes.

Manhole Materials - Precast or cast-in-place concrete manholes with O-ring gasketed joints manhole covers adjusted to grade using concrete spacer rings shall be used. Manhole cover type shall be specified on the plans and shall be either steel, cast iron or ductile iron. Water tight, gasketed covers shall be used in areas subject to flooding.

Watertightness - The specifications shall include a requirement for inspection of manholes for watertightness prior to placing into service. Leakage tests may include appropriate water or vacuum testing.

Location Relative to Water Supplies - Sewers shall be kept remote from public water supply wells or other potable water supply sources and structures. Wherever possible, sewers shall be laid at a minimum of at least 10 feet (3.0 m), horizontally, from any existing or proposed water main. Should local conditions prevent a lateral separation of 10 feet, a sewer may be laid closer than 10 feet to a water main if it is laid in a separate trench and the elevation of the crown of the sewer is at least 18 inches (46 cm) below the invert of the water main.

Whenever sewers must cross under water mains, the sewer shall be laid at such an elevation that the crown of the sewer is at least 18 inches (46 cm) below the invert of the water main. When the elevation of the sewer cannot be varied to meet this requirement, the water main shall be relocated to provide this separation or constructed with mechanical-joint pipe for a distance of 10 feet (3.0 m) on each side of the sewer. One full length of water main shall be centered over the sewer so that both joints will be as far from the sewer as possible.

When it is impossible to obtain horizontal and/or vertical separation as stipulated above, both the water main and sewer shall be constructed of mechanical-joint cement-lined ductile iron pipe or equivalent that is watertight and structurally sound. Both pipes should be pressure tested to 150m psi to ensure that they are watertight.

Pressure Sewer Systems - Wastewater can be conveyed to a pressure sewer using various approaches, such as septic tank effluent pumping (STEP) or grinder pumps. A pressure main is common to both systems. In addition, components such as isolation valves, air release valves, and cleanouts make up a pressure sewer system. The branched configuration of a pressure sewer is similar to that of a conventional gravity sewer system. Pipe routing should include long radial sweeps no less than those recommended by the pipe manufacturer. Pressure piping should be deep, enough to prevent freezing. The diameter of the pressure sewer should be sized to provide a cleansing velocity based on the average daily flow. Use of the equivalent of Class 200, SDR 21 PVC piping or greater should be used in order to provide the necessary working pressure rating for the system.

Air relief valves should be provided at high points in the pressure sewer system to release air trapped in pressure lines. Air relief valves should be located to allow access for repair and maintenance. Automatic air release valves should be considered to reduce operating and maintenance costs. A means should be provided for cleaning out pressure mains at sags and other locations where debris can accumulate and clog the lines.

The pressure system owner should provide in writing how the pumps in the system will operate during a prolonged power outage. The components of a proper emergency plan will be required as part of an Operations & Maintenance plan.

Vacuum Sewer Systems – Vacuum sewers use differential air pressure to create flow. Each home is provided with a vacuum unit, which is equipped with a valve that seals the line leading to the main so that the required vacuum levels can be kept in the main. When a given amount of wastewater accumulates behind the valve, the valve is programmed to open and the wastewater is drawn into a central station. From there, the wastewater is pumped into the transmission system for transport into the treatment facilities.

The vacuum sewer pipelines should be the equivalent of Class 200, SDR 21 PVC piping or greater to provide the necessary working pressure rating for the system, and to provide durability during installation. Piping should be deep enough to prevent freezing.

Vacuum pumps are necessary to produce the vacuum necessary for liquid transport. The optimum operating range in vacuum sewers is 16-20 inches Hg but the pumps should have the capability of providing up to 25 inches Hg. Redundancy is necessary with each pump capable of providing 100 percent of the required airflow.

The vacuum system owner should provide in writing how the pumps in the system will operate during a prolonged power outage. The components of a proper emergency plan will be required as part of an Operations & Maintenance plan.

B. RAW SEWAGE PUMPING STATIONS

General Location - Sewage pumping stations shall be used only where necessary. Pumping stations shall be protected from physical damage and remain fully operational during a 100 year frequency flood. Wherever possible, pump stations for small-scale installation shall be constructed without a superstructure. Pumping stations shall be readily accessible during all weather conditions.

Type - Submersible pumps shall be used whenever possible. Manholes over pumps shall be of a size that will permit removal of pumps via slide-rails without entering the pump chamber. Minimum access diameter of 24 inches (61 cm) shall be provided. Wet wells shall be vented to the atmosphere by means of a vent pipe, extending not less than 15 feet (4.57 m) above the finish grade, attached to a utility pole, or adjacent building, or other appropriate structure. Centrifugal, suction head pumps are allowed provided the pump station consists of separate wet and dry well.

Capacity – The working capacity (between pump-on and pump-off) should provide a holding period not to exceed 10 minutes for the average daily design flow. All pump stations shall have an emergency storage capacity (above the working level) of 6 hours without overflowing or causing backups.

Pump Type - Submersible pumps shall be designed specifically for submerged use in raw sewage. An effective method to detect shaft seal failure or potential seal failure shall be provided. Pumps shall be capable of passing spheres of at least 3 inches (7.62 cm) in diameter. Pump suction and discharge openings shall be at least 4 inches (10.2 cm) in diameter. A full description of the pumps including pump curves shall be provided in the specifications. Discharge openings of 2 inches (5.08 cm) will be allowed in the case of grinder pumps.

Pump Removal - Submersible pumps shall be readily removable and replaceable without dewatering the wet well or disconnecting any piping in the wet well. Pumps shall be mounted on a slide rail for easy removal.

Duplicate Pumps - Duplicate pumping equipment shall be provided. If only two pumps are provided, either shall be capable of handling peak design flows. Where three or more pumps are provided, they shall be designed to fit actual flow conditions and must be so designed so that with any one pump out of service the remaining pumps will have capacity to pump peak design flows.

Level Controls - Level sensing devices shall be located in the wet well so as not to be unduly affected by flows entering the chamber or by the suction of the pumps. Provisions shall be made to automatically alternate the pumps in use. Please see the chapter on Instrumentation Guidance for additional detail.

Alarms - An alarm system shall be provided for all pump stations. The alarm shall be activated in any one of the following cases:

- low water in the wet wells
- high water in the wet well;
- loss of one or more phases of power supply;
- loss of the alarm transmission line; or
- pump failure.

The alarm shall signal at the treatment plant and a facility that is manned 24 hours a day. An automatic dial up capable of dialing several numbers will be accepted as an alternative to the secondary alarm at a manned facility. Please see the chapter on Instrumentation Guidance for additional detail.

Valves - Suitable shut-off valves shall be placed on the discharge lines of each submersible pump. A suitable check valve shall be placed on a horizontal section of each discharge line between the shut-off valve and the pump. A valve pit outside of the wet well shall be provided.

Electrical - Electrical supply and control circuits shall be designed to allow disconnection at a junction box located or accessible from outside the wet well. Terminals and connectors shall be protected from corrosion by location outside of the wet well or by watertight seals and shall be protected by separate strain relief.

Electrical equipment in enclosed areas where explosive gases such as methane and hydrogen sulfide vapors may be present should be corrosive resistant and must comply with the requirements provided in the most recent editions of the National Electric Code for Class I Group D, Division I locations.

Alternate Power - Pump stations shall be equipped with an alternate electrical supply or a permanently installed standby generator sized to operate all electrical components. Where it is infeasible to provide a connection to the treatment plant generator, a separate generator(s) shall be provided. Portable backup generators may only be used for pump stations with pumps of 5 hp or less.

Motor Control - The motor control center shall be located outside of the wet well and protected by a conduit seal or other appropriate sealing method meeting the requirements of the National Electrical Code for Class I, Division 2 locations.

Pump Motor - The pump motor shall meet the requirements of the National Electrical Code for Class I, Division 2 locations.

Pump Removal Hoists - Provisions should be made to remove pumps and motors, including provisions for portable or permanent chain lifts.

Flow Metering - Run-time meters should be installed on the motor control of each pump. A flow-totalizing meter should be installed on the force main just before it exits the pump station structure.

Buoyancy Calculations and Anti-Buoyancy Ballast - In order to assure that the wet well of the pump stations will not float when the wet well is empty and the groundwater level is at grade, buoyancy calculations for all structures of any pump station constructed below grade should be submitted for review. In the event that these calculations determine that anti-buoyancy ballast is needed, the designed should specify on the pump station design plans, the thickness and coverage of the ballast required.

Power Cords - Pump motor power cords shall be designed for flexibility and serviceability under conditions of extreme usage and shall meet the requirements of the Mine Safety and Health Administration for trailing cables. Ground fault interruption protection shall be used to de-energize the circuit in the event of any failure in the electrical integrity of the cable. Power cord terminal fittings shall be provided with strain relief appurtenances, and shall be designed to facilitate field connecting.

Force Main - The minimum diameter of force mains shall be 4 inches (10.2 Diameter cm). Smaller diameters may be allowed where grinder pumps are used.

Velocity - At design flow, a velocity in excess of 2 feet per second (0.61 m/s) shall be maintained.

Air Relief - An automatic air relief valve shall be placed at all relative high points in the force main.

Thrust Blocks - Thrust blocks or other method of joint restraint shall be provided at all bends and changes of direction of the force main.

Termination - Force mains shall enter the gravity sewer at a point not more than 2 feet (0.61 m) above the flow line of the receiving manhole.

Drains - Drain valves shall be placed at all low points in the force main. These valves should be connected to gravity sewers if feasible or provided with connections for vacuum pumps.

Overflows - Overflows and by-passes shall not be provided on pumping stations.

C. PRELIMINARY AND PRIMARY TREATMENT

General - Either septic tank pretreatment or mechanically cleaned (circular or rectangular) settling tanks shall be provided for all small-scale sewage treatment facilities.

Grit removal should be provided for all facilities, either by means of septic tank pretreatment or separate grit removal facilities. This is necessary to protect downstream mechanical equipment.

Septic Tank Pretreatment

Capacity - A septic tank used for pretreatment shall have an effective liquid capacity of not less than 50 percent of the estimated design flow. When garbage grinders are employed or the septic tank is used for sludge storage the effective liquid capacity shall be no less than 75 percent of the estimated design flow. When garbage grinders are employed and the septic tank is utilized for sludge storage, the effective liquid capacity shall be no less than 100 percent of the design flow. Multiple tanks are encouraged for tank sizes greater than 25,000 gallons.

Liquid Depth - The liquid depth of the septic tank shall be a minimum of 4 feet. The septic tank may be rectangular, or square in plan, provided the distance between the outlet and the inlet of the tank is at least equal to the liquid depth of the tank.

Compartments - Multi-compartment tanks with transverse baffles may be used for pretreatment.

Tanks in Parallel - Septic pretreatment tanks may be installed in parallel provided the sewage flow is properly divided such that each tank receives an equal proportion of the total flow.

Construction -Septic pretreatment tanks shall be watertight (type WT) and shall be constructed of reinforced concrete. Tanks and covers shall be designed and constructed so as to withstand an H-20 wheel load. Any tank installed in a location where there is high ground water shall be weighted to prevent the tank from floating when emptied. Buoyancy calculations shall be included on the design plans for any tank with any portion installed below the anticipated high groundwater elevation.

Tees - Inlet and outlet tees shall be of cast-iron, SDR - 35 PVC, or cast-in-place concrete, and shall extend a minimum of 6 inches above the flow line of the septic tank and be on the centerline of the septic tank located directly beneath the clean out manhole. Any piping extending beyond 6 inches (15 cm) from a tank wall shall be properly supported. There shall be an air space of at least 3 inches (7.62 cm) between the tops of the tees and the inside of the tank cover, and the tops of the tees shall be left open to provide ventilation.

Depth of Tees - The inlet tee (baffles are not acceptable) shall extend a minimum of 12 inches (30 cm) below the flow line. The outlet shall be provided with a tee extending below the flow line in accordance with the following table:

Depth of Outlet Tee

Liquid Depth in Tank	Below Flow Line
4 feet	14 inches
5 feet	19 inches
6 feet	24 inches
7 feet	29 inches
8 feet	34 inches
9 feet	39 inches
10 feet	44 inches

Base - Septic tanks shall be installed on a level stable base that will not settle.

Materials - Septic tanks may be constructed of poured reinforced concrete or precast reinforced concrete.

Access Manholes - Septic tanks used for pretreatment shall be provided with at least two 24-inch (61 cm) diameter manholes (over inlet and outlet tees) with metal frames and covers at finished grade. Manhole covers shall be labeled and the type shall be specified in the specifications. Distance between access manholes shall not exceed 15 feet (4.57 m) on center.

Accessibility - Septic tanks shall be located so as to be accessible for servicing and cleaning

Invert Elevation -The invert elevation of the inlet of a septic tank shall be at least 2 inches (5.1 cm) above the invert elevation of the outlet.

Backfill - Backfill around the septic tank shall be placed in such a manner as to prevent damage to the tank and piping.

Groundwater - The invert elevation of the septic tank outlet shall be at least one foot above the maximum ground water elevation. In the case of segmented tanks all joints shall be at least one foot above the maximum ground water elevation.

Mechanically Cleaned Setting Tanks

Inlets - Inlets shall be designed to dissipate the inlet velocity, to distribute the flow equally and to prevent short-circuiting. Channels shall be designed to maintain a velocity of at least one foot per second (30 cm/s) at one-half design flow and to distribute the flow proportionately between parallel units. Corner pockets and dead ends shall be eliminated and corner fillets or channeling shall be used where necessary. Provisions shall be made for easy removal of floating materials in inlet structures having submerged ports.

Scum Baffles - Scum baffles shall be provided ahead of outlet weirs. Baffles shall be constructed of plate steel or other suitable material.

Weirs - Overflow weirs shall be constructed of plate steel or other suitable material. Weirs shall be properly supported and fully adjustable. Multiple weir troughs shall be placed sufficiently far apart to avoid excessive upward velocity between the troughs.

Protective Devices - All settling tanks shall be designed to provide easy access for maintenance and protection to the operator. Such features shall include stairways, walkways and handrails.

Surface Loading Rates - Surface loading rates for mechanically cleaned setting tanks shall not exceed 600 gallons per day per square foot (24 m^3/m^2d) under average flow conditions nor shall the surface loading rates exceed 3000 gallons per day per square foot (122 m^3/m^2d) under peak conditions.

Scum Removal - Provisions shall be made for automatic equipment for scum removal. Provisions shall be made to discharge the scum with the sludge.

Sludge Removal - Removal of sludge from primary settling tanks shall be by direct pump suction. A sludge well shall be provided. All sludge hoppers shall have an individual valved sludge withdrawal line at least 3 inches (7.6 cm) in diameter.

Depth - The liquid depth of mechanically cleaned settling tanks shall not be less than 8.0 feet (2.441.82 m).

Diameter - The diameter of primary settling tanks shall not be less than 8.0 feet (2.4 m).

Tank Material - Primary settling tanks shall be constructed of reinforced concrete or structural grade steel. Steel tanks shall be adequately protected from corrosion through the use of appropriate coating material. Cathodic protection shall be provided for all buried steel tanks.

Foundation Pad - A poured reinforced concrete foundation pad of sufficient design to withstand the structural load of the settling tank under peak operating conditions shall be provided. The foundation pad shall be flat and level. If steel tanks are used, anchoring devices shall be provided to properly secure the settling tank to the foundation pad.

TABLE 4

SUMMARY OF PRIMARY CLARIFIER DESIGN CONSIDERATIONS

Avg. Surf. Load Rate	600 gpd per square foot
Peak Surf. Load Rate	2,000 gpd per square foot[8]
Side Water Depth	8.0 feet minimum
Scum and Sludge Removal:	mechanical at least once per hour
Placement	before equalization
Tank Material	steel or concrete
Base	reinforced concrete
Can Use a Septic Tank	with Inlet/Outlet Tees

[8] If waste activated sludge is cosettled, the peak loading rate will be 1,200 gpd per square foot.

D. FLOW EQUALIZATION

General - Flow equalization shall be provided at all small-scale installations to normalize the flow over a twenty-four (24) hour period. (Note: Larger facilities designed on the basis of both average day and maximum day flows will not be required to provide flow equalization unless otherwise needed for a specific unit operation/process.) Pumps shall normalize flow through the use of timers and not floats. Float controls for pump activation shall only be utilized for high and low water alarm events or to prevent overflow conditions.

Location - The flow equalization tank shall be located after the primary settling tank(s) and prior to all other treatment processes.

Capacity - The flow equalization tank shall have an adequate effective liquid capacity to accommodate variations in the influent flow rate when the effluent is pumped (or gravity flow is controlled) at a constant rate equal to the average design flow for the facility. For treatment plants serving residential developments with design flows of less than 40,000 gallons per day (151 m^3/d) the flow equalization tank shall have a minimum effective liquid capacity of fifty (50) percent of the design flow. For treatment plants serving residential developments with design flows between 40,000 and 100,000 gallons per day (151 - 379 m^3/d) the flow equalization tank shall have a minimum effective liquid capacity of thirty-three (33) percent of the design flow. For treatment plants serving residential developments with design flows greater than 100,000 gallons per day (379 m^3/d) the flow equalization tank shall have a minimum effective liquid capacity of twenty-five (25) percent of the design flow. Smaller or larger capacity flow equalization tanks may be warranted for nonresidential uses depending on the expected variations in sewage flow rates.

Construction - The flow equalization tank shall be watertight and shall be constructed of reinforced concrete. The tank and covers shall be designed and constructed so as to withstand an H-20 wheel load. Any tank installed in a location where there is high ground water shall be weighted to prevent the tank from floating when emptied. Buoyancy calculations shall be included on the design plans for any tank with any portion installed below the anticipated high ground water elevation.

Base - The flow equalization tanks shall be installed on a level stable base that will not settle.

Material - The flow equalization tank may be constructed of poured reinforced concrete or precast reinforced concrete.

Access Manholes - The flow equalization tank shall be provided with at least two 24-inch (61 cm) diameter manholes (over inlet and tank center) with metal frames and covers at finished grade. Additionally a double leaf, hinged pump access frame and lid at grade, large enough to accommodate the removal of pumps without entering the tank, shall be provided over the flow equalization pumps. Distance between access manholes shall not exceed fifteen feet (4.57 m) on center.

Accessibility - The flow equalization tank shall be located so as to be accessible for servicing and cleaning.

Backfill - Backfill around the flow equalization tank shall be placed in such a manner as to prevent damage to the tank and piping.

Groundwater - The invert elevation of the inlet and outlet and any joint of the flow equalization tank shall be at least one foot (0.3m) above the maximum ground water elevation.

Pumps - The flow equalization tank shall be equipped with at least two (2) submersible sewage pumps. Pumps shall be non-clog or grinder type. The design criteria for pump removal, level controls, alarms, valves, electrical, motor control, pump motor, and power cords, shall be the same as those listed under sewage pump stations. Centrifugal suction lift pumps may be used provided a separate dry well is provided or the pumps are located within the treatment plant building. Air lift pumps are also acceptable. Gravity flow through the equalization tank should be considered where the hydraulics permit.

E. SECONDARY TREATMENT PROCESSES

The following processes are commonly used for biological wastewater treatment. However, this is not a complete list of technology, and the Department will consider other processes on a case-by-case basis.

Rotating Biological Contactor

General: The Rotating Biological Contactor (RBC) process is the biological treatment system most commonly used at small-scale installations in Massachusetts. Its popularity is attributed to its ease of operation, ability to withstand shock loadings both hydraulically and organically and its low operating costs.

Bases of Design: The basis of design for the RBC process is typically pounds per day of soluble BOD_5 applied per 1,000 square feet (lbs BOD_5/day/1,000 sf) of available surface area. Soluble BOD accounts for approximately fifty (50) percent of the total BOD_5 of sanitary sewage.

Organic Loading: The total amount of media surface area required shall be calculated on the following basis:

Effluent Limit	Organic Loading
30 mg/l BOD_5	≤ 1.8 lbs soluble BOD_5/day/1000 sf
20 mg/l BOD_5	≤ 1.25 lbs soluble BOD_5/day/1000 sf
10 mg/l BOD_5	≤ 0.825 lbs soluble BOD_5/day/1000 sf

The required surface area shall be increased by (50) percent for systems with septic tank pretreatment.

Nitrification: Where nitrification is desired additional surface area shall be provided. The amount of additional surface area required for nitrification shall be calculated on the basis of 0.2-0.4 pounds per day of ammonia removed per 1,000 sf of available surface area (lbs ammonia removed/day/1000 sf) depending on the required effluent concentration. A typical design value is 0.24 lbs. Ammonia removed/day/1000 sf.

Actual influent wastewater characteristics (or in the case of new construction, experience from similar establishments) must be provided for facilities that generate higher than expected amounts of nitrogen such as schools and office parks.

Temperature: Wastewater temperatures below 55° F (13°C) will result in a reduction of biological activity and in a decrease in BOD removal. Temperature corrections shall be made using the appropriate manufacturer's correction factors for installation where the wastewater temperature is expected to fall below 55° F (13°C).

Effects of temperature should be examined in cases where the detention time of wastewater preceding the RBC unit is excessive resulting in heat loss or in cases where pre-treatment tanks are susceptible to ambient temperatures. In such cases provisions to heat the wastewater may be necessary.

Bucket Feed Well: Some RBC units employ a bucket feed well to convey wastewater to the RBC via rotating buckets with a varying number of plugs. In these cases the number of buckets and plugs utilized must be determined at design flow. The flowrate of the buckets cannot exceed the allowable loading rate of the RBC unit.

Floats and alarms must be provided in the bucket feed well if preceded by a pump station. Any pumping to a bucket feed well shall be designed as to prevent the need for an overflow pipe.

Stage: Media shall be arranged on the shaft in groupings or stages. Staging is used in order to maximize the effectiveness of a given amount of media surface area in addition to eliminating short-circuiting and dampening shock loadings. Baffles shall be provided within the tank to separate stages.

First Stage Organic Loading: First stage organic loadings shall not exceed 4.0 pounds soluble BOD5/day/1000 sf.

Number of Stages: A minimum of three (3) stages shall be provided. Where nitrification/denitrification is required a minimum of four (4) stages shall be provided. In such cases provisions shall be included to recirculate a portion of the flow from the denitrification unit back to the fourth RBC stage to enhance the nitrification/denitrification process.

Recirculation: Provisions must be provided for piping to recirculate effluent from the RBC unit(s) to either the headworks, pretreatment septic tank, or to the beginning of the RBC unit(s).

Tank Volume: The tank liquid volume-to-media surface area shall not be less than 0.12-gallons/square foot (0.0049 m3/m2).

Media Submergence: At least forty (40) percent of the media shall be submerged at anytime.

Tank Material: Tanks shall be constructed of structural grade steel or reinforced concrete. Steel tanks shall be provided with a protective coating of coal tar epoxy, or other suitable covering to protect against corrosion.

The tank configuration shall be shaped to conform to the general shape of the media to eliminate dead spots where solids could settle and cause septic conditions and odors.

Underdrains or another means of removal of solids, which may settle out in the tank, must be provided.

Enclosure: All RBC units shall be enclosed in a building. If the RBC unit is proposed to be enclosed within a fiberglass cover located outside a building then sufficient heating and ventilation must be provided.

pH control Alkalinity control: Treatability of wastewater is dependent on the pH level and the alkalinity especially when dealing with nitrification. Provisions must be included for at the head of the RBC unit(s) for chemical addition for controlling pH and alkalinity.

Media Material: Media shall be constructed of polyethylene containing UV inhibitors or other suitable plastic materials properly supported on the shaft to withstand the load of the biological growth.

Media shall not be exposed to direct sunlight to prevent growth of algae.

Shaft Material: RBC shafts shall be fabricated from structural steel and provided with a heavy protective coating of coal tar epoxy suitable for water and high humidity service. Shafts shall be capable of withstanding the expected stresses without failure for at least a twenty (20) year design life.

Drive Units: RBC units shall be equipped with the necessary motor drive assembly and bearings to obtain a constant rotation of the shaft and media sufficient to maintain a peripheral speed of at least (60) feet per minute (18.3 m/minute).

Foundation Pad: A poured reinforced concrete foundation pad of sufficient design to withstand the structural load of the RBC tank and appurtenances, under peak operating conditions shall be provided. The foundation pad shall be flat and level.

Sampling: Sampling provisions for process control and compliance monitoring shall be incorporated into the system. It is recommended that sampling ports be included for influent, effluent, and within any recycle lines. Sampling locations shall be clearly labeled on the plans.

Splash Guards: These are to be included in the design.

Table 5
Summary of Rotating Biological Contactor Design Considerations

Total Maximum Organic Loading	1.25 lbs. soluble BOD_5/day/1000 sf.
1st Stage Maximum Organic Loading	4.0 lbs. soluble BOD_5/day/1000 sf.
Wastewater Temperature	Corrections for T < 55°F
Rotational Speed	60 ft/min peripheral velocity
Submergence	40%
Configuration	3 stages minimum
Tank Volume	0.12 gallons/sf media
Tank Material	Coated steel/reinforced concrete
Tank Base	Reinforced concrete
Media Material	Polyethylene copolymer
Shaft	Coated/structural steel
Drive	Gear/chain/belt

Activated Sludge

General: The activated sludge process and its various modifications have proven to be an effective treatment technology. It should be noted; however, that these processes require close attention and competent operating supervision, including routine laboratory control. These requirements should be considered when proposing these treatment processes.

A number of modifications of the activated sludge process have been developed, some of which are referred to herein. To allow for proper responses to varying plant loading and process demands, aeration tanks should, wherever possible, have the capability to change mode of operation from plug flow, to step feed, to contact stabilization.

Tank Capacities: Aeration tank capacities and permissible loadings for the several adaptations of the activated sludge process are shown in Table 6.

Tank Arrangement: The dimensions of each independent mixed liquor aeration tank or return sludge reaeration tank shall be such as to maintain effective mixing and utilization of air. Ordinarily, liquid depths should not be less than six (6) feet (1.82 m).

Tank geometry may affect aeration efficiency especially if diffused air is employed. The width of the tank in relation to its depth is important if spiral-flow mixing is used in a plug-flow configuration. The width-to-depth ratio for such tanks should be between 1.0:1 and 2.2:1.

Table 6
Aeration Tank Capacities and Permissible Loadings

Process	Average Organic Loading (lbs. BOD_5/1000 cf/day)
Conventional	30
Step Feed Aeration	30 – 50
Contact Stabilization	30
Extended Aeration	12.5 – 17

Tank Material: Aeration tanks shall be constructed of reinforced concrete or structural steel. Steel tanks shall be provided with a protective coating of coal tar epoxy, or other suitable covering. For aboveground steel tanks, anodes shall be installed for galvanic protection. For very small tanks, the shape of the tank and the installation of aeration equipment shall provide for positive control of short-circuiting through the tank.

Drains or sumps for aeration tanks are desirable for dewatering.

Foundation Pad: A poured reinforced concrete foundation pad of sufficient design to withstand the structural load of the aeration tank and appurtenances under peak operating conditions shall be provided. The foundation pad shall be level and flat. Anchoring devices shall be provided to properly secure the aeration tank to the foundation pad.

Inlet and Outlet Controls: Inlets and outlets for each aeration tank unit shall be suitably equipped with valves, gates, stop plates, weirs, or other devices to permit controlling the flow to any unit and to maintain reasonably constant liquid level.

For multiple tank configurations the flow must be equalized to each tank through splitter boxes equipped with weirs or control valves or influent control gates.

The valving shall provide the ability for individual tanks to be removed from service for inspection and repair. The common walls of multiple tanks must therefore be able to withstand the full hydrostatic pressure from either side.

Conduits: Channels and pipes carrying liquids with solids in suspension shall be designed to maintain self-cleansing velocities.

Freeboard: All aeration tanks shall have a freeboard of not less than eighteen (18) inches (46 cm). Suitable water spray systems or other approved means of froth and foam control shall be provided.

Mixing: The aeration tanks shall have sufficient mixing to prevent solids deposition in all areas of the tank. Fillets shall be provided around the bottom of aeration tanks where the walls and bottoms meet.

Aeration Equipment:

Aeration equipment shall be capable of maintaining a minimum of 2.0 mg/l of dissolved oxygen in the mixed liquor at all times and providing thorough mixing of the mixed liquor.

A separate means of mixing and aeration shall be employed utilizing any combination of mechanical aerators, coarse air or fine bubble diffusers, and anoxic mixers so that so that aeration can be adjusted independently without affecting mixing characteristics.

Return Activated Sludge (RAS):

The importance of the return of activated sludge is to maintain a sufficient concentration of activated sludge in the aeration tank so that the required degree of treatment can be obtained in the time interval desired.

The configuration of the piping from the secondary clarifier to the aeration basin is dependent upon the type of activated process: conventional plug-flow, step-feed aeration, or extended aeration. Ample return sludge pump capacity shall be provided. Return sludge pumping capacities of 50 to 150 percent of the wastewater flowrate are required. All piping of RAS shall be valved accordingly to isolate any pipe section and distribute the RAS in varying configurations.

Flow meters and sampling provisions for process control shall be provided on all RAS lines.

Waste Activated Sludge (WAS):

The excess activated sludge produced each day must be wasted to maintain a given food-to-microorganism ratio or mean cell residence time. The waste sludge may be discharged to a dedicated sludge holding tank or to the primary settling tank.

A flow meter shall be provided on the WAS line.

pH control Alkalinity control:

Treatability of wastewater is dependent on the pH level and the alkalinity especially when dealing with nitrification. Provisions must be included for chemical addition for pH and alkalinity control throughout the aeration tank.

Air Requirements: The aeration equipment should be sized to maintain minimum DO levels of 2 mg/l under maximum organic and nitrogen loadings or mixing requirements, whichever governs.

Oxygen Transfer: The air requirements assume equipment capable of transferring at least 1.0 lbs of oxygen to the mixed liquor per pound of BOD_5 aeration tank loading (1kg O_2/kg BOD_5) and, when nitrification is required, 4.2 lbs. of oxygen per pound of ammonia nitrogen oxidized. . To these air volume requirements shall be added air required for channels, pumps or other air-use demand.

Blower Capacity: The specified capacity of blowers or air compressors should take into account that the air intake temperature may reach 104° F (40 °C) or higher and the pressure may be less than normal.

Motor Capacity: The specified capacity of the motor drive should also take into account that the intake air may be -22°F (-30°C) or less and may require over sizing of the motor or a means of reducing the rate of air deliver to prevent overheating or damage to the motors.

Blowers: The blowers shall be provided in multiple units, so arranged and in such capacities as to meet the maximum air demand with the single largest unit out of service. The design should also provide for varying the volume of air delivered in proportion to the load demand of the plant. The discharge line from the blower shall be equipped with an air relief valve, which protects the blower from excessive backpressure and overload.

Piping from the blower unit should be designed in order to keep vibration to a minimum and to allow for heat expansion.

For multiple blower units a check valve is recommended following a blower unit, which can be used for air flow regulation and which can be closed to prevent the blower from operating in reverse should other blowers in the same system be operating while any one blower is off line. Air filters shall precede any blower unit.

Diffuser and Piping: The air diffusion piping and diffuser system shall be capable of supplying peak diurnal oxygen demand or 200 percent of the normal air requirements, whichever is larger. The spacing of diffusers should be in accordance with the oxygenation requirements through the length of the channel or tank, and should be designed to facilitate adjustments of their spacing without major revision to air header piping. Unless multiple tanks are provided, the arrangement of diffusers should also permit their removal for inspection, maintenance and replacement without dewatering the tank and without shutting off the air supply to other diffusers in the tank.

The piping should be sized so that losses in headers and diffuser manifolds are small in comparison to the losses in the diffusers.

High temperatures of air discharge are expected necessitating the need for incorporating provisions for pipe expansion and contraction.

For diffused aeration systems an electric or mechanical hoist shall be provided to raise the header/diffuser components for servicing.

Alarms: Alarms, which signifies overheating, or high oil temperature shall be provided.

Valves: Individual assembly units of diffusers shall be equipped with control valves, preferable with indicator markings for throttling, or for complete shut off. Diffusers in any single assembly shall have substantially uniform pressure loss.

Filters: Air filters shall be provided in numbers, arrangement, and capacities to furnish at all times an air supply sufficiently free from dust to prevent damage to the blower and clogging of the diffuser system used.

Silencers: Intake and discharge silencers should be provided to minimize nuisance noise from blowers.

Sampling: Sampling provisions for process control and compliance monitoring shall be incorporated into the system. It is recommended that sampling ports be included for influent, effluent, and within the return activated sludge lines.

Safety: All exposed tanks shall have handrails along the perimeter.

F. SECONDARY CLARIFICATION

General: Secondary clarifiers shall be circular or rectangular. Hopper, and scoop-type clarifiers will not be approved, nor will scum skimmers that depend upon surface velocity created by the removal device. The use of plate settlers may be allowed on a case-by-case basis. Sizing is based on solids loadings, sludge settling, settled sludge concentration, and return sludge rates. Clarifier design based solely on standard overflow rates can lead to improperly designed clarifiers if not based on the above parameters.

Inlets: Inlets shall be designed to dissipate the inlet velocity, to distribute the flow equally to prevent short-circuiting, minimize sludge-blanket disturbance, and promote flocculation. Channels shall be designed to maintain a velocity of at least one (1) foot per second (30 cm/s) at one-half (½) design flow and to distribute the flow proportionately between parallel units. Corner pockets and dead ends shall be eliminated and corner fillets or channeling shall be used where necessary. Provisions shall be made for easy removal of floating material in inlet structures having submerged ports.

Baffles: Scum baffles shall be provided ahead of outlet weirs.

Weirs: Overflow weirs shall be constructed of plate steel or other suitable material. Weirs shall be properly supported and fully adjustable.

Solids Loading Rate: The peak solids loading is based on the design MLSS under aeration and the maximum daily flow rate plus the corresponding recycling rate required to maintain the design MLSS. It can also be calculated by dividing the total solids applied by the surface area of the tankage. Since the solids loading rate is impacted by the particular characteristics of the sludge, the effluent quality can deteriorate if the rate is excessive. Without the benefit of experimental testing, the designer should be conservative in the choice of rates (Tables 7 & 8).

Surface Overflow Rate: Surface overflow rates for secondary clarifiers shall not exceed those values listed in Table 8. Peak surface overflow rates with one unit out of service shall not exceed 1,000 gallons per day per square foot (41 m^3/m^2) regardless of the treatment process; however, for clarification following extended aeration process the peak surface overflow rate shall not exceed 700 gallons per day per square foot. If chemical addition for phosphorus removal is added, then the peak surface overflow rate shall not exceed 600 gallons per day per square foot.

Scum Removal: Provisions shall be made for automatic equipment for scum collection and removal. Provisions shall be made to discharge the scum with wasted sludge.

Sludge Removal: Sludge removal from the secondary clarifier shall be accomplished with the use of appropriate scrappers and/or appropriate suction devices. A sludge well shall be provided. All sludge hoppers shall have an individual valved sludge withdrawal line at least 3.0 inches (7.6 cm) in diameter. Sludge removal shall be controlled by the use of adjustable timers. Timers shall be capable of being adjusted from continuous operation to intermittent operation with sludge removal as infrequent as once per hour for three minutes. Positive displacement or airlift type pumps shall be provided. Rapid sludge return systems are recommended in the case of activated sludge processes.

Sludge and scum collection and withdrawal facilities shall be designed so as to minimize density currents and assure the rapid removal of accumulated solids.

Drive Units: Secondary clarifiers shall be equipped with motor and drive assemblies to rotate the sludge scrapper and surface skimmer arms. A torque limiter shall be provided between the output drive and the main collector drive shaft. Torque overload shall activate a malfunction alarm. As an alternative to the torque limiter, a second torque overload set point could be used to shutdown the drive motor.

Depth: The liquid depth of secondary clarifiers shall not be less than 10 feet (3.05 m).

Diameter: The diameter of secondary clarifiers shall not be less than 8.0 feet (2.4 m).

Tank Material: Secondary clarifiers shall be constructed of reinforced concrete or structural grade steel. Steel tanks shall be adequately protected from corrosion through the use of appropriate coating material.

Foundation Pad: A poured reinforced concrete foundation pad of sufficient design to withstand the structural load of the clarifier, under peak operating conditions shall be provided. The foundation pad shall be flat and level. Anchoring devices shall be provided to properly secure the clarifier to the foundation pad.

Access: The secondary clarifiers shall be designed and installed so that there is a ready and convenient access to the motor and drive assemblies for proper inspection and maintenance. A stairway or ladder, service walkway and handrails shall be provided.

Table 7

Permissible Overflow Rates for Secondary Clarifiers at Average Design Flow

Process	Surface Settling Rates (gal/day/sf.)	Solids Loading Rates (lb/hr/sf)
Rotating Biological Contactor: Secondary effluent Nitrified effluent	 600 500	 0.8-1.2 0.6-1.0
Air Activated Sludge (excluding Extended Aeration)	600	0.8-1.2
Oxygen Activated Sludge	600	1.0-1.4
Extended Aeration	300	0.2-1.0

Table 8

Secondary Clarifier Design Considerations

Average Surface Overflow Rate	Varies, typically 500 gpd/sf (see Table 7)
Peak Surface Overflow Rate	< 1,000 gpd/sf (< 700 gpd/sf for extended aeration)
Average Solids Loading Rate	Varies (see Table 7)
Peak Solids Loading Rate	<2.0 lb/hr/sf (<1.4 lb/hr/sf for extended aeration)
Side water depth	10 feet min.
Scum and Sludge Removal	Continuous/intermittent
Configuration	# of units/location
Tank material	Coated steel/concrete
Base	Reinforced concrete

Please note that in the above tables consideration must also be given to the concentration of MLSS in the aeration tanks. Higher MLSS results in a lower overflow rate. Additionally, the use of selectors will limit filamentous organisms and produce a better settling sludge.

G. NITROGEN AND PHOSPHORUS REMOVAL

NITROGEN REMOVAL

Total Nitrogen consists of Total Kjeldahl Nitrogen (TKN) that is a combination organic and Ammonia nitrogen (NH_3), Nitrite-nitrogen (NO_2-N) and Nitrate-nitrogen (NO_3-N). Raw wastewater typically has nitrogen in the form of TKN (ammonia nitrogen and organic nitrogen). Common concentrations for domestic wastewater are about 45 mg/l for TKN. Schools, roadside rest facilities and office parks can have influent TKN concentrations above 100 mg/l. Systems should be designed according to what the actual concentrations are. Nitrification (the conversion of NH_3 to NO_2-N and then NO_3-N) works best when wastewater flows through at a constant flow: thereby necessitating the need for flow equalization. Below are factors that should be considered when designing a nitrification system:

1. Temperature – Nitrification growth rates are affected by temperature. When temperatures drop below 12 degrees Celsius nitrification can be inhibited or reaction rates significantly slowed. If nitrification is needed year round the treatment units should be enclosed or designed larger to account for slower reaction rates.

2. pH – The nitrification process is affected by pH. The optimum pH range for nitrification is generally 6.5 to 8.5 standard units. For denitrification the optimum pH range is 7.0-8.0. Nitrification consumes alkalinity so a bicarbonate alkalinity concentration in a wastewater is important. Effluent alkalinity in nitrification systems must be maintained at 50 mg/l or higher. Denitrification will add alkalinity back to the wastewater. If alkalinity is low to begin, or the wastewater has high ammonia-nitrogen concentrations such as observed in schools and office parks, pH control will be needed.

3. Aeration – Aeration systems that conduct nitrification must have an ability to vary the amount of oxygen. Dissolved oxygen concentrations must be a minimum of at least 1-2 mg/l for nitrification to occur.

DENITRIFICATION

Denitrification occurs when the nitrate nitrogen ($N0_3$-N) in nitrified effluent is converted to nitrogen gas under anoxic conditions. . It is important to make sure complete nitrification has occurred prior to denitrification. An outside source of carbon is often needed. Denitrification can occur using fixed media or suspended growth systems. Fixed media treatment is usually anoxic RBC's and denitrification filters. Suspended growth systems are usually the construction of one or more anoxic chambers either before or after the nitrification process. Anoxic units before nitrification will require large recirculation rates. When methanol is used as a carbon source, all denitrificaton systems must include reaeration to remove excess methanol. Since this aeration can create a scum layer, a scum baffle must be provided to reduce carry-over to subsequent treatment units.

ATTACHED GROWTH DENITRIFICATION SYSTEMS

1. RBC – The RBC shall be submerged in the effluent. The loading rate shall be 1.0 lbs NO_3-N/day/1000 square feet. Methanol or another carbon source shall be added prior to the unit.

2. Denitrification filters – Denitrification filters shall consist of media, an underdrain and a backwash facility. The media shall be large round sand with an effective size of 1.8-2.3 mm, a sphericity of 0.8-0.9 and a specific gravity of 2.4-2.6. The media shall be 4-6 feet in depth. The loading rate shall be 1 gpm/sq ft and the time to travel through should be approximately 30 minutes. The air/water backwashing shall be 5-10 minutes at a rate of 6-8 gpm/sq/foot. Air scouring is 5-6 cfm/sq/ft. The rate should not be too large to cause air to be trapped in the media. Backwashes should occur every one to five days. Backwashing too often will cause air entrainment within the media and the filter not to be anoxic. Every one to six hours the denite filter should have a nitrogen release cycle where water is run through the filter to release the nitrogen gas and air. This is a water only wash at a rate of 5 gpm/sq/ft for up to 5 minutes.

3. Carbon addition – Attached growth denitrification systems will require an additional carbon source added prior to the unit. The use of raw effluent is often ineffective in these systems. Methanol is the most common carbon source. Methanol addition shall be flow paced so that methanol is not added when flow is not passing the unit. Additional methanol will cause BOD violations in the effluent and a scum layer build up in the clear well of the denite backwash filter.

SUSPENDED GROWTH DENITRIFICATION SYSTEMS

1. Anoxic zones – Anoxic zones are areas or tankage where the nitrified effluent from an aeration process passes through. Dissolved oxygen in these tanks shall be 0.2 mg/l or less. These zones will need a submerged mixer to prevent solids from settling. Care must be used to prevent aeration from occurring. A carbon source is added prior to the anoxic zone. The carbon source is often methanol, but can be raw wastewater if the anoxic zone precedes the aeration system. Anoxic zones shall be sized based on denitrification requirements, temperatures, and appropriate denitrification rates or selector volume requirements, whichever governs.

   a. Anoxic Zone Pre-aeration – When the anoxic zone precedes the aeration process, the raw wastewater entering the zone is often used as a carbon source. A supplemental carbon source such as methanol should also be present if the BOD:N ratio is not adequate. This set up requires the wastewater from the aeration tank to be recycled back to the head of the anoxic zone at a rate of up to four or more times the design flow.

b. Post-aeration – When the anoxic zone is after aeration the zones are often divided into two sections with the first compartment having a DO approximately 0.5 mg/l and the second compartment with a DO approximately 0.2 mg/l. Mixers keep the solids in suspension. Sludge and (or) methanol can be added to the first anoxic zone as a carbon source.

2. Post aeration – After the wastewater has been denitrified in suspended solid anoxic zones, the wastewater must be aerated to remove excess methanol.

PHOSPHORUS REMOVAL

Phosphorus is present in raw wastewater at typical concentrations of 6-12 mg/l. A typical biological treatment unit will remove at least 2 mg/l of phosphorus. To remove additional phosphorus there is biological phosphorus removal that takes a specific design and closer operator control, or chemical addition. The most common form of chemical addition is a Metal Salt Chemical Addition that forms an insoluble precipitate with orthophosphate. Phosphorus removal efficiencies decrease in cold weather due to decreased settleability of chemical flocs. Chemical addition of metal salts can lower pH levels in the effluent to concentrations below permit limits so pH control may be required. Very low concentrations may also require the addition of polymer to aid in chemical floc settling.

CHEMICAL PHOSPHORUS REMOVAL

If phosphorus concentrations less than 1.0 mg/l are required and metal salt chemical addition is proposed, the following shall be included in the design:

1. Two-point chemical addition – Metal Salts shall be added prior to the primary pretreatment unit and before the final clarifier. The addition of the chemicals shall be flow paced and the chemical shall have adequate a good turbulent mixing zone of at least 30 seconds travel time with the wastewater so a floc can be formed between the chemical and the wastewater.
2. Polymer Addition – Design for addition of polymer to the wastewater in addition to the metal salt addition to aid in settling of inorganic solids in the clarifiers. Inorganic solids may carry over to the RBC or final sand filter if polymer is not added. Inorganic solids going to an RBC will result in a biofilm layer that will interfere with normal treatment.
3. pH control – Metal Salts will drop the pH in the effluent and bring the facility out of compliance with permit limits.
4. Effluent polishing – A filter will be required after flocculation and settling to remove remaining suspended solids.

5. Solids handling – Chemical addition for phosphorus removal can double the amount of sludge handled at the facility. The sludge storage tanks shall be sized as large as possible to accommodate the additional sludge. In addition, the clarifiers should have lower loading rates, <600 gpd/sq.ft to aid in the settling of the sludge.
6. The Suspended Solids concentrations must be 15 mg/l or less. The treatment system should be designed for stricter TSS removal.
7. Eye Wash and Emergency showers should be located close by. Hand and face protection will be required when handling.
8. Sludge streams must be treated to prevent removed phosphorus from being released from the sludge. Phosphate release occurs from sludge when there are changes in pH, in the redox condition or in anoxic or anaerobic conditions. Additional storage facilities other than the pretreatment tank will be necessary to prevent phosphorus release.
9. For facilities using ultraviolet (UV) light for disinfection, the use of iron salts is discouraged as they produce fouling of the quartz jackets. This leads to an accumulation of scale over the wetted surface of the quartz jacket and will impede radiation transmission.
10. For facilities using aluminum salts, care should be taken to insure that their addition will not lead to a violation of effluent standards for aluminum.

Their are three main chemicals used for Chemical Precipitation of Phosphorus in Wastewater; Aluminum, Ferric iron or Lime. Each has different handling issues. Look for the following in the designs:

1. Aluminum Sulfate (Alum)
   a. The pH of Alum is 3.0-3.5 so pH control will be needed afterwards.
   b. Corrosive when wet. All storage bins and piping should be constructed with stainless steel, fiberglass-reinforced plastic, PVC or other plastics, or concrete tanks.
   c. Shall be stored and added at temperatures 25 degrees F and above to prevent crystallization.
   d. Works best at wastewater pH of 5.5-6.5.

2. Sodium Aluminate
   a. Formation of NaOH increases pH. This is a strong caustic and is not corrosive.
   b. Shall be store and used within three months. Dry Aluminate deteriorates with exposure to the atmosphere.
   c. Store in stainless Steel or concrete. Avoid alloys, rubber and aluminum parts.

3. Ferric Chloride
   a. Has a pH of 2.0 and is <u>very</u> corrosive. Will require pH control.
   b. Corrosive, use steel lined with rubber or plastic or synthetic resin storage tanks.

c. Stored in heated building or in heated tanks to prevent crystallization.
d. Pump component should be constructed of graphite or rubber lined pumps with Teflon seals. Metering pumps are typically of the positive displacement type, either diaphragm or plunger.
e. Piping, use steel lined with Saran, FRP or plastics. Valves should be rubber or resin lined diaphragm valves, Saran lined valves with Teflon diaphragms, rubber sleeved pinch valves or plastic ball valves.
f. Works best at wastewater pH of 4.5-5.0.

4. Ferrous Chloride
   a. Corrosive. Same storage, pumping and piping as Ferric Chloride.
   b. Precipitation will not occur until ferrous ion is oxidized to ferric ion.
   c. Works best at wastewater pH of 8.0.

5. Ferrous Sulfate.
   a. Acidic when dissolved in water.
   b. Phosphorus precipitation does not occur until ferrous ion is oxidized to ferric ion.
   c. Oxidizes and hydrates in moist air. Must be kept in dry area and out of humidity.
   d. Will cake up at storage temperatures greater than 68 F, must be kept cool.
   e. Storage containers may be constructed of concrete, synthetic resin or steel lined with asphalt, rubber, PVC or chemically resistant resins.
   f. Works best at wastewater temperature of 8.0.

6. Lime (Calcium Carbonate)
   a. Creates significant increases in sludge up to 2-3 times the normal amount generated.
   b. Must be added till pH is up around 10. This often causes the biological upsets in treatment facilities.
   c. Phosphorus is released under anaerobic conditions. Sludge handling must be addressed.

7. Polymer – dry or liquid form
   a. Used in conjunction with aluminum and iron salts to assist in flocculation and settling of metal phosphate floc.
   b. Added at least 10 seconds after metal salt addition, preferably 2-5 minutes later.
   c. Dry polymers require mixing and aging before use. Liquid polymers can be used immediately.
   d. Must be stored in cool, low humidity areas. Storage tanks are FRP, type 316 stainless steel, or plastic lined steel tanks.
   e. Do not store polymer for a long time, three days after dry solution is mixed.

BIOLOGICAL PHOSPHORUS REMOVAL

Biological phosphorus removal occurs when wastewater is cycled through alternating anaerobic and aerobic conditions. Wastewater sludge must first pass through an anaerobic condition where bacteria release stored phosphorus. The wastewater then passes through an aerobic phase where bacteria store excess phosphorus in their cells. Design calculations shall show the sludge retention time, the anaerobic contact time and the aerobic detention time.

References:

1. EPA Design Manual Phosphorus Removal, EPA/625/1-87/001, September 1987
2. EPA Manual Nitrogen Control, EPA/625/R-93-010, September 1993
3. Sedlak, Richard. Phosphorus and Nitrogen Removal from Municipal Wastewater, Principles and Practice, Second Edition.1991. Lewis Publishers, New York.

H. FILTRATION

There are three main filtration treatment technologies in the market. They are sand filtration, cloth filtration and microfiltration. Cloth filtration and microfiltration are both proprietary methods and it is up to the manufacturer to properly size the units for the design of the WWTF. Below is sampling of what should be looked for when reviewing the designs:

1. SAND FILTRATION – Sand Filtration consists of upflow or downflow sand filters. The filters consist of sand media overlying air scour and backwash lines. Units also contain a clear well of treated effluent to backwash the filters and a method to pump or flow the backwash water back to the headworks. Sand filters shall have dual units so that as one unit is backwashing, the other unit shall be able to handle the flows. Design should not exceed a loading rate of 5-gpd/square foot at peak flow. Backwashes shall be on timers and be float activated if the filter gets clogged before its allotted backwash occurs. The clear well shall contain at least enough water for a complete backwash and shall have a permissive float that will not allow a backwash to occur unless there is enough water. Automatic backwash filters, where the filter is backwashed continuously, can also be used. In this system, the filter is divided into cells, and each cell is individually backwashed by the traveling bridge, which continuously moves over the length of the filter and positions itself over the cell that is to be cleaned. This method of backwashing does not require the entire filter to be taken out of service for cleaning, reduces the headloss through the filter, and reduces the washwater flowrate which in turn will eliminate the need for a washwater collection and equalization basin.

2. CLOTH FILTRATION – Cloth filtration consists of cloth discs. The discs have the ability to spray off particulate matter and backwash. The spray water should be disinfected prior to spraying on the media.

3. MICROFILTRATION – Microfiltration is composed of small microfilter membranes with small pores where wastewater filters through. The membranes must be located in a continuously aerated tank, backwashed hourly and have periodic cleaning in a soak tank every one to four months. Studies have shown that the use of membranes works best when there is grit removal at the headworks and Sludge Retention Times of 25 days or more in the aeration system. Having an SRT less than 25 days causes more fouling and the need for more membranes to account for the increase in maintenance and reduced efficiency of the membranes. Membrane technology should always be overdesigned to account for one or more systems being cleaned and backwashed.

I. OTHER ADVANCED TREATMENT PROCESSES

SEQUENCING BATCH REACTORS

The Sequencing Batch Reactor (SBR) is a suspended growth biological treatment system. As opposed to a conventional activated sludge system where aeration and clarification are carried out simultaneously in separate tanks, in an SBR system the processes are carried out sequentially in the same tank.

In the SBR, there are five steps that are performed in sequence:

- Fill – mixing and/or aeration occur as necessary for biological oxidation
- React – mixing and/or aeration occur as necessary for biological oxidation
- Settle – mixing and aeration terminated. Biomass settles
- Decant – Treated effluent removed
- Idle – Reactor ready to be placed back in service to receive effluent

Completion of all of these steps is referred to as a cycle. The cycle times can vary but generally there are 4 to 6 cycles per tank per day. Additionally, the times of each step within a cycle can be varied depending on the treatment objective. Solids' wasting is typically done at the end of the settle period. Following the decant period, the liquid and biomass remaining in the reactor constitutes the biomass recycle for the next cycle. Therefore, a return activated sludge system (RAS) is not needed.

Because wastewater is only fed during the fill step, a minimum of two reactors is necessary for continuous operation. When one reactor is filling, the other is completing the other steps in the cycle. SBR systems will also require an effluent equalization tank of sufficient size to maintain a constant flow to downstream units, since treated wastewater is withdrawn only during the decant step. (Note: There are several proprietary designs that allow for the continuous addition of influent, including settling and decant. This would permit the operation in a single-tank mode if one reactor were taken off-line. If proposed, please review tank sizing, influent piping and baffle arrangements, and effluent decanter location to minimize short-circuiting during monthly maximum flow conditions.)

The SBR process offers a great deal of flexibility to vary the environmental conditions within the reactor to yield particular results. If the fill and react periods are aerobic throughout, then only carbon oxidation and nitrification will occur. On the other hand, denitrification will result if the air is cycled on and off during portions of the fill and react steps, thereby creating anoxic conditions.

In terms of design criteria, an SBR shares many of the same principles as an activated sludge system. It should be noted, however, that only a portion of each cycle is devoted to biological reaction, namely the fill and react cycles. Depending on such factors as wastewater characteristics, effluent requirements, and sludge production rates, the active reaction time is 40-60% of the total cycle time. An SBR and an activated sludge system will yield a similar overall process performance if the solids retention time (SRT) for the two systems is comparable. To do this, and insure that the SBR has sufficient volume to adequately treat the wastewater, one must account for the portion of the cycle not devoted to biological reaction. Remember that an SBR includes volume for both reaction and settling. This can be illustrated using the following example for nitrification:

SRT = solids retention time (varies, but assume 11 days for a nitrifying system at 10 degrees C)
BOD_r = BOD removed in lbs/day
Y = net yield coefficient in lbs/lbs BOD_r (typical range of 0.6-1.2 [M&E-3rd Edition])
F = aerated fraction of total reaction time (typical range of 45-50%)
LWL_{volume} = Total reactor volume at low water level in million gallons
LWL_{MLSS} = Mixed liquor suspended solids at low water level (typical range of 1500-5000 mg/l [M&E-3rd Edition] with the higher range, say 4500 mg/l, used)
HWL_{volume} = Total reactor volume at high water level in million gallons

Solids produced (lbs/day) = Y x BOD_r

Required mass under air (MLSS in lbs) = Solids produced x SRT

Required mass SBR system = Required mass under air/F

LWL_{volume} = Required mass SBR system/(LWL_{MLSS} x 8.34)

The ***HWLvolume*** is then calculated to accommodate the maximum day wastewater flow based on the selected number of cycles per day. This allows the operator to treat the maximum day flow during the design period without any reduction in cycle time.

To complete the design, make the following assumptions:

Average day flow = 0.25 mgd
Maximum day flow = 0.5 mgd
LWL_{volume} = 220,000 gallons
2 reactors
Depth at lwl = 12 feet
5 cycles each tank = 10 cycles total

With an *LWL_{volume}* of 220,000 gallons, two SBR reactors and an lwl of 12 feet, each tank is 35 feet by 35 feet. At a max day flow of 0.5 mgd and 5 cycles per reactor, then each reactor would fill 5.5 feet to a depth of 17.5 feet (hwl). Then add 2 feet for freeboard. Each reactor is 35 feet by 35 feet at a depth of 19.5 feet.

If the SBR system must also denitrify, the design process is similar. The *Required mass SBR system* also includes both the MLSS associated with aeration and denitrification divided by the fraction of the total cycle time associated with both aerobic and anoxic conditions. To calculate the required mass, you must determine an SRT under anoxic conditions that is to be added to the aerobic SRT. The value of anoxic SRT ranges from

1.5-4 days (Grady, Daigger & Lim – Biological Wastewater treatment – 2nd Edition). To account for low temperatures in the winter months, the SRT will most likely be in the higher range, such as 4 days. Therefore, the combined total system aerobic/anoxic SRT is 15 days in this example. Substituting the combined SRT and F values in the above equations will yield the necessary tank volume for denitrification.

Other design considerations include:

a. When chemical addition for phosphorus removal is proposed, then the tank size must be checked to verify that sufficient space is available for the additional chemical sludge.

b. The design must include provisions for screening and grit removal.

c. The design must incorporate provisions for access to diffusers, decanter, and mixer to facilitate maintenance and repair.

d. Design must include provisions for monitoring DO, pH, and other operational control parameters.

e. Sidestream flows should be added at an equalized rate throughout the day to avoid shock loading.

f. The system should be operated to minimize filamentous bacteria that could carry over into the equalization tank. This is accomplished by creating an anoxic/anaerobic condition during the "Fill" phase.

Please note that many of the values for the design parameters, such as SRT and MLSS, are not absolute numbers, but typical values that have been used in approved designs. The consultant engineer can propose different criteria. If there are questions concerning the design criteria, then the reviewer can request that the consultant submit justification for those values.

J. DISINFECTION

General - Disinfection capability shall be provided at all small-scale treatment facilities unless otherwise directed by the Department. Disinfection is required at facilities that discharge their effluent by means outlined in the Department’s guidelines on Reclaimed Water Use. The following reclaimed water uses will require disinfection; discharge to a Zone II of a Community Water Supply System, spray irrigation of a golf course, landscaping, artificially recharging aquifers and toilet flushing.

The disinfection method should be selected after consideration of wastewater flow, intended application, demand rates, pH of the wastewater, cost of equipment, availability, reliability, maintenance issues and safety concerns. The most common methods of disinfection in small wastewater treatment facilities today are ultraviolet (UV) disinfection and chlorination. The form of chlorine most often used is solid chlorine tablets and sodium hypochlorite liquid. Advantages and disadvantages must be weighed when choosing a method of disinfection.

Please note the Department does not recommend the use of gaseous chlorine for disinfection in small wastewater treatment facilities due to increased safety concerns. The Department prefers the use of non-chlorine disinfection. Although the use of ultraviolet lamps and chlorination are the only methods discussed herein other methods may be acceptable to the Department.

> Note: Any type of disinfection system that is incorporated into a wastewater treatment facility shall be capable of meeting a minimum standard of 200 col/100ml of fecal coliform in the effluent wastewater.

Ultraviolet (UV)

Ultraviolet disinfection occurs by the UV rays inactivating the pathogenic organisms through induced photochemical changes in the cells’ DNA. The UV radiation inactivates the pathogens by interfering with their ability to replicate.

In order to maintain peak performance and operate within permitted parameters the UV disinfection system should consist of multiple banks of lamps modules, which are capable of continuously disinfecting the peak flow with one bank out of service.

The UV disinfection system shall maintain a minimum dose of 30,000microwatt seconds/sq cm while operating under the following conditions:

- Peak flow of effluent
- 65% of new lamp output, representing lamps
- Clear quartz sleeves

- Minimum average UV intensity in the UV reactor of 6,100 microwatts/sq cm.

- WWTF design incorporating total suspended solids of less than 30mg/l and UV transmittance of 250 – 265 nanometers.

- The UV lamp shall be a low-pressure mercury vapor lamp that will produce short-wave (2000-2959A) ultraviolet energy.

All electronic and electrical components in the UV system shall be designed and installed in accordance with the National Electrical Code. The control box shall be housed outside the UV disinfection chamber. All electrical components shall be tied into the main control panel located in the control room.

Each UV disinfection unit shall be equipped with an automatic shutoff for electrical power when the access panels to the disinfection chamber are opened. A sight port shall be provided for visual inspection of lamp operation.

The most common lamp array configuration is in the horizontal direction, with all of the lamps parallel to each other and to the flow of effluent. The system shall be designed for complete immersion of the UV lamps in the effluent at normal operation. The design shall ensure that a constant head of effluent is maintained above the lamp surfaces. If the UV lamps are housed in a concrete pit then a drain shall be installed to collect any wastewater.

Monitoring of the UV disinfection system is a necessary part of maintaining the system at peak performance. Each UV disinfection unit shall be equipped with a UV intensity meter (housed behind a quartz window) that is fixed at the area of minimum expected intensity. An audio/visual alarm will be activated in the event that the UV intensity has dropped to 70% of the original lamps output or when any of the individual lamps fail. All alarm functions will be connected to the main control panel housed in the control room.

Each UV disinfection system shall be designed and equipped with a convenient method for cleaning all surfaces that come into contact with the effluent. Each system shall have a mechanical wiper system for cleaning the sleeve surface without having to shut down the unit. The system should allow for manual cleaning as well. A cleaning and bulb replacement schedule shall be provided in the Operation and Maintenance Manual, and the design must include adequate room for cleaning and bulb replacement.

Some advantages in using UV disinfection are:

- Most of the pathogens are inactivated by the UV radiation.

- Since UV disinfection is a physical process, the need to handle corrosive chemicals is eliminated.

- UV disinfection also requires shorter contact times and takes up considerably less space.

Some disadvantages in using UV disinfection are:

- If the UV dosage is low some pathogens may not be inactivated. In some cases pathogenic organisms can repair themselves after being exposed to UV radiation.

- Strict maintenance must be followed to prevent the tubes from being fouled.

- If Turbidity and Total Suspended Solids are not within permitted levels, UV radiation becomes ineffective.

- When ferric salts are used for phosphorus removal, the bulbs may become fouled.

The UV disinfection process is susceptible to interference from color, which can reduce the effective transmittance of the UV rays. Appropriate measures should be taken to reduce the color in the effluent in order to achieve optimal transmittance through the wastewater.

Chlorination

The chlorine should be applied to the wastewater in an area that can provide adequate mixing. Typically the chlorination equipment is fixed at the inlet end of the chlorine contact chamber. The chlorine diffuser shall be located at a maximum depth below the water surface. In order to provide adequate disinfection the minimum contact period at peak flows shall be 30 minutes.

A baffle type chlorine chamber shall be provided. The chamber shall be constructed of reinforced concrete or structural grade steel. Steel chambers shall be protected against corrosion through the use of adequate covering material. A sump shall be provided in the chamber as a method to remove any solids buildup. Baffles shall be provided within the chamber to prevent short-circuiting and shall be designed to keep floating material from leaving the chamber. A method for removing any floating material shall be provided.

If dechlorination equipment is necessary for the treatment process the guidelines outlined in Tr-16, Guides for the Design of Wastewater Treatment Works (Section8.4) must be followed.

Equipment shall be provided at the plant to monitor free and total chlorine levels using accepted test procedures. All chlorine products shall be stored in a dry location and in suitable containers. Safety equipment shall be kept on hand in case of an emergency.

Some advantages in using chlorination:

- Established technology using established delivery systems.
- It is a very effective disinfectant.
- Residual is maintained to inhibit regrowth of bacteria.

Some disadvantages in using chlorination:

- Residual chlorine is toxic to aquatic life.
- Trihalomethane (THM) formation possible.
- Potential for volatile organic compounds (VOC's) being released from the chlorine contact chamber.
- Extensive safety issues with the handling of chlorine.

K. RESIDUALS MANAGEMENT

Sewage sludge is the resultant residual of the wastewater treatment process. Residuals management has become a major environmental problem for any wastewater treatment facility that is being proposed today. Reliable and environmentally sound long term residuals handling and re-use or disposal are critical to the operation of a wastewater treatment facility. Effective residuals management will help a wastewater treatment facility maintain compliance with its discharge permit requirements.

The design and operation of residuals management and disposal facilities should comply with all federal and state regulations. The applicable federal regulations are 40 CFR, Part 503, "Standards for the Use or Disposal of Sewage Sludge". State regulations that govern these facilities are 314 CMR 12.00 and, if beneficial re-use is proposed, 310 CMR 32.00, "Regulations for Land Application of Sludge and Septage".

For beneficial re-use and land application of residuals the Department has developed a permit fact sheet that directs the applicant to all appropriate permit applications and policies. The permit fact sheet and any relevant applications can be found in the Department's service center. However, due to the complexity of equipment and process control, staffing requirements, and issues related to odor control; sludge processing facilities are commonly not associated with small wastewater treatment facilities. Efficient sludge processing requires continuous operation under close supervision of the treatment plant operator. Guidelines for all methods for sludge processing and disposal that are not covered in this document can be found in TR-16, "Guides for the Design of Wastewater Treatment Works", 1998 addition.

Therefore, as a general rule when dealing with small facilities, wasted sludge shall be collected, properly stored and periodically transported to an approved off-site facility for proper treatment and disposal as a liquid or, in some situations, dewatered product.

Sludge holding tanks shall be provided at a capacity of 2.0 cubic feet/population equivalent for either aerobic or anaerobic designs. Sludge may be stored in the septic pretreatment tanks provided that additional capacity (an increase in 25%) for sludge storage is taken into account in the final design.

Sludge holding tanks shall be water tight and constructed of sound and durable material not subject to excessive corrosion decay, frost damage, cracking or buckling due to settlement or backfilling. To ensure proper placement the tank shall be installed on a six (6) inch bed of gravel. Tanks and covers shall be designed and constructed to withstand an H-20 wheel load. All specifications outlined in the previous section on septic tanks shall apply to sludge holding tanks except that the outlet (supernatant return) shall be connected to the septic pretreatment tank or the flow equalization tank.

All septic pretreatment tanks and sludge holding tanks shall be vented to the atmosphere through vent pipes that extend above the roofline. Odor control may become necessary for these vent lines.

L. INSTRUMENTATION GUIDANCE

Instrumentation is used for the control of equipment and processes. An integral component of an instrumentation system is the ability to alarm components critical to the integrity of the system.

Instrumentation systems are integral components of raw wastewater pumping stations and wastewater treatment facilities. The majority of equipment and processes are automatically controlled via instrumentation control systems. All automatically controlled equipment should have the capability of manual control in the event of a failure of feedback sensors or the instrumentation control system.

The instrumentation control system design should be based on the type of operator interface to be provided. Small wastewater treatment plants that do not have full time operator presence may need control automation that provides for remote process control and at a minimum alarm telemetry. Large wastewater treatment plants, even with a 24-hour/day on-site operator presence, should also be highly automated to achieve process control that will maximize treatment efficiency at the lowest cost.

Instrumentation is used in raw wastewater pumping/ejector stations and wastewater treatment facilities for:

- Pump and process equipment control
- Flow metering
- Alarms
- Data acquisition
- Lighting control
- Ventilation control

PUMP CONTROL

Instrumentation for the automatic control of raw wastewater pumps shall at a minimum consist of:

- Low level alarm
- Pump “OFF”
- Lead pump “ON”
- High level alarm
- Lag pump “ON”

Instrumentation should be provided to alternate the pumps to the “lead” position after each pump cycle. Alternating pumps evenly distributes wear and checks the operability of both pumps through regular usage.

Types of level controls switches include the trash service float switch, the air activated pressure switch, and impedance switch.

Alarms should at a minimum be:

- locally indicated on a control panel and visually alarmed to a flashing beacon on the exterior of the building visible from a traveled roadway.
- telemetered, 24-hours/day, to the wastewater treatment plant personnel via a priority call sequence. In some cases the alarm may be transmitted to a continuously manned dispatch station, such as the local police department, which in turn will contact the response personnel.
- automatically logged by the computer, or manually recorded in a logbook by the wastewater operator. Resetting alarm horns and lights shall require an operator acknowledgement to ensure that the problem has been addressed.

All alarms and instrumentation should be tested/activated to verify operational status prior to regular operation of any facility.

PROCESS EQUIPMENT CONTROL

Instrumentation for the manual and automatic control of process equipment is often times equipment specific. For equipment systems provided as an integral unit the critical control functions should be integrated into a local control panel and as necessary may also be integrated into a remote control panel.

Flexibility in the design of the instrumentation for key mechanical process equipment is necessary to provide for good process control. Systems which benefit from sophisticated control systems that can match the supply requirements to the process demand will require feed back control. Signal output from instruments in the process will be used as the input to a programmable logic controller (PLC) or to a Supervisory Control and Data Acquisition (SCADA) System. A diffused aeration system can benefit from such control with the result being lower energy costs by matching blower output to the oxygen demands of the aeration system. Also the chlorine feed rate for disinfection can be paced off of the plant flow rate and trimmed off of the concentration of chlorine residual in the plant effluent.

Other wastewater processes can benefit from basic control via a timer. The introduction of septage into the plant influent can be automatically controlled to occur regularly over a 24-hour period via a timer. A low level septage pump shut-off should be provided in the event the septage receiving tank level is too low, and a high level alarm should be provided in the event that the septage receiving tank level is too high.

ALARMS

Alarms for abnormal conditions for mechanical equipment, electrical systems, and treatment processes shall be provided. The alarm telemetry system should be battery powered. Alarms signals can be transmitted by wire via phone lines, or wireless by radio frequency transmission.

Electrical system alarms shall at a minimum include:

- Loss of primary power supply
- Tripped breaker
- Failure of back-up power supply (if applicable)

Alarms for major mechanical equipment typically include:

- High oil temperature
- High water temperature (i.e. emergency generator coolant)
- High/Low tank or channel liquid level
- Torque overload (i.e. clarifier drive)
- High/Low vacuum
- High/Low air pressure

Alarms for treatment processes typically include:

- High/Low pH
- High/Low DO

The electrical, mechanical, and process systems must function without major interruption to assure the continued conveyance and treatment of the wastewater. Rapid response to alarms 24-hours/day, 7-days/week is essential. As the sophistication of the process equipment increases, so should the number of alarms to increase the reliability of the systems and treatment processes.

Alarms for personnel safety typically warn of unsafe levels of toxic gases. These alarms shall include a local alarm nearby but outside the area to be monitored. The alarm must be capable of warning personnel prior to entering the monitored space as well as warning personnel within the monitored space of an abnormal condition. The alarms should also be relayed to the plant's central control panel. The alarms should be wired into the emergency electrical power circuit in the event of a primary power outage.

Where a building interior space or confined space is exposed to raw wastewater or sludges the alarms should at a minimum include:

- Hydrogen sulfide
- Oxygen
- Combustible gases

Where a building interior space or confined space has the potential to be exposed to toxic gases the alarms should be provided for the specific gas. Chlorine gas is commonly used for disinfection in treatment plants and a chlorine gas specific alarm is require for those areas where exposure is possible. Hydrogen sulfide is also toxic and enclosed areas where raw sewage and/or sludges are present should be monitored for the presence of this gas to ensure that personnel do not enter a potentially lethal atmosphere.

Where a building interior space or confined space has the potential to be exposed to exhaust gases from fossil fired fuels a carbon monoxide alarm should be provided.

Special care must be taken in siting emergency generators to prevent the intake of exhaust gases through the buildings fresh air intake.

Portable instrumentation is available for monitoring the above parameters for use in entering confined spaces, and other areas where access is infrequent.

FLOW METERING

Flow measurement is critical for the proper control of a wastewater treatment facility, as well as for measuring a plant's influent and effluent organic and inorganic loading for compliance reporting. Flow meters must be selected with respect to the characteristics of the liquid being measured, piping configuration, plant hydraulics, accuracy, and flow range.

Flow meters are at a minimum required to measure the total plant flow rate. For this purpose they can be located at either the influent or effluent end of the wastewater treatment facility. Flow meters used for measuring either plant influent or effluent flow shall indicate the flow rate and also record the total flow volume. The flow streams that should be metered include return and waste sludge pumped by centrifugal pumps. Chemical addition is often flow paced and is dependent on an accurate flow measurement.

The typical components of a flow meter follow:

- Primary flow element
- Transmitter
- Local and/or remote indicator
- Recorder
- Totalizer

For sludge wasting the total volume and not the rate of flow of the sludge pumped is important. Therefore positive displacement wastewater pumps can be equipped with a pump cycle counter to determine the volume of sludge wasted.

For a description of the various types of flow measurement equipment consult "TR-16 Guides for the Design of Wastewater Treatment Works."

DATA ACQUISITION

Data acquisition is necessary to monitor and evaluate the performance of the wastewater treatment facility. Data acquisition can be performed manually by logging data from indicators or automatically with systems ranging from chart recorders to SCADA systems.

The effluent discharge permit will dictate whether a regulated parameter must be monitored continuously. Flow measurement and pH are two parameters typically monitored continuously by in-situ instrumentation.

Most current major wastewater treatment system mechanical and process systems are compatible with a type of control system referred to as a Supervisory Control and Data Acquisition (SCADA) System. SCADA systems employ a Man Machine Interface (MMI). This type of an interface consists of customized software to set and adjust equipment operational parameters, alarm set points, and data acquisition. This software operates on a personal computer which can be password restricted. The computer can be networked with hard wiring from the equipment and process transmitters and may be connected on-line for remote control from either an on-site or off-site location.

A distributed control system (DCS) is a type of SCADA system where control is decentralized to remote processing units (RTU's) that are interfaced to a central control location. The advantage of a DCS over a conventional SCADA system is that control is not lost with problems with the network wiring or with the centralized computer.

For a description of the various types of control equipment consult "TR-16 Guides for the Design of Wastewater Treatment Works."

LIGHTING CONTROL

Proper lighting should be provided to perform the required operational and maintenance tasks. Lighting control can be automated so that the facility is only illuminated to the degree necessary to maintain safe operation. Photocells, timers, and motion detectors with a manual over-ride can be used to activate lighting in secure areas not regularly traveled.

Lighting systems shall be of the appropriate electrical service classification for the area served. Enclosed areas with exposure to raw wastewater, wastewater sludges, and corrosive or hazardous atmospheres will require that the lightning and electrical systems be of the appropriate hazard classification.

Energy efficient lighting systems should be used where lighting is on for long periods of time. Lighting fixture type and placement should be designed to minimize the effect on off-site properties.
Lighting systems shall be connected and activated with the emergency power generation system serving the facility.

VENTILATION CONTROL

Proper ventilation is essential to maintaining a safe working environment. Confined spaces regularly entered should be equipped with a ventilation system interlocked with the lighting switch for the area.

In the event of a power failure, the power and control load demand of the ventilation equipment serving confined spaces and other potentially hazardous areas shall be transferred to the emergency generator if so equipped.

Building fresh air intakes should be located away from and upwind (based on the prevailing wind in the area) of the emergency generator exhaust stack to prevent exhaust gases from being drawn into the building. The generator exhaust stack shall terminate a minimum of five feet above the highest building roofline. A generator shall not be exhausted to a roof containing a ventilation system.

The service classification and size of the ventilation equipment shall be in accordance with OSHA, the NFPA, TR-16 - Guides for the Design of Wastewater Treatment Works, ASHRAE, and Industrial Ventilation – A Manual of Recommended Practices, and any other applicable codes and industry standard guidance.

M. PACKAGE TREATMENT FACILITIES

Package Wastewater treatment plants are utilized for treating wastewater from a single-family residence to large decentralized systems for neighborhood, commercial facilities, schools and other types of facilities. In most cases these facilities discharge treated effluent to the groundwater through a below ground drainfield.

When correctly designed the package treatment facilities can provide an effluent to meet at least secondary treatment standards of 30 mg/L for both BOD_5 and TSS. Some systems are capable of producing a tertiary effluent. In areas where nutrients such as nitrogen are a problem, these systems can be designed to produce an effluent with a total nitrogen concentration below 10 mg/L.

To assure that these systems can meet their permit limits and operate for their design life, designers must be aware of a number of issues and take them into account when designing these systems.

1. Many of these systems require a preliminary design report which details:
    a. Design flows and organic loading
    b. Design criteria including nutrient, nitrogen and phosphorous, and/or pathogen removal requirements
    c. Capital and annual O&M costs
    d. Treatment technology
    e. Sizing of the pretreatment, treatment and post treatment facilities
    f. Special design considerations such as equalization tanks.
    g. Operation and maintenance requirements

2. Most systems will discharge effluent to the ground, and the designer may need to evaluate depth to ground water, water quality, soil capacity, mounding, and direction of movement. The effluent disposal system can conform to the requirements of Section VII herein.

3. Designers should collect representative wastewater samples where existing systems are to be upgraded or replaced. Composite sampling over several days should provide sufficient information on flow and organic loading. Designs for new facilities should be based on well-established design criteria.

4. Systems designed in accordance with Title 5 will generally require a septic tank as a pretreatment unit. In some cases, i.e. - for schools, the designer must evaluate the need to include an equalization tank after the septic tank but before the treatment unit. Systems in excess of 10,000 gpd may require a septic tank or equalization tank. In those instances where equalization is required the designer should also evaluate and design mixing to maintain solids in suspension and pre-aeration for high BOD waste.

5. All package treatment technology must have state approval. Title 5 systems must have an appropriate technology approval issued under the most recent version of Title 5. In instances where the technology has not been previously used in the state, it is the designer's responsibility to provide sufficient operating data to obtain approval for the system.

6. Larger package treatment plants should have dual treatment trains, equivalent to or greater than the treatment capacity required so that systems can be taken out of operation to service without a loss of treatment efficiency. Pumps, motors, blowers and other mechanical equipment that can fail and disrupt treatment must be installed in duplicate. Single pumps can be installed in Title 5 systems less than 2000 gpd provided that 24 hours excess storage capacity is provided in the pump chamber. The systems shall be equipped with suitable audio and visual alarms to alert the owner or operator of equipment malfunction or failure.

7. The designer must provide flexible designs in both the larger systems and the under 10,000 gpd range to assure that variations in flow due to seasonal use, such as at schools and other facilities, do not cause system upset. Large seasonal flow variations can cause system upsets unless the designer has taken this variation into account.

8. Treatment units shall be constructed of non-corrosive materials, reinforced plastics, fiberglass, coated steel and reinforced concrete. All treatment units shall be tested for water tightness.

9. Where systems are installed above ground they shall be installed on adequate concrete pads and housed to protect them from Massachusetts climatic condition, including the use of anodes to prevent corrosion.

10. Where units are buried adequate access must be provided to service or replace mechanical parts, control systems, under drain, weirs or other elements. Ventilation shall be provided for aeration and to ensure adequate oxygen transfer to the units.

11. When nutrient removal is required the designer shall design adequate chemical feed and storage equipment. This equipment must be housed in a weatherproofed structure.

12. All electrical components must be designed to NEC code and shall be waterproof and housed to protect from the elements. Pumps, drives, and other mechanical devices shall be designed for continuous heavy-duty service and for climatic conditions in Massachusetts. Mechanical components must be either housed to protect them from the elements or waterproofed

13. Lights shall be installed in a readily accessible location so that the bulbs can be easily changed.

14. Standby or emergency power shall be provided for systems that do not have adequate emergency storage capacity or must be continually operated.

15. Most systems will require sampling at some point in time. Systems shall be designed with adequate accessible sampling ports or manholes, including access ports in pressure distribution systems and leaching areas. Designed sample ports and locations shall be shown or noted on design plans for the system.

16. The designer shall ensure that a detailed and up to date Operation and Maintenance manual is provided to the owner or operator prior to start up.

N. SCHOOLS AND OTHER SEASONAL FACILITIES

Designing a wastewater treatment facility (WWTF) to serve seasonal operations such as a public school facility or a campground present a number of special challenges for the designer. Most school WWTP's operate under discharge permits requiring a high degree of treatment, usually including both conventional secondary treatment plus one or two forms of nutrient (nitrogen and phosphorus) removal as well. Many of today's treatment systems use biological processes employing microorganisms to achieve this. Biological processes operate best in a narrow range of temperature, pH and oxygen, and require a relatively steady supply of organic matter as a food source.

Most public schools operate in a narrow time period, usually 8 hours/day, 5 days/week, 40 weeks a year. Schools can be closed for extended periods of time, creating a widely fluctuating range of conditions under which the biological systems must operate. These fluctuating conditions must be accounted for in the WWTF design.

The attached figure provides the steps involved in designing a wastewater treatment plant to serve a public school facility.

1. The first step in the design is to determine the wastewater characteristics. To do this the designer must identify the "universe" of different activities (both curricular and non-curricular) that may occur at this facility. For example, will the school have a pool or gymnasium with showers? Will there be full food preparation at this facility or will prepared meals be delivered? Will the school have evening or weekend activities, or summer classes? Will the facility be utilized for non-curricular activities such as public meetings, election polling center, or for events involving food preparation?

   Once the full universe of activities is determined the individual wastewater characteristics for each type of activity is first determined and then combined using a mass balance approach to determine the actual range of flows and pollutant loads (from initial start-up conditions to ultimate build-out) which the treatment system will experience. The design must reflect realistic per capita flows and pollutant loadings. This requires obtaining wastewater measurements from an existing school facility with a similar range of activities. School wastewater is typically much higher in nitrogen and lower in C-BOD than typical sanitary sewage. One possible explanation is that schools typically utilize cleaning solutions and floor strippers containing high concentrations of quaternary ammonia that in turn is discharged to the treatment facility. Designs based only Title 5 design flows and literature values for typical sanitary wastewater strength fail to reflect the actual flow and load ranges public schools actually generate. Furthermore, such designs fail to reflect the fact that new schools tend to open at less than full build-out occupancy

2. The second step in the design is to obtain from the appropriate regulatory authority the effluent limits that will be required at this facility. In Massachusetts

most school WWTF's operating under a groundwater discharge permit must meet a BOD/TSS of 30 mg/l, a nitrate-N and total N of 10 mg/l, pH of 6.0 to 8.0, and an oil/grease limit of 15 mg/l. This means the treatment process must include denitrification as well as conventional secondary treatment. Some permits also contain phosphorus limits and disinfection requirements as well.

3. The designer must now determine whether the school treatment system is to be operated continuously all year, or to be periodically shut down for summer vacation and possibly other extended breaks. If the school WWTF is to operate continuously, the biological treatment system shall be designed to operate over a significantly wide loading range. If the system is to be periodically shut down, the design must allow for rapid start-up as well as the actual loading range that will be experienced. In either situation, ease of process operation must be a principal design consideration. As an added measure, prior to the discharge of wastes containing high concentrations of ammonia, such as when the floors are cleaned, the facility operator should be notified.

4. The designer must then select the various biological treatment processes best suited to achieve permit limits over the entire flow and loading ranges that will be experienced. In selecting these biological processes the designer should consider all of the following factors:

   a. Process reliability in meeting permit limits.
   b. Flexibility (the range of conditions over which the process can effectively operate).
   c. Overall ease of operation.
   d. Capital and O&M costs

   Some conventional technologies, such as fixed film contactors and microfilters, have proven compliance records, and if properly designed, can have both the flexibility and ease of operation needed for school WWTF's. This is not to say that other systems may not be as attractive. Those processes employing a pre-anoxic stage may offer the added advantage of reduced chemical costs for both nitrification and denitrification. In selecting these processes the designer is advised to compare actual performance records and cost data.

5. Once a reliable treatment process is selected a detailed unit-by-unit design is performed using preceding sections of these design guidelines. Each process unit design must be based on process criteria, to include hydraulic detention time, BOD loading rates, Mean Cell Residence Time(MCRT), hydraulic overflow rates, etc. The WWTF must be designed so as to operate effectively over the <u>entire</u> range of flow and pollutant loadings the school may generate, from the first day of operation to ultimate build-out conditions. It may be advantageous to employ multiple process trains, with each train designed to operate in a different flow/loading range. In this way the operator could alternate between the process trains as conditions change.

An effective design must also provide for ease in process control. This means installing sufficient sampling locations in the process train to allow the operator to selectively evaluate each and every process unit. Flow equalization tanks must be equipped with timers rather than float switches to evenly distribute flow over the entire 24-hour period. Chemical feed systems must be regulated by flow-paced metering systems. Aeration tanks should be equipped with separate mixers so that the oxygen transfer may be adjusted without adversely effecting mixing characteristics. We strongly encourage designers to visit similar operating WWTF's and talk with operators about process considerations.

X. OPERATION AND MAINTENANCE PLAN

General:

The purpose of the Operation and Maintenance (O&M) manual is to provide treatment system personnel with the proper understanding of recommended operating techniques and procedures, and the references necessary to efficiently operate and maintain their facilities.

An individual O&M manual shall be prepared and stamped by a registered Professional Engineer and kept current for all small sewage treatment facilities. The O&M manual shall contain all information necessary for the plant operator to properly operate and maintain the collection, treatment and disposal systems in accordance with all applicable laws and regulations. A copy of the approved O&M manual shall be maintained at the treatment plant at all times.

In accordance with 314 CMR 12.04, the O&M manual shall include the following:

a) Introduction
b) Permits and Standards
c) Description, Operation and Control of Wastewater Treatment Facilities
d) Description, Operation and Control of Sludge Handling Facilities
e) Personnel
f) Sampling and Laboratory Analysis
g) Records and Reporting
h) Maintenance
i) Emergency Operating and Response Program
j) Safety
k) Utilities

A draft copy of the O&M manual shall be submitted to the Department and the local Board of Health at approximately 80 per cent completion of the construction of the treatment facilities. A final O&M shall be submitted for approval at least fourteen (14) days prior to scheduling with the Department the clear water hydraulic test of the facility. The final O&M must be approved by the Department prior to the facility going on-line.

The O&M manual shall be kept current at all times. A review by the owner of the O&M manual shall be made at least every two years. The following is a further narrative of the above referenced items:

Introduction:

The introduction shall include a general description of the nature of the establishment (e.g. office park, commercial strip mall, etc.) that is served by the wastewater treatment plant (WWTF). Included with the introduction shall be the location of the WWTF and any environmentally sensitive areas within ½ mile of the WWTF, a locus map should be provided.

Permits and Standards

The Permits and Standards section shall discuss the type of permit issued and include a copy of all permits including conditions granted by the Department in regards to the WWTF. This section shall state where engineering plans approved by the Department will be located.

A detailed description of responsibilities of the owner, operator and consulting engineer necessary to meet all permit conditions shall be provided.

Description of Operation and Control of Wastewater Treatment Facilities:

The substance of how to operate the treatment facility lies within this section. This section is intended to provide a description of the various treatment plant components and their function. Each component should be presented in a sequential order and discussed individually. The narrative should discuss the treatment system from the point of generation (including the conveyance system) through the treatment processes to final disposal.

The method for operating each unit of the treatment system shall be discussed in this section. For example, if pretreatment tanks are proposed then how often they require sludge removal should be mentioned.

The O&M manual shall include the manufacturer's operating, maintenance and repair instructions for all process units and appurtenances associated with the WWTF such as: motors, pumps, valves, blowers, bearings, drive assemblies, control panels, electrical systems, alarms, piping, tankage, and equipment. This information can be incorporated into the body of the Operation and Control of Wastewater Treatment Facilities section or included as appendices. This section shall go on to provide detailed instructions on treatment plant operation including chemical storage and handling, process testing, standard operational mode, optional modes available (such as seasonal operations), process controls and safeguards.

If the WWTF includes storage of chemicals that are required as part of the treatment process (e.g. methanol) the O&M must provide information such as name, address, and telephone number for each chemical supplier.

Description of Operation and Control of Sludge Handling Facilities:

All WWTFs generate waste solids that require handling separate from the wastewater treatment system. This section shall provide a description of the sludge handling and disposal requirements including the name and telephone number of the septage hauler, name and telephone number of the sludge disposal facility and record keeping requirements.

For any process unit that either generates or stores waste solids an expected removal frequency and means of removal shall be provided.

Personnel:

The owner of a WWTF must employ sufficient personnel to ensure the proper operation of the facility. A description of the number and qualifications of the personnel necessary for proper and continuous operation of the collection, treatment and disposal systems shall be given. It shall include the Grade of the Chief Operator and that of any backup or staff operators. The duties and responsibilities of the staff shall be provided.

It shall include the number of days per week and hours per day the facility shall be staffed, holiday and weekend staff coverage, and on-call and emergency operating personnel.

Sampling and Analysis:

A listing of all sampling (operational and compliance monitoring) and analyses required together with appropriate protocols for proper sampling, storage, transportation, and analysis shall be provided. In addition, a quality control/quality assurance plan shall be developed.

The sampling and analysis plan must include a description of sampling that is reflective of the conditions of the permit for: influent, effluent, and groundwater monitoring wells. The plan must include the parameter that is being tested for (e.g. pH, BOD5, etc.), its frequency of testing (e.g. daily, weekly, monthly, etc), and the method for testing (e.g. Standard Methods # xx). The method of sampling (e.g. grab or composite) shall also be stated in the sampling plan.

Process control testing and the parameter and frequency must also be incorporated. The sampling and analysis plan must include locations of where testing must be performed to ensure that process units are operating properly and efficiently.

The sampling plan for the groundwater monitoring wells must state the location of the well and its designation number.

If analysis is done on site or transported to a certified lab then this must be so stated in the plan. Any on-site equipment such as pH meters must have documentation for the proper operation of such equipment including calibration information. If chemicals or buffer solutions are required for calibrating equipment they must be stored and handled according to manufacturer’s recommendations.

Records and Reporting:

A listing of all reporting requirements and location and method of record keeping shall be included. The Records and Reporting section shall reference daily log of plant operations, process changes and equipment maintenance. Copies of daily logs as well as any inspection reports shall be kept at the facility at all times.

This section shall provide a description of events that require reporting to the Department (e.g. anticipated non-compliance, planned alterations, etc.).

Maintenance:

The Maintenance section shall include a list of spare parts and supplies that shall be available to the operator for the maintenance and repair of the treatment plant and related appurtenances.

This section shall include a chart itemizing all equipment within the treatment facility and its associated maintenance action (e.g. lubricate motor bearings) and the frequency of such action (e.g. every 6 months). The chart should include provisions for including notes or comments by the operator.

Included in this section shall be a lubrication chart, which details for all equipment routine inspections, lubrication and adjustment, which must be performed by the operator.

It should be noted that only equipment or materials associated with the treatment plant are allowed to be stored within the confines of the WWTP. The treatment plant should not be used as a storage structure for items not related to the WWTP.

Emergency Operations & Response:

An emergency operating and response program shall be discussed. It shall detail procedures to be followed in the event of the following emergency situation: power failures, storms, flooding, hydraulic overload/ruptures, fire, explosions, equipment failure, spills of hazardous materials, maintenance shutdowns, and personnel injury. A description of who should be notified, and when, for each emergency situation shall be provided along with an appropriate telephone number.

The procedures to follow shall include information as to identifying the emergency condition, investigating the severity of the emergency, actions to be taken and notification of responsible authorities, corrective actions to rectify the situation, and necessary follow-up. Follow-up procedures should include feasible measures to prevent or minimize the likelihood of a similar situation from reoccurring.

At a minimum the following telephone numbers shall be incorporated into the Emergency Operations & Response Section: local fire department, local police department, ambulance, poison control center, Regional Office of the Department and local Board of Health. This section should state where the phone numbers would be posted within the treatment plant.

Safety:

A description of proper material handling and precautionary safeguards shall be included. This shall include a listing of an instruction for use of all necessary safety and first aid equipment. An itemized list of safety equipment shall be provided.

Training for personnel is a key component of a proper safety program. The Safety section must include what training (e.g. OSHA, first-aid, CPR) is required for all staff employed to work within the WWTP.

All Material Safety Data Sheets (MSDS) for any chemicals stored on site must be included in the O&M as well as available within the WWTP.

Utilities:

A listing and directory providing names and notification requirements for water, electric, gas and telephone services shall be included in the O&M manual.

XI. CONTENT AND REQUIREMENTS OF THE GROUNDWATER DISCHARGE PERMIT

Pursuant to 314 CMR 5.00, WWTFs which discharge to the ground with design flows of 10,000 gallons per day or greater must apply for and obtain a groundwater discharge permit. Although each groundwater discharge permit issued to a WWTF will contain requirements and conditions unique to that facility, there is a general format that is used for all permits. This chapter will review the various sections of the groundwater discharge permit and the basic requirements of each of those sections.

The front page of the permit will contain the permittee & facility address information, the date the permit application was made, the issuance date, the expiration date, and the effective date. Additionally, the front page will include a description of the facility served by the WWTF (e.g. 240,000 sf office building, 200 bedroom condominium, etc.)Permits become effective on the date of issuance provided no comments were received on the permit during the public comment period. If comments were received, the permit will become effective 30 days from the date of issuance.

Section I. Special Conditions is the next part of the permit and is divided into three parts:

Part A, contains the effluent limitations that the discharge must meet. Effluent limitations are a combination of both water quality based effluent limitations and technology based effluent limitations and will be determined on a case-by-case basis. The effluent characteristics and discharge limitations shown in the template permit are typical requirements for a sanitary waste discharge undergoing tertiary treatment with disinfection. The effluent characteristics and limitations will vary in each permit depending on the specifics of the discharge and applicable Department policies.

Part B of the Special Conditions contains the monitoring and reporting requirements for the discharge. The permittee will be responsible for monitoring the influent, the effluent and a minimum of three monitoring wells (at least one upgradient and two downgradient of the discharge) in order to demonstrate compliance with the permit limitations and the groundwater quality standards (314 CMR 6.00). Under this section the specific parameters that need to be monitored for at each sampling location will be specified along with the minimum frequency of monitoring and what type of sample needs to be taken, i.e. composite or grab. The last paragraph of Part B., details when the monitoring analyses must be submitted and whom the reports must be submitted to. For all permits, monitoring reports are required to be submitted to the DEP Regional Office, the DEP Boston office, and the Board of Health for the town in which the discharge is located. The “acceptable forms” for the data submittals are the Groundwater Permit Monthly Report Summary Sheet and the monitoring well report form. Upon issuance of the permit, the permittee will be sent both of these forms. The Summary Sheet is specific to the monitoring requirements of each permit.

Part C contains the Supplemental Conditions of the permit. These conditions pertain to the operation and maintenance of the facility and will vary for each facility. For small WWTFs, conditions may include ownership change notification, staffing plan submittals, operational notifications and financial conditions. Other conditions deemed necessary for the proper operation of the facility will be included in this section.

The next section of the permit, titled Appeal Rights, gives instructions for how to request a hearing on the issued permit. Any person aggrieved by the issuance of a permit may request a hearing within thirty days of the permit's issuance date as directed by this section.

The last part of the permit is Section II. General Conditions. These conditions are from 314 CMR 5.00, section 5.19 in its entirety, and apply to all permits.

Finally, a **Section 61 Finding** is required for any DEP permit action if the project has been required to submit an Environmental Impact Report (EIR) under MEPA. The Finding will be prepared to comply with M.G.L. c.30, s.61 and 301 CMR 11.12(5) and to complete the public overview of the mitigation program for the project, and will contain a discussion of potential impacts and mitigation measures developed in response to concerns outlined in the EOEA Secretary's Certificate for the project, and the anticipated implementation schedule for the project and mitigation measures. Typically, the project proponent prepares a draft Finding for DEP review, comment, and finalization. The completed Finding will be incorporated into the permit. Implementation of any mitigation measures will occur in accordance with the terms and conditions of the permit. Please note that a copy of the Section 61 Finding must also be filed with the MEPA Office.

XII. CERTIFICATION & PERFORMANCE GUARANTEES

Should a treatment technology for which little historical operating data is available, the Department may approve such technologies with an approved letter of credit, loan guaranty, or escrow account in an amount and under conditions determined by the Department to ensure the availability of funds for needed repairs, replacement and/or temporary hauling of sewage to an approved off-site treatment facility.

When equipment and unit processes other than those specified in this document are proposed, the Department may require a performance guaranty in the amount of 100 per cent of the costs associated with the removal and replacement of that piece of equipment or process with an alternate which is capable of meeting the specified performance standards. In all cases where a piece of equipment or a unit process other than those specified in this document are proposed, the Department shall set an appropriate performance standard for that piece of equipment or process and shall require performance monitoring by an independent consulting engineer for a period of at least one year. At the end of the monitoring period the independent consultant shall prepare a report that summarizes the performance monitoring and which:

(1) provides a certification to the owner that the piece of equipment or unit process has continuously met or exceeded its performance standards; or

(2) makes recommendations to the owner on necessary modifications and additional testing required; or

(3) recommends and designs an alternate system for the owner which is capable of meeting the specified performance standards.

A copy of the consultant's report shall be submitted to the Department and the local Board of Health. In the event that the effluent limitation specified in the facilities discharge permit can not be obtained or maintained due to the piece of equipment or unit process being tested, steps shall be taken to immediately replace it.

APPENDIX

INFILTRATION RATE & INFILTRATION RATE TEST

Infiltration Rate

The **infiltration rate** is the velocity or speed at which water enters into the soil. It is usually measured by the depth (in mm) of the water layer that can enter the soil in one hour. An infiltration rate of 15 mm/hour means that a water layer of 15 mm on the soil surface will take one hour to infiltrate.

In dry soil, water infiltrates rapidly. This is called the **initial infiltration** rate. As more water replaces the air in the pores, the water from the soil surface infiltrates more slowly and eventually reaches a steady rate. This is called the basic infiltration or saturated infiltration rate (Table A).

The infiltration rate depends on soil texture (the size of the soil particles), the grain size distribution and soil structure (the arrangement of the soil particles.

The most common method to measure the infiltration rate is by a field test using a cylinder or ring infiltrometer.

Table A-1

BASIC INFILTRATION RATES FOR VARIOUS SOIL TYPES

Soil Class	Soil type	Basic infiltration rate (mm/hour)	Basic infiltration rate (in/hour)
I	Sand	less than 30	0.50 to 1
I	Loamy Sand	25-30	0.45 to 0.50
II	Sandy loam	20 - 25	0.39 to 0.44
II	Loam	15 - 20	0.34 to 0.38
III	Silt Loams, less than 27% Silt	10-15	0.25 to 0.34
III	Sandy clay loam, less than 27% clay	5 - 10	0.10 to 0.24
IV	Clay	1 - 5	Less than 0.10

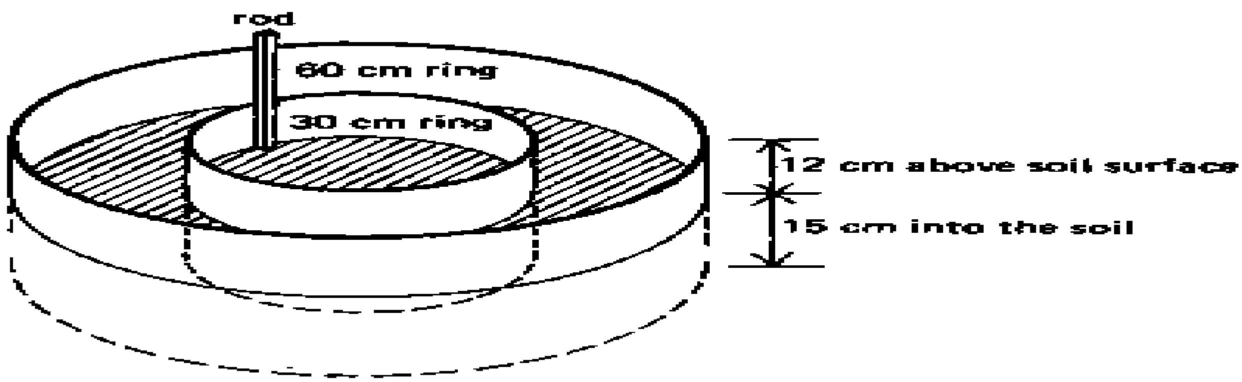
Double Ring Infiltration Test

<u>Equipment required</u>

Shovel/hoe
Hammer (2 kg)
Watch or clock
5 liter bucket
Timber (75 x 75 x 400)
Hessian (300 x 300) or jute cloth
At least 100 liters of water
Ring infiltrometer of 30 cm diameter and 60 cm diameter.
(other diameter may be substituted with Department approval)
Instead of the outer cylinder a berm could be made to prevent lateral water flow.
Measuring rod graduated (e.g. 300 mm ruler)

<u>Figure A-1</u>

SET-UP OF FIELD TEST



<u>Method</u>

Step 1: Hammer the 30 cm diameter ring at least 15 cm into the soil. Use the timber to protect the ring from damage during hammering. Keep the side of the ring vertical and drive the measuring rod into the soil so that approximately 12 cm is left above the ground.

Step 2: Hammer the 60 cm ring into the soil or construct an earth berm around the 30 cm ring to the same height as the ring and place the hessian inside the infiltrometer to protect the soil surface when pouring in the water

Step 3: Start the test by pouring water into the ring until the depth is approximately 70-100 mm. At the same time, add water to the space between the two rings or the ring and the bund to the same depth. Do this quickly.

The water in the berm or within the two rings is to prevent a lateral spread of water from the infiltrometer.

Step 4: Record the clock time when the test begins and note the water level on the measuring rod.

Step 5: After 1-2 minutes, record the drop in water level in the inner ring on the measuring rod and add water to bring the level back to approximately the original level at the start of the test. Record the water level. Maintain the water level outside the ring similar to that inside.

Step 6: Continue the test until the drop in water level is the same over the same time interval. Take readings frequently (e.g. every 1-2 minutes) at the beginning of the test, but extend the interval between readings as the time goes on (e.g. every 20-30 minutes).

Methodology For Infiltration Testing

Prepare a table, as follows:

- Column 1 indicates the readings on the clock in hours, minutes and seconds.

- Column 2 indicates the difference in time (in minutes) between two readings.

- Column 3 indicates the cumulative time (in minutes); this is the time (in minutes) since the test started.

- Column 4 indicates the water level readings (in mm) on the measuring rod: before and after filling (see step 5).

- Column 5 indicates the infiltration (in mm) between two readings; this is the difference in the measured water levels between two readings. How the infiltration is calculated is indicated in brackets.

- Column 6 indicates the infiltration rate (in mm/minute); this is the infiltration (in mm; column 5) divided by the difference in time (in minutes, column 2).

- Column 7 indicates the infiltration rate (in mm/hour); this is the infiltration rate (in mm/minute, column 6) multiplied by 60 (60 minutes in 1 hour).

- Column 8 indicates the cumulative infiltration (in mm); this is the infiltration (in mm) since the test started. How the cumulative infiltration is calculated is indicated in brackets.

<u>Soil Infiltration Data Work Sheet</u>

Site Name: ____

Name of Collector/Analyst/Recorder: ____

Sample collection

- date: _______
- time: _______ (hours and minutes) check one: UT___ Local ___

Distance to Soil Moisture study site marker _____ m

Sample Set number: ________ Width of your reference band: ______mm

Diameter: Inner Ring: ______ cm Outer Ring: _______ cm

Heights of reference band above ground level: Upper: _____ mm Lower: ______ mm

Saturated Soil Water Content below infiltrometer after the experiment:

A. Wet Weight: _____ g B. Dry Weight: _____ g C. Water Weight (A-B): _____ g

D. Container Weight: _____ g E. Dry Soil Weight (B-D): _____ g

F. Soil Water Content (C/E) x 100 _____

<u>Daily Metadata/Comments: (optional)</u>

<u>Directions:</u>

Take 3 sets of infiltration rate measurements within a 5 m diameter area. Use a different data work sheet for each set. Each set consists of multiple timings of the same water level drop or change until the flow rate becomes constant or 45 minutes is up. Record your data below for one set of infiltration measurements you take.

The form below is setup to help you calculate the flow rate.

For data analysis, plot the Flow Rate (F) vs. Midpoint time (D).

<u>Observations:</u>

	A. Start (min) (sec)	B. End (min) (sec)	C. Interval (min) (B-A)	D. Midpoint (min) (A+C/2)	E. Water Level Change (mm)	F. Flow Rate (mm/min) (E/C)
1	___ ___	___ ___	_______	_______	_______	_______
2	___ ___	___ ___	_______	_______	_______	_______
3	___ ___	___ ___	_______	_______	_______	_______
4	___ ___	___ ___	_______	_______	_______	_______
5	___ ___	___ ___	_______	_______	_______	_______
6	___ ___	___ ___	_______	_______	_______	_______
7	___ ___	___ ___	_______	_______	_______	_______

8	___ ___	___ ___	_______	_______	_______	_______
9	___ ___	___ ___	_______	_______	_______	_______

Field Meaurement Using a Double-Ring Infiltrometer with a Sealed Inner Ring (ASTM D 5093 –90)

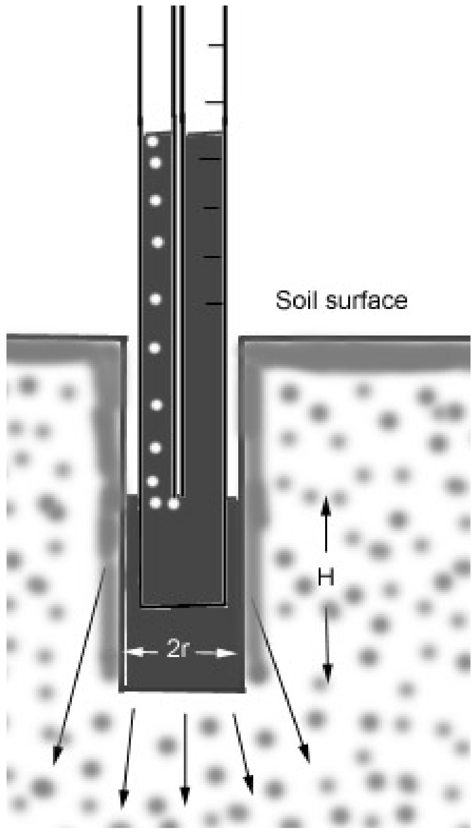
The infiltration rate of water through soil is measured using a double-ring infiltrometer with a sealed or covered inner ring. The infiltrometer consists of an open outer and a sealed inner ring. The rings are embedded and sealed in trenches excavated in the soil. Both rings are filled with water such that the inner ring is submerged.

The rate of flow is measured by connecting a flexible bag filled with a known weight of water to a port on the inner ring. As water infiltrates into the ground from the inner ring, an equal amount of water flows into the inner ring from the flexible bag. After a known interval of time, the flexible bag is removed and weighed. The weight loss, converted to volume, is equal to the amount of water that has infiltrated into the ground. An infiltration rate is then determined from this volume of water, the area of the inner ring, and the interval of time. This process is repeated and a plot of infiltration rate versus time is constructed. The test if continued until the infiltration rate becomes steady or until it becomes equal to or less than a specified value.

Two-Stage Borehole Permeameter

The rate of flow of water into soil through the bottom of a sealed, cased borehole is measured in each of two stages, normally with a standpipe in the falling head procedure. The standpipe can be refilled as necessary. In stage 1, the bottom of the borehole is flush with the bottom of the casing for maximum effect of Kv. The test is continued until the flow rate becomes quasi-steady. For Stage 2, the borehole is extended below the bottom of the casing for maximum effect of Kh. This stage of the test is also continued until the flow rate becomes quasi-steady. The direct results of the test are apparent hydraulic conductivities K1 and K2. The actual hydraulic conductivities Kv and Kh can be calculated from these values.

Schematic of Two-Stage Borehole Permeameter



Field Hydraulic Conductivity Measurement By Using Guelph Permeameter
(ASTM D 1556)

The Model 2800K1 Guelph Permeameter is a constant-head device that operates on the Mariotte siphon principle and provides a quick and simple method for simultaneously determining field saturated hydraulic conductivity, matrix flux potential and soil sorptivity in the field.

Loading Test

A loading test may be done at the design scale or a percentage of the final design size. It is performed in either an open bed, trench or other method similar to the proposed final method of disposal. The test is designed to demonstrate the maximum hydraulic loading potential of the proposed site. Based upon site conditions and the proposed layout of the final discharge locations, multiple tests may be required. This is true especially for large sites where site heterogeneity exists, where several areas with differing soil conditions exist and if multiple disposal methods are proposed. The receiving area shall be constructed in a manner similar to that of the final design. A staff gage or other measuring device shall be placed in the receiving area and secured to prevent slippage and calibrated if a pressure transducer is being used. An observation well may be installed in the testing area if a bentonite seal is present to eliminate downward flow along the side of the well.

Observation wells shall be installed at intervals space out from the area being tested. Recommended spacing is 5, 25, 50, 100 and 200 feet. This may be modified given site conditions, and the anticipated discharge. Smaller flows or smaller scale tests should concentrate observation wells closer to the test. Wells should be positioned with respect to the groundwater flow direction with the focus of the data collection being down gradient of the test.

Precipitation data should be collected either on site or if a meteorological data collection station is in close proximity this data may be used. Several days prior to and after the test water level data must be collected. Water levels after the test should be collected until stabilization is achieved.

Whether trenches, open beds or other method is proposed, the test shall involve discharge of clean water in the receiving area at a rate at a multiple (such as 5 times) of the anticipated maximum loading rate. After the receiving area is full, the flow shall be decreased incrementally and the rate and corresponding water levels recorded. The goal is to have one step where the flow equals the rate of infiltration of the saturated testing area (Q). The final step shall be the design discharge loading rate (if less than the Q).

The report shall contain a location map with testing site, well locations, water level elevations and discharge rate numbers. Well boring and installation data shall be provided. Metrological data shall be included along with a summary of the impact of any precipitation. If precipitation has a significant impact on the test is must be performed again.