Montana Department of Environmental Quality

CIRCULAR DEQ-2

DESIGN STANDARDS
FOR
PUBLIC SEWAGE SYSTEMS

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Montana Department of Environmental Quality
(Established 07/01/95; formerly Montana Department of Health and Environmental Sciences)

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FOREWORD

The Board of Environmental Review of the State of Montana, as authorized by 75-6-103(2)(f), MCA, has adopted the following standards for wastewater works. The terms "Department", as used in these standards refer to the Montana Department of Environmental Quality (DEQ) or its authorized agents.

These standards are intended to establish planning and design criteria for Public Sewage Systems as defined in 17-6-102(13) MCA insofar as the criteria are applicable to normal situations for an individual project. The design criteria in these standards are intended for the more conventional municipal wastewater collection and treatment systems where any industrial component of the wastewater is relatively small. When a significant industrial component exists or is planned within a collection system, an effective pretreatment program must be enacted to ensure toxic substances will not disrupt the biological treatment process.

Lack of description or criteria for a unit process does not suggest it should not be used, only that consideration by the Department will be on the basis of information submitted with the design. Engineering data that may be required by the Department, for new process and application evaluation is included in Section 53.2 (Engineering and Performance Requirements for Innovative Wastewater Treatment Alternatives).

These standards are intended to define limiting values for items upon which an evaluation of such plans and specifications will be made by the Department; and to establish, as far as practicable, uniformity of practice. Users should also be cognizant of applicable federal requirements.

Where monitoring or sampling procedures are required within this document, the procedures and methods used to analyze each sample must follow the Standard Methods for the Examination of Water & Wastewater, 21st edition or its updates.

Deviations from the criteria are allowed on a case-by-case basis. The design engineer must submit a request, with appropriate technical justification, for a deviation from a specific section of the standards indicating how the criteria will be changed.

The terms "shall", "must" and "required" are used where practice is sufficiently standardized to permit specific delineation of requirements or where safeguarding of the public health or protection of water quality justifies such definite action. Other terms, such as "should," "may," "recommended," and "preferred," indicate desirable procedures or methods.

Definition of terms and their use in these standards is intended to be in accordance with GLOSSARY-WATER AND WASTEWATER CONTROL ENGINEERING, jointly prepared by APHA, ASCE, AWWA and WEF (formerly WPCF). The units of expression used are in accordance with those recommended in WEF (formerly WPCF) MANUAL OF PRACTICE NUMBER 6, UNITS OF EXPRESSION FOR WASTEWATER TREATMENT.

These standards are based on Circular DEQ-2, Montana Department of Environmental Quality, Design Standards for Wastewater Facilities, 1999 Edition, that were based on "The Recommended Standards for Wastewater Facilities", 1997 Edition, prepared by the Great Lakes - Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. Some modifications were prompted by the "Recommended Standards for Wastewater Facilities", 2004 Edition, prepared by the Great Lakes - Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. The Board of Environmental Review expresses its appreciation to the Great Lakes Upper Mississippi River

Board of State and Provincial Public Health and Environmental Managers for its contribution to public health and water quality protection.

CHAPTER 10

ENGINEERING REPORTS AND FACILITY PLANS

10. GENERAL

10.1 Project Submittals

The engineering report or facility plan, including project design criteria, must be submitted prior to submission of project plans and specifications. One draft copy of the engineering report or facility plan should be submitted for solicitation of comments from the Department. Two copies of the final engineering report or facility plan must be submitted. Upon approval, one copy will be stamped “approved,” dated, signed by a Department representative and returned to the applicant.

11. ENGINEERING REPORT OR FACILITY PLAN

For federal or state financed grant or loan projects, additional requirements may apply.

The Engineering Report or Facility Plan: identifies and evaluates wastewater related problems; assembles basic information; presents criteria and assumptions; examines alternate projects with preliminary layouts and cost estimates; describes financing methods, sets forth anticipated charges for users; reviews organizational and staffing requirements; offers a conclusion with a proposed project for client consideration and outlines official actions and procedures to implement the project. The planning document must clearly describe the benefits and purpose of the proposed project and must include sufficient detail to demonstrate that the proposed project meets applicable criteria.

The concept (including process description and sizing), factual data and controlling assumptions, and considerations for the functional planning of wastewater facilities are presented for each process unit and for the whole system. These data form the continuing technical basis for the detailed design and preparation of construction plans and specifications. Architectural, structural, mechanical, and electrical designs are usually excluded. Sketches may be desirable to aid in presentation of a project. Outline specifications of process units, special equipment, etc., are occasionally included.

Engineering Reports must be completed for minor collection system, pump station, and interceptor projects. Comprehensive Facility Plans must be completed or have been completed for projects involving new, expanded, upgraded, or rehabilitated wastewater treatment facilities and major collection, interceptor sewer, and pump station projects. The determination of classification as major or minor collection interceptor sewer and pump station projects will be made by the Department.

11.1 Engineering Reports

Engineering reports for minor sewer extensions, lift stations, and interceptors must contain the following and other pertinent information as required by the Department.

11.11 Problem Defined

Description of the existing system should include an evaluation of the conditions and problems needing correction.

11.12 Design Conditions

The anticipated average and peak flows and waste load for existing and ultimate conditions must be established. The basis of the projection of initial and future flows and waste loads must be included and must reflect the existing or initial service area and the anticipated future service area. Hydraulic and organic load information and data needed for new facilities are included in Sections 11.24 (Hydraulic Capacity) and 11.25 (Organic Capacity).

11.13 Impact on Existing Wastewater Facilities

The impact of the proposed project on all existing wastewater facilities including gravity sewers, lift stations, and treatment facilities must be evaluated.

11.14 Project Description

A written description of the project is required.

11.15 Drawings

Preliminary drawings identifying the site of the project, including the location and alignment of proposed facilities are required.

11.16 Design Criteria

Engineering design criteria to be used in design of the project must be included.

11.17 Site Information

Project site information should include topography, soils, geologic conditions, depth to bedrock, groundwater level, floodway or floodplain considerations, and other pertinent site information.

11.18 Alternative Selection/Analysis

The reasons for selection of the proposed alternative: including any lift station sites, feasibility and how the project fits into a long term plan, should be discussed.

11.19 Environmental Impacts

Adverse environmental impacts, including cumulative and secondary impacts, resulting from the project must be addressed along with mitigation efforts. Consideration should be given to minimizing any potential adverse environmental impacts of the proposed project. If appropriate, compliance with planning requirements of federal, state and local regulatory agencies must be documented.

11.2 Facility Plans

Facility Plans must be completed for wastewater treatment facilities, major collection systems, and interceptor sewers and pump stations serving major areas. Facility Plans must contain the following and other pertinent information as required by the Department.

11.21 Problem Evaluation and Existing Facility Review

a. Descriptions of existing system including condition and evaluation of problems needing correction.

b. Summary of existing and previous local and regional wastewater facility and related planning documents.

11.22 Planning and Service Area

The planning area and existing and potential future service area should be described on a drawing.

11.23 Population Projection and Planning Period

Present and predicted population must be based on a 20 year planning period. Phased construction of wastewater facilities should be considered in rapid growth areas. Sewers and other facilities with a design life in excess of 20 years should be designed for the extended period.

11.24 Hydraulic Capacity

11.241 Flow Definitions and Identification

The following flows for the design year must be identified and used as a basis for design for sewers, lift stations, wastewater treatment plants, treatment units, and other wastewater handling facilities. Where any of the terms defined in this section are used in these design standards, the definition contained in this section applies.

a. Design Average Flow

The design average flow is the average of the daily volumes to be received for a continuous 12-month period expressed as a volume per unit time. However, the design average flow for facilities having critical seasonal high hydraulic loading periods must be based on the daily average flow during the seasonal period.

b. Design Maximum Day Flow

The design maximum day flow is the largest volume of flow to be received during a continuous 24-hour period expressed as a volume per unit time.

c. Design Peak Hourly Flow

The design peak hourly flow is the largest volume of flow to be received during a one-hour period expressed as a volume per unit time.

d. Design Peak Instantaneous Flow

The design peak instantaneous flow is the highest recorded flow rate occurring for a period consistent with the recording equipment.

e. Design Maximum Month Flow

The design maximum month flow is the average daily flow received during the maximum calendar month, or 30 consecutive days, (whichever is greater) expressed as a volume per unit time

11.242 Hydraulic Capacity for Wastewater Facilities to Serve Existing Collection Systems

a. Projections must be made from actual flow data to the greatest extent possible, including the influence of infiltration and inflow. Seasonal variations in flow must be considered.

b. The probable degree of accuracy of data and projections must be evaluated. This reliability estimation should include an evaluation of the accuracy of existing data, as well as an evaluation of the reliability of estimates of flow reduction anticipated due to infiltration/inflow (I/I) reduction or flow increases due to elimination of sewer bypasses and backups.

c. Critical data and methodology used must be included. It is recommended that graphical displays of critical peak wet weather flow data (refer to 11.241 (b) (c) (d) and (e)) be included for a sustained wet weather flow period of significance to the project.

11.243 Hydraulic Capacity for Wastewater Facilities to Serve New Collection Systems

a. The sizing of wastewater facilities receiving flows from new wastewater collection systems must be based on an average daily flow of 100 gallons ($0.38m^3$) per capita plus wastewater flow from industrial plants and major institutional and commercial facilities unless water use data or other justification upon which to better estimate flow is provided.

b. The 100 gpcd figure must be used which, in conjunction with a peaking factor from equation (10-1), is intended to cover normal infiltration for systems built with modern construction techniques (refer to Section 31 Separation of Clear Water). An additional allowance should be made where conditions are unfavorable.

$$\frac{\text{Design Peak Hourly Flow}}{\text{Design Average Flow}} = \frac{\left(18 + \sqrt{P}\right)}{\left(4 + \sqrt{P}\right)} \qquad (10\text{-}1)$$

P = population in thousands

Source: Fair, G.M. and Geyer, J.C. "Water Supply and Waste-water Disposal" 1st Ed. John Wiley & Sons, Inc. New York, (1954), P. 136

c. If the new collection system is to serve existing development the likelihood of I/I contributions from existing service lines must be evaluated and wastewater facilities designed accordingly.

11.244 Combined Sewer Interceptors

In addition to the above requirements, interceptors for combined sewers must have capacity to receive sufficient quantity of combined wastewater for transport to treatment facilities to ensure attainment of the appropriate state and federal water quality standards.

11.25 Organic/Nutrient Capacity

11.251 Organic Load Definitions and Identification

Where applicable, the following organic loads for the design year must be identified and used as a basis for design of wastewater treatment facilities. Where any of the terms defined in this section are used in these design standards, the definition contained in this section applies.

a. Biochemical Oxygen Demand

The 5-day Biochemical Oxygen Demand (BOD_5) is defined as the amount of oxygen required to stabilize biodegradable organic matter under aerobic conditions within a five day period in accordance with "Standard Methods for the Examination of Water and Wastewater", latest edition. Total 5-day Biochemical Oxygen Demand ($TBOD_5$) is equivalent to BOD_5 and is sometimes used in order to differentiate carbonaceous plus nitrogenous oxygen demand from strictly carbonaceous oxygen demand.

The carbonaceous 5-day Biochemical Oxygen Demand ($CBOD_5$) is defined as BOD_5 less the nitrogenous oxygen demand of the wastewater. See "Standard Methods for the Examination of Water and Wastewater", latest edition.

1. Design Average BOD_5

The design average BOD_5 is generally the average of the organic load received for a continuous 12-month period for the design year expressed as weight per day. However, the design average BOD_5 for facilities having critical seasonal high loading periods must be based on the daily average BOD_5 during the seasonal period.

2. Design Maximum Day BOD_5

The design maximum day BOD_5 is the largest amount of organic load to be received during a continuous 24-hour period expressed as weight per day.

3. Design Peak Hourly BOD_5

The design peak hourly BOD_5 is the largest amount of organic load to be received during a one-hour period expressed as weight per day.

b. Total Nitrogen

Total nitrogen is the sum of organic nitrogen, ammonia, nitrite and nitrate (all expressed as N). Analytically, organic nitrogen and ammonia are typically reported as Total Kjeldahl Nitrogen (TKN). See "Standard Methods for the Examination of Water and Wastewater", latest edition.

1. Design Average Total Nitrogen

The design average total nitrogen loading is generally the average of the nitrogen load received for a continuous 12-month period for the design year expressed as weight per day. However, the design total nitrogen value for facilities having critical seasonal high loading periods must be based on the daily average total nitrogen load during the seasonal period.

2. Design Diurnal Peak TKN

The design diurnal peak TKN is the largest amount of TKN load to be received during a continuous 24-hour period expressed as weight per day. Where data are not available on TKN variation, a diurnal peak TKN load (lbs/day) of 2.0 times the average load must be assumed.

c. Total Phosphorus

Total phosphorus includes all orthophosphates and condensed phosphates, dissolved and particulate, organic and inorganic. See "Standard Methods for the Examination of Water and Wastewater", latest edition.

1. Design Average Total Phosphorus

The design average total phosphorus loading is generally the average of the phosphorus load received for a continuous 12-month period for the design year expressed as weight per day. However, the design total phosphorus value for facilities having critical seasonal high loading periods must be based on the daily average total phosphorus load during the seasonal period.

11.252 Design of Organic Capacity of Wastewater Treatment Facilities to Serve Existing Collection Systems.

a. Projections must be made from actual waste load data to the fullest extent possible.

b. Projections must be compared to Section 11.253 and an accounting made for significant variations from those values.

c. Impact of industrial sources must be documented. For projects with significant industrial contributions, evidence of adequate pretreatment strategies must be included, along with documentation that industries are aware of the pretreatment limitations and user costs associated with the project. Documentation of the individual industrial participation in the project plan including user charges must be provided.

d. Septage and leachate may contribute significant organic load and other materials which can cause operational problems and non-compliance with discharge permit limitations. The discharge of septage must be considered in evaluating the organic loading to the proposed treatment facility. See Appendix A (Handling and Treatment of Septage at a Wastewater Treatment Plant).

11.253 Organic Capacity of Wastewater Treatment Facilities to Serve New Collection Systems.

a. Public sewage treatment design must be on the basis of at least 0.20 pounds (0.09 kg) of BOD_5 per capita per day and 0.22 pounds (0.10 kg) of suspended solids per capita per day, unless information is submitted to justify alternate designs.
Nutrient loading must be on the basis of at least 0.033 pounds (0.015 kg) of Total Nitrogen per capita per day and 0.009 pounds (0.004 kg) of Total Phosphorus per capita per day, unless information is submitted to justify alternate designs.

b. Industrial contributions. Refer to Section 11.252(c).

c. Septage and leachate. Refer to Section 11.252(d).

d. Data from similar communities (i.e. municipalities, districts, etc.) with generally equivalent conditions may be utilized in the case of new systems. However, a thorough investigation that is adequately documented must be provided to the Department to establish the reliability and applicability of such data.

11.26 Wastewater Treatment Facility Design Capacity

The wastewater treatment facility design capacity is the design average flow at the design average BOD_5 for the most restrictive unit process. Refer to Sections 11.24 (Hydraulic Capacity) and 11.25 (Organic Capacity) for peaking factors that will be required.

11.27 State and Federal Treatment Standards

The facility plan must identify current and anticipated effluent requirements and describe how the proposed facility will comply with the standards. The effect of the State Nondegradation Policy, approved TMDL, and water quality standards must also be addressed.

11.28 Initial Alternative Development

The process of selection of wastewater treatment alternatives for detailed evaluation must be discussed in the facility plan. All wastewater management alternatives considered, including no action, and the basis for the engineering judgment for selection of the alternatives chosen for detailed evaluation, must be included.

11.29 Detailed Alternative Evaluation

The following must be included for the alternatives to be evaluated in detail.

a. Sewer System Revisions

The proposed revisions to the existing sewer system, including adequacy of portions not being changed by the project, must be discussed in the facility plan.

b. Wet Weather Flows

Facilities to transport and treat wet weather flows in a manner that complies with state and local regulations must be provided.

c. Site Evaluation

When a site must be used which is critical with respect to the following items, appropriate measures must be taken to minimize adverse impacts.

1. Compatibility of the treatment process with the present and planned future land use, including noise, potential odors, air quality, and anticipated sludge processing and disposal techniques, must be considered.

Non-aerated treatment ponds should not be used if excessive sulfate is present in the wastewater.

Wastewater treatment facilities should be separate from human habitation or any area likely to be built up within a reasonable future period and must be separated in accordance with state and local requirements. Refer to Section 93.21 (Distance from Habitation).

2. Zoning and other land use restrictions must be identified.

3. An evaluation of the accessibility and topography of the site must be submitted.

4. Area for future plant expansion must be identified.

5. Direction of prevailing wind must be identified. Other climatological data may be required.

6. Flood considerations, including the 25 and 100 year flood levels, impact on floodplain and floodway, and compliance with applicable regulations regarding construction in flood prone areas, must be evaluated. Refer to Section 51.2 (Flood Protection) for requirements.

7. Geologic information, depth to bedrock, karst features, or other geologic considerations of significance to the project must be included. Lagoons must not be located in karst areas unless the specific geologic and construction details are acceptable.

8. Protection of groundwater including public and private wells is of utmost importance. Demonstration that protection will be provided must be included. The Department must be contacted for required separation. Protection for water wells within 1,000 feet of the design high water mark of any sewage ponds must be in accordance with ARM 17.30.1702.

9. Soil type and suitability for construction and depth to normal and seasonal high groundwater must be identified.

10. The location, depth, and discharge point of any field tile in the immediate area of the proposed site must be identified.

11. A preliminary assessment of site availability must be included.

12. Present and known future effluent quality requirements determined by the Department must be included.

13. Access to the receiving stream for the outfall line must be discussed and displayed.

14. Historical, archeological, or paleontological resources in the immediate area of the proposed project boundary must be identified.

15. Any wetlands within the proposed project boundary must be identified.

16. Federal Aviation Administration (FAA) site determination criteria must be evaluated.

17. Unique, endangered, fragile, or limited environmental resources, including federally listed threatened or endangered species must be identified.

18. Where spray irrigation is proposed for effluent disposal, a summary of all applicable site characteristics (i.e. soil permeability, soil water holding capacity, soil salinity and sodium adsorption ratio, soil pH, nitrogen concentrations in existing soils, topography, geologic factors, etc.) must be included.

d. Unit Sizing

Unit operation and unit process sizing and basis must be provided.

e. Flow Diagram

Flow diagram of treatment facilities including all recycle flows must be provided.

f. Emergency Operation

Emergency operation requirements as outlined in Section 47 (Emergency Operation) and 56.1 (Emergency Power Facilities) must be provided. State or local regulatory agencies may have more stringent requirements.

g. Technology Not Included in These Standards

Proposals to use technology and procedures for introducing and obtaining approval to use technology not included in these standards must address the requirements of Section 53.2 (Engineering and Performance Requirements for Innovative Wastewater Treatment Alternatives).

h. Sludge

The solids disposal options considered and method selected must be included. This is critical to completion of a successful project. Compliance with requirements of Chapter 80 (Sludge Processing, Storage, and Disposal), must be assured.

i. Treatment During Construction

A plan for the method and level of treatment to be achieved during construction must be developed and included in the facility plan for review and approval by the Department. This approved treatment plan must be implemented by inclusion in the plans and specifications to be bid for the project. Refer to Section 20.15 (Operation

During Construction) and Section 21 (Specifications).

For facilities with a discharge permit, appropriate personnel in the Department's Permitting program must be notified of a planned unit bypass as required in the discharge permit.

j. Plan of Operation / Start-Up Protocol

A Plan of Operation for the start-up the new facility may be required by the Department. The hiring and/or training of wastewater treatment operator(s), required operation and maintenance practices, and projected costs of operation and maintenance may be required.

k. Operation and Maintenance

Portions of the project which involve complex operation or maintenance requirements must be identified including laboratory requirements for operation, industrial sampling, and self-monitoring. In all cases, an operation and maintenance manual will be required unless waived by the Department.

l. Cost Estimates

Cost estimates for capital, operation and maintenance (including basis), engineering services (i.e. design, construction, inspection, etc.), administration, and contingencies must be included. An economic analysis (i.e., a present worth analysis) of these costs must also be included.

m. Staffing Requirements

Consideration must be given to operator requirements and their related impacts to the operation and maintenance budget for the alternatives proposed. Current wastewater treatment system classifications and corresponding certifications are found in ARM 17.40.202.

For more complex treatment systems (e.g., membrane bioreactors, biological nutrient removal, sequencing batch reactors, etc.), two or more full-time operators, with formal training specific to system operations are strongly recommended. A back-up operator is recommended for all systems.

n. Environmental Review

Environmental impacts, including cumulative and secondary impacts, of each alternative must be evaluated. Impacts on the physical environment and human population, as outlined under the Montana Environmental Policy Act (MEPA), must be considered. Consideration must be given to minimizing any potential adverse environmental impacts of the proposed project. Compliance with planning requirements of federal, state, and local regulatory agencies must be documented. Environmental information provided on the proposed project will be used by the Department in complying with review procedures required under MEPA and related administrative rules.

11.30 Final Project Selection

The project selected from the alternatives considered under Section 11.29 (Detailed Alternative Evaluation) must be set forth in the final facility plan document to be forwarded to the Department for review and approval, including the financing considerations and recommendations for implementation of the plan. Evidence that the owner agrees (e.g., council resolution) with the recommendations of the plan should be provided.

CHAPTER 20
ENGINEERING PLANS AND SPECIFICATIONS

20. PLANS AND SUPPORT DOCUMENTS

Submissions to the Department, prepared by a professional engineer licensed in Montana, must include sealed plans, specifications, design report criteria, capacity development information required in Appendix E (Capacity Development for Wastewater Systems), and plan review fee, if required.

Complete final plans must be submitted at least 60 days prior to the date on which action by the Department is desired. No approval for construction can be issued until final, detailed plans and specifications have been submitted and approved by the Department. Three copies of the final plans must be submitted. Documentation must be provided that indicates the owner will provide as-built drawings of the project, prepared by a registered professional engineer, and a certification letter as required in ARM 17.38.101.

Upon approval, one set of the approved plans and specifications will be stamped “approved”, dated, signed by a Department representative, and returned to the applicant. Construction of the project must be completed within three years of the Department approval date or the approval is void. If more than three years elapse before completing construction; plans, specifications, and appropriate review fees must be resubmitted for review and approval by the Department before construction can begin.

Within 90 days following completion of project construction, a professional engineer registered in Montana must certify that the project was built in accordance with the approved plans and specifications and a complete set of certified “as-built” drawings must be submitted to the Department. The project (or portion of the project to be activated) may not be placed into service until the project engineer certifies by letter to the Department that the project (or activated portion of the project) was constructed in accordance with the plans and specifications approved by the Department.

20.1 General

20.11 Plan Title

All plans for wastewater facilities must bear a suitable title showing the name of the municipality, sewer district, or institution. They must show the scale in feet or metric measure, a graphical scale, the north point, date, and the name of the engineer, with his or her certificate number and imprint of the registration seal. A space should be provided for signature and/or approval stamp of the Department.

20.12 Plan Format

The plans must be clear and legible (suitable for microfilming). They must be drawn to a scale which will permit all necessary information to be plainly shown. Generally, the size of the plans should not be larger than 22 inches x 34 inches (559 mm x 864 mm). Datum used should be indicated. Locations and logs of test borings, when required, must be shown on the plans.

20.13 Plan Contents

Detail plans must consist of: plan views, elevations, sections, and supplementary views which, together with the specifications and general layouts, provide the working information for the contract and construction of the facilities. They must also include: dimensions and relative elevations of structures, the location and outline form of equipment, location and size of piping, water levels, and ground elevations.

20.14 Design Criteria

Design criteria must be included on all plans and a hydraulic profile must be included for all wastewater treatment facilities. For sewer and lift station projects, information must be submitted to verify adequate downstream sewer, pump station, and treatment plant capacity.

20.15 Operation During Construction

Project documents must specify the procedure for operation during construction that complies with the plan required by Section 11.29 (i) (Treatment During Construction). This procedure must explain the roles and responsibilities of all persons or parties involved in the project.

20.2 Plans of Sewers

20.21 General Plan

A comprehensive plan of existing and proposed sewers must be submitted for projects involving new sewer systems and substantial additions to existing systems. This plan must show the following:

20.211 Geographical Features

a. Topography and elevations - Existing or proposed streets and all streams or water surfaces must be clearly shown. Contour lines at suitable intervals should be included.

b. Streams - The direction of flow in all streams, and high and low water elevations of all water surfaces at sewer outlets and overflows must be shown.

c. Boundaries - The boundary lines of the municipality or the sewer district, and the area to be sewered, must be shown.

20.212 Sewers

The plan must show the location, size, and direction of flow of relevant existing and proposed sanitary and combined sewers draining to the treatment facility concerned.

20.22 Detail Plans

Detail plans must be submitted. Profiles should have a horizontal scale of not more than 100 feet to the inch (1200:1) and a vertical scale of not more than 10 feet to the inch (120:1). Plan views must be drawn to a corresponding horizontal scale and must be shown on the same sheet. Plans and profiles must show:

a. Location of streets and sewers;

b. Line of ground surface; size, material, and type of pipe; length between manholes; invert and surface elevation at each manhole; and grade of sewer between each adjacent manhole (all manholes must be numbered on the profile);

Where there is any question of the sewer being sufficiently deep to serve any residence, the elevation and location of the basement floor must be plotted on the profile of the sewer which is to serve the house in question. The engineer shall state that all sewers are sufficiently deep to serve adjacent basements except where otherwise noted on the plans;

c. Locations of all special features such as inverted siphons, concrete encasements, elevated sewers, etc.;

d. All known existing structures and utilities, both above and below ground, which might interfere with the proposed construction or require a setback, particularly water mains and water supply structures (i.e., wells, clear wells, basins, etc.), gas mains, storm drains, and telephone and power conduits;

e. Detail drawings, made to a scale to clearly show the nature of the design, must be furnished to show the following particulars:

All stream crossings and sewer outlets, with elevations of the stream bed and normal and extreme high and low water levels;

Details of all special sewer joints and cross sections;

Details of all sewer appurtenances such as manholes, lampholes, inspection chambers, inverted siphons, regulators, tide gates, and elevated sewers.

20.3 Plans of Sewage Pumping Stations

20.31 Location Plan

A plan must be submitted for projects involving construction or revision of pumping stations. This plan must show the following:

a. The location and extent of the tributary area;

b. Any municipal boundaries within the tributary area;

c. The location of the pumping station and force main, and pertinent elevations.

20.32 Detail Plans

Detail plans must be submitted showing the following, where applicable:

a. Topography of the site;

b. Existing pumping station;

c. Proposed pumping station, including provisions for installation of future pumps or ejectors;

d. Elevation of high water at the site, and maximum elevation of wastewater in the collection system upon occasion of power failure;

e. Maximum hydraulic gradient in force main (including surge) and downstream gravity sewers when all installed pumps are in operation;

f. Test borings and groundwater elevations.

20.4 Plans of Wastewater Treatment Plants

20.41 Location Plan

A plan must be submitted showing the wastewater treatment plant in relation to the remainder of the system.

Sufficient topographic features must be included to indicate the plant's location with relation to streams and the point of discharge of treated effluent.

20.42 General Layout

Layouts of the proposed wastewater treatment plant must be submitted, showing:

- **a.** Topography of the site;
- **b.** Size and location of plant structures;
- **c.** Schematic flow diagram(s) showing the flow through various plant units, and showing utility systems serving the plant processes;
- **d.** Piping, including any arrangements for bypassing individual units (materials handled and direction of flow through pipes must be shown);
- **e.** Hydraulic profiles showing the flow of wastewater, supernatant liquor, and sludge;
- **f.** Test borings and groundwater elevations.
- **g.** All wells located within 1,00 feet of the design high water mark of the sewage pond(s). Wells must meet the setback distance to sewage ponds as established in ARM 17.30.1702.

20.43 Detail Plans

Detail plans must show the following, where applicable:

- **a.** Location, dimensions, capacities, volumes, and elevations of all existing and proposed plant facilities;
- **b.** Elevations of high and low water level of the body of water to which the plant effluent is to be discharged;
- **c.** Type, size, pertinent features and operating capacity of all pumps, blowers, motors, and other mechanical devices;
- **d.** Minimum, design average, and peak hourly hydraulic flow in profile;
- **e.** Adequate description of any features not otherwise covered by specifications or engineering report.

21. SPECIFICATIONS

Complete signed and sealed detailed technical specifications must be submitted for the construction of sewers, wastewater pumping stations, wastewater treatment facilities, and all other appurtenances, and must accompany the plans.

The specifications accompanying construction drawings plans must include, but are not limited to, specifications for the approved procedures for operation during construction in accordance with Sections 11.29(i) (Treatment During Construction) and 20.15 (Operation During Construction), all construction information not shown on the plans which is necessary to inform the builder in detail of the design requirements for the quality of materials, workmanship, and fabrication of the project.

The specifications must also include: the type, size, strength, operating characteristics, and rating of equipment; allowable infiltration; the complete requirements for all mechanical and electrical equipment, including machinery, valves, piping and jointing of pipe; electrical apparatus, wiring, instrumentation, and meters; laboratory fixtures and equipment; operating tools, construction materials; special filter materials, such as, stone, sand, gravel, or slag; miscellaneous appurtenances; chemicals when used; instructions for testing materials and equipment as necessary to meet design standards; and performance tests for the completed works and component units. It is suggested that these performance tests be conducted at design load conditions wherever practical.

22. REVISIONS TO APPROVED PLANS

Changes to the approved plans or specifications affecting public safety, capacity, flow, operation of units, or point of discharge must be approved in writing, before such changes are made. Plans or specifications so revised should be submitted well in advance of any construction work which will be affected by such changes to allow sufficient time for review and approval. Structural revision or other minor changes not affecting capacities, flows or operation will be permitted during construction without approval.

"As built" plans clearly showing such alterations must be submitted to the Department at the completion of the work.

23. ADDITIONAL INFORMATION REQUIRED

The Department may require additional information which is not part of the plans, such as head loss calculations, pump curves, buoyancy calculations, proprietary technical data, copies of deeds, copies of contracts, etc.

24. DEVIATIONS FROM STANDARDS

The DEQ Deviation Review Committee, on a case-by-case basis for specific projects, may grant deviations from the mandatory requirements of these standards.

24.1 Procedure

A professional engineer desiring a deviation shall make a request in writing on the Department of Environmental Quality *Public Water and Sewage System Deviation Request for Deviations Submitted by a Professional Engineer* form. The deviation request must identify the specific standards to be considered and the proposed change to that standard. Adequate justification for the deviation must be provided. "Engineering judgment" or "professional opinion" without supporting data is not considered adequate justification. Multiple deviations must be completed on separate deviation forms.

A panel of three persons from the Department will review the request and make a final determination on whether or not a deviation may be granted. A file of all deviations will be maintained by the Department.

25. OPERATION & MAINTENANCE MANUAL

A complete and comprehensive Operation and Maintenance Manual (O&M Manual) is required when expanding, modifying, or constructing new wastewater treatment and disposal facilities and sewage lift stations. Two copies of the O&M Manual are required and must be submitted to DEQ for review and approval prior to start-up of the new facility. Once approved by DEQ, a copy of the O&M Manual will be marked approved and provided to the owner for the treatment facility. If requested by the Owner and acceptable to the Department, the O&M manual may be submitted electronically for review and approval.

The O&M Manual must include the following minimum information: facility description, process description, start-up procedures, routine operation and maintenance responsibilities/requirements (including manufacturer's service and maintenance recommendations and operational protocols should the PLC unit fail), MBR cleaning strategies (if applicable), trouble-shooting, equipment and component contact information, monitoring and sampling plan for operational purposes and permit requirements, solids handling plan, record keeping, operator safety (including emergency contact numbers), an emergency operating response plan for the facility, and warranty information.

The design engineer must be retained by the system owner to provide technical assistance during system start-up and to modify the manual as needed during the first year of operation.

Section E.4 of Appendix E (Capacity Development for Wastewater Systems) includes additional financial O&M information that may be required by DEQ prior to approval of the project.

CHAPTER 30

DESIGN OF SEWERS

31. SEPARATION OF CLEAR WATER

Sewers must be designed for municipal wastewater only. Rain water from roofs, streets, and other areas, and groundwater from foundation drains must not be permitted in municipal wastewater sewers.

32. DESIGN CAPACITY AND DESIGN FLOW

In general, sewer capacities should be designed for the estimated ultimate tributary population, except in considering parts of the systems that can be readily increased in capacity. Similarly, consideration should be given to the maximum anticipated capacity of institutions, industrial parks, etc. See Sections 11.24 (Hydraulic Capacity) and 20.2 (Plans of Sewers).

33. DETAILS OF DESIGN AND CONSTRUCTION

33.1 Minimum Size

A gravity sewer main conveying raw wastewater must be at least 8 inches (203 mm) in diameter, except gravity sewer mains within private property. Trailer courts, condominiums, apartments, etc. are allowed mains no smaller than 6 inches in diameter, provided that the 6 inch diameter main can be shown to be hydraulically feasible, that no future expansion is anticipated, and that maintenance will not be increased due to the smaller diameter.

33.2 Depth

In general, sewers should be sufficiently deep to receive wastewater from basements and to prevent freezing. The minimum depth of bury must not be less than 4 feet (to the top of pipe) without justification by the design engineer. The prevailing local building code must be used in determining the maximum frost depth; however, the designer must consider increasing that depth if the site is located where local information suggests greater frost penetration. Insulation must be provided for sewers that cannot be placed at a depth sufficient to prevent freezing. Insulation used for this purpose must be specifically designed to withstand compaction and for use in subsurface locations. It must retain the insulating value for the design life of the sewer.

33.3 Buoyancy

Buoyancy of sewers and manholes must be considered and flotation of the component must be prevented with appropriate construction where high groundwater conditions are anticipated.

33.4 Slope

33.41 Recommended Minimum Slopes

Sewers 48 inches (1200 mm) or larger should be designed to give mean velocities, when flowing full, of not less than 3.0 feet per second (0.9 m/s), based on Manning's Formula using an "n" value of 0.013.The following are the minimum slopes that must be provided; however, slopes greater than these are desirable:

Sewer Size	Minimum Slope in Feet Per 100 Feet (m/100m)
6 inch (152 mm)	0.60
8 inch (203 mm)	0.40
10 inch (254 mm)	0.28
12 inch (305 mm)	0.22
14 inch (356 mm)	0.17
15 inch (381 mm)	0.15
16 inch (406 mm)	0.14
18 inch (457 mm)	0.12
21 inch (533 mm)	0.10
24 inch (610 mm)	0.08
27 inch (686 mm)	0.067
30 inch (762 mm)	0.058
33 inch (838 mm)	0.052
36 inch (914 mm)	0.046
39 inch (991 mm)	0.041
42 inch (1067 mm)	0.037

33.42 Minimum Flow Depth

Pipe slopes slightly less than those required may be permitted, only under extenuating circumstances, through an approved deviation. Such decreased slopes will only be considered where the depth of flow will be 0.3 of the diameter or greater for design average flow. The operating authority of the sewer system will give written assurance to the Department that any additional sewer maintenance required by reduced slopes can be provided.

33.43 Minimize Solids Deposition

The pipe diameter and slope must be selected to obtain the greatest practical velocities to minimize settling problems. Oversize sewers will not be approved to justify using flatter slopes. If the proposed slope is less than the minimum slope of the smallest pipe which can accommodate the design peak hourly flow, the actual depths and velocities at minimum, average, and design maximum day and peak hourly flow for each design section of the sewer must be calculated by the design engineer and included within the design report.

33.44 Slope Between Manholes

Sewers must be laid with uniform slope between manholes.

33.45 High Velocity Protection

Where velocities greater than 15 feet per second (4.6 m/s) are attained, special provision must be made to protect against displacement by erosion and impact.

33.46 Steep Slope Protection

Sewers on 20 percent slopes or greater must be anchored securely with concrete, or equal, with anchors spaced as follows (as a minimum):

a. Not over 36 feet (11 m) center to center on grades 20 percent and up to 35 percent;

b. Not over 24 feet (7.3 m) center to center on grades 35 percent and up to 50 percent;

c. Not over 16 feet (4.9 m) center to center on grades 50 percent and over.

33.5 Alignment

Sewers 24 inches (610 mm) or less in diameter must be laid with straight alignment between manholes. Straight alignment must be checked by either using a laser beam or lamping.

Curvilinear alignment of sewers larger than 24 inches (610 mm) may be considered on a case-by-case basis providing compression joints are specified and ASTM or specific pipe manufacturers' maximum allowable pipe joint deflection limits are not exceeded. Curvilinear sewers must be limited to simple curves which start and end at manholes. When curvilinear sewers are proposed, the required minimum slopes indicated in 33.41 (Recommended Minimum Slopes) must be increased accordingly to provide a minimum velocity of 2.0 feet per second (0.6 m/s) when flowing full.

33.6 Changes in Pipe Size

When a smaller sewer joins a large one, the invert of the larger sewer should be lowered sufficiently to maintain the same energy gradient. An approximate method for securing these results is to place the 0.8 depth point of both sewers at the same elevation.

Sewer extensions should be designed for projected flows even when the diameter of the receiving sewer is less than the diameter of the proposed extension. Special consideration should be given to minimizing turbulence when designing a flow channel within a manhole where there is a change in pipe size. The Department may require a schedule for construction of future downstream sewer relief.

33.7 Materials

Any generally accepted material for sewers will be given consideration, but the material selected should be adapted to local conditions, such as: character of industrial wastes, possibility of septicity, soil characteristics, exceptionally heavy external loadings, abrasion, corrosion, and similar problems.

Suitable couplings complying with ASTM specifications must be used for joining dissimilar materials. The leakage limitations on these joints must be in accordance with Section 33.92 (Leakage Tests).

All sewers must be designed to prevent damage from superimposed live, dead, and frost induced loads. Proper allowance must be made for loads on the sewer because of soil and potential groundwater conditions, as well as the width and depth of the trench. Where necessary, special bedding, haunching and initial backfill, concrete cradle, or other special construction must be used to withstand anticipated potential superimposed loading or loss of trench wall stability. See ASTM D 2321 or ASTM C 12 when appropriate.

For new pipe materials for which ASTM standards have not been established, the design engineer shall provide complete pipe specifications and installation specifications developed on the basis of criteria adequately documented and certified in writing by the pipe manufacturer to be satisfactory for the specific application.

33.8 Installation

33.81 Standards

Installation specifications must contain appropriate requirements based on the criteria, standards, and requirements established by industry in technical publications. Requirements must be set forth in the project specifications for the pipe and methods of bedding and backfilling the pipe so as not to damage the pipe or its joints, impede cleaning operations and future tapping, or create excessive side fill pressures and ovalation of the pipe, or impair flow capacity.

33.82 Trenching

a. The width of the trench must be ample enough to allow the pipe to be laid and jointed properly and to allow the bedding and haunching to be placed and compacted to adequately support the pipe. The trench sides must be kept as nearly vertical as possible. When wider trenches are specified, appropriate bedding class and pipe strength must be used.

All trenches must be constructed according to current Montana Department of Labor and Industry or O.S.H.A. standards, as appropriate. In unsupported, unstable soil, the size and stiffness of the pipe, stiffness of the embedment and *in-situ* soil and depth of cover must be considered in determining the minimum trench width necessary to adequately support the pipe.

b. Ledge rock, boulders and large stones must be removed to provide a minimum clearance of 4 inches (102 mm) below and on each side of all pipe(s).

33.83 Pipe Bedding Materials and Placement

a. Type 1 Pipe Bedding includes the material placed from 4 inches (100 mm) below the bottom of the pipe, around the pipe, and up to the springline of the pipe.

Provide Type 1 Bedding consisting of sand, sandy gravel, or gravel having a maximum 3/4 inch size (19 mm) and a maximum plasticity index of 6, determined by AASHTO T89 and T90 or by ASTM D4318.

Where trench excavation encounters wet or unstable material, Type 1 Pipe Bedding must be free draining and non-plastic.

Refer to Standard Drawing 02221-1 and Special Provisions for other requirements.

b. Select Type 1 Bedding includes the material placed from the springline of the pipe to 6 inches (15 cm) over the pipe.

Select Type I Bedding shall consist of soil, sand or fine gravel, free from clods, lumps of frozen material, or rock exceeding 1-1/2 inches (38 mm) in its greatest dimension.

Excavated trench material may be screened or sorted for use as backfill subject to approval of the Engineer.

Where trench excavation encounters wet or unstable material, Select Type 1 Bedding must be free draining and non-plastic.

c. Type 2 Pipe Bedding is used as directed by the Engineer to replace unsuitable material encountered in the trench bottom.

Place Type 2 Pipe Bedding from the bottom of the Type 1 Bedding material to the depth required to adequately support the pipe.

Type 2 Bedding shall consist of granular material meeting the following gradation:

Sieve Opening	% Passing
3 Inch -	100
No. 4 0 -	25
No. 8 0 –	10

d. Place in maximum 6” lifts and compacted to 95% of Maximum Dry Density as determined using AASHTO T-99 or ASTM D698.

e. All water entering the excavations or other parts of the work must be removed until all the work has been completed. No sanitary sewer may be used for the disposal of trench water A construction Dewatering Discharge Permit, issued by the Department, is required if water from construction is discharged to state waters. The Department must be contacted immediately if either contaminated soil or contaminated groundwater is encountered. If contamination is anticipated, an acceptable plan for handling and disposal must be submitted to the Department for approval.

33.84 Trench Backfill

a. Final trench backfill must be of a suitable material removed from the excavation except where other material is specified. Debris, frozen material, clods or stones larger than 8 inches, organic matter, or other unstable materials may not be used for final backfill within 1 foot (304.8 mm) of the top of the pipe.

Type A trench backfill used in streets and paved areas must be placed in 8 inch (203 mm) lifts within 3 percent of optimum moisture content and compacted to at least 95 percent of maximum dry density determined by AASHTO T99 or by ASTM D698 or as recommended by a geotechnical engineer.

Type B trench backfill used for unpaved alleys, cultivated areas, borrow pits, unimproved streets, or other unsurfaced areas must be placed in 8 inch (203 mm) lifts within 3 percent of optimum moisture content and compacted to at least 90 percent of maximum dry density determined by AASHTO T99 or by ASTM D698 or as recommended by a geotechnical engineer.

Type C trench backfill used in open and unimproved areas outside of the public right-of-way must be placed in 12 inch (304.8 mm) lifts at densities equal to or greater than the densities of adjoining undisturbed soils.

b. Final backfill must be placed in such a manner as not to disturb the alignment of the pipe.

33.85 Deflection Test

a. The Engineer has the option of requiring deflection testing of a portion, or all, of flexible pipe installations to assure the quality of construction. Flexible pipe is considered a conduit that will deflect at least 2 percent without any sign of structural distress.

Deflection tests, when performed on PVC pipe, must be conducted in accordance with ASTM D3034 and must satisfy either of the following deflection limitations:

Minimum Period Between Trench Backfilling & Testing	Minimum Mandrel Diameter as a Percent of Inside Pipe Diameter
7 days	95.0
30 days	92.5

b. If deflection exceeds the specified limits, replacement or correction must be accomplished in accordance with requirements in the approved specifications.

c. The rigid ball or mandrel used for the deflection test must have a diameter of at least 95 percent or 92.5 percent (depending on the time of test) of the base inside diameter or average inside diameter of the pipe depending on which is specified in the ASTM Specification, including the appendix, to which the pipe is manufactured. The pipe must be measured in compliance with ASTM D 2122 Standard Test Method of Determining Dimensions of Thermoplastic Pipe and Fittings. Mandrels must have at least nine arms. The test must be performed without mechanical pulling devices.

d. Deflection testing requirements for flexible pipe, other than PVC, must be determined by the design engineer.

33.9 Joints and Infiltration

33.91 Joints

The installation of joints and the materials used must be included in the specifications. Sewer joints must be designed to minimize infiltration and to prevent the entrance of roots throughout the life of the system.

33.92 Leakage Tests

Leakage tests must be specified. This may include appropriate water or low pressure air testing. The testing methods selected should take into consideration the range in groundwater elevations during the test and anticipated during the design life of the sewer.

Sewers with active service connections may be leak tested via video inspection.

a. Water (Hydrostatic) Test

The leakage exfiltration or infiltration may not exceed 200 gallons per inch of pipe diameter per mile per day (0.019 m^3/mm of pipe dia/km/day) for any section of the system. An exfiltration or infiltration test must be performed with a minimum positive head of 2 feet (610 mm).

b. Air Test

The air test must, at a minimum, conform to the test procedure described in ASTM C-828-86 for clay pipe, ASTM C 924 for concrete pipe, UNI-B-690 low pressure test for PVC pipe. For other materials, test procedures must be approved by the Department.

33.93 Service Connections

Service connections to the sewer main must be water tight and may not protrude into the sewer. If a saddle type connection is used, it must be a pre-manufactured device that is designed to join the types of pipe that are to be connected. All materials used to make service connections must be compatible with each other and with the pipe materials to be joined. All materials must be corrosion resistant.

33.10 Casing Piping

Where casing pipe is used to carry sewers at horizontal borings, stream crossings, water line crossings and other locations, the pipe must conform to the slope requirements of Section 33.4 (Slope), if necessary, and must be rated for the structural and environmental conditions to which it will be exposed. The engineer must provide supporting manufacturer's documentation and calculations as necessary to justify the type and size of casing pipe proposed.

34. MANHOLES

34.1 Location

Manholes must be installed: at the end of each sewer line; at all changes in grade, size, or alignment; at all intersections; and at distances not greater than 400 feet (122 m) for sewers 15 inches (381 mm) or less in diameter; and 500 feet (152 m) for sewers 18 inches (457 mm) to 30 inches (762 mm). Greater spacing may be permitted in larger sewers at the discretion of the Department.

Distances up to 600 feet (183 m) may be approved where cleaning equipment for the stated spacing is provided. Documentation must be provided that such cleaning equipment is readily available and has the cleaning capability stated. Cleanouts may be used only for special conditions and may not be substituted for manholes or installed at the end of laterals greater than 150 feet (46 m) in length.

34.2 Drop Type

A drop pipe must be provided for a sewer entering a manhole at an elevation of 24 inches (610 mm) or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than 24 inches (610 mm), the invert should be filleted to prevent solids deposition.

Drop manholes should be constructed with an outside drop connection. Inside drop connections (when necessary) must be secured to the interior wall of the manhole and provide access for cleaning.

Due to the unequal earth pressures that would result from the backfilling operation in the vicinity of the manhole, the entire outside drop connection must be encased in concrete.

34.3 Diameter

The minimum inside diameter for manholes is 48 inches (1.22 m); larger diameters are preferable for large diameter sewers. A minimum access diameter of 22 inches (559 mm) must be provided.

34.4 Flow Channel

The flow channel straight through a manhole should be made to conform as closely as possible in shape and slope to that of the connecting sewers. For pipes greater than 8 inches (203 mm) in diameter, the channel walls must be formed or shaped to the full height of the crown of the outlet sewer in such a manner as to not obstruct maintenance, inspection or flow in the sewers. For pipes 8 inches (203 mm) or less in diameter, the channel must be formed at least to the spring line of the pipe.

When curved flow channels are specified in manholes, including branch inlets, or when entrance or exit losses are significant, minimum slopes indicated in Section 33.41 (Recommended Minimum Slopes), must be increased to maintain acceptable velocities.

34.5 Bench

A bench must be provided on each side of any manhole channel when the pipe diameter(s) are less than the manhole diameter. The bench should be sloped no less than 1/2 inch (13 mm) per foot (305 mm) (4 percent). A lateral sewer, service connection, or drop manhole pipe may not discharge onto the surface of the bench.

34.6 Watertightness

Manholes must be of the pre-cast concrete or poured-in-place concrete type. Manholes must be waterproofed on the exterior. Pre-cast concrete manhole sections manufactured in accordance with ASTM C 478M-93 (with Section 16 rejection requirements made mandatory) are exempt from the exterior waterproofing requirement. Manhole lift holes and grade adjustment rings must be sealed with non-shrinking mortar or other material approved by the Department.

Inlet and outlet pipes must be joined to the manhole with a gasketed flexible watertight connection or any watertight connection arrangement that allows differential settlement of the pipe and manhole wall to take place.

Watertight manhole covers must be used wherever the manhole tops may be flooded by street runoff or high water. Locked manhole covers may be desirable in isolated easement locations or where vandalism may be a problem.

34.7 Inspection and Testing

The specifications must include a requirement for inspection and testing for watertightness or damage prior to placing into service.

Vacuum testing, if specified for concrete sewer manholes, must conform to the test procedures described in ASTM C 1244.

Water testing will only be allowed where groundwater is below the bottom of the manhole during testing. Hydrostatic testing shall be conducted by sealing all pipe penetrations to the manhole and filling the manhole to the top of the manhole cone with water. Water may be added over a 24-hour period to compensate for losses due to evaporation and absorption. Following the 24-hour saturation period any loss of water within a 30-minute period shall be a failed test and the manhole must be rejected.

34.8 Corrosion Protection for Manholes

Where corrosive conditions, due to septicity or other causes, are anticipated, consideration must be given to providing corrosion protection on the interior of the manholes.

34.9 Electrical

Electrical equipment installed or used in manholes must conform to Section 42.35 (Electrical Equipment).

35. INVERTED SIPHONS

Inverted siphons must not have less than two barrels, with a minimum pipe size of 6 inches (152 mm). They must be provided with necessary appurtenances for maintenance, convenient flushing, and cleaning equipment. The inlet and discharge structures must have adequate clearances for cleaning equipment, inspection, and flushing. Design must provide sufficient head and appropriate pipe sizes to secure velocities of at least 3 feet per second (0.92 m/s) for design average flows. The inlet and outlet details must be arranged so that the design average flow is diverted to one barrel, and so that either barrel may be taken out of service for cleaning. The vertical alignment should permit cleaning and maintenance.

36. SEWERS IN RELATION TO STREAMS

36.1 Location of Sewers in Streams

36.11 Cover Depth

The top of all sewers entering or crossing streams must be at a sufficient depth below the natural bottom of the stream bed to protect the sewer. In general, the following cover requirements must be met:

a. One foot (0.3 m) of cover where the sewer is located in rock;

b. Three feet (0.9 m) of cover in other material. In streams with high seasonal flows or streams with an alluvial foundation, more than three feet (0.9 m) of cover may be required. The engineer must provide scour analysis to justify the bury depth in these cases;

c. In paved stream channels, the top of the sewer should be placed below the bottom of the channel pavement.

Less cover will be approved only if the proposed sewer crossing will not interfere with future improvements or reasonably anticipated natural changes to the stream channel. Reasons for requesting less cover must be provided in the project proposal.

36.12 Horizontal Location

Sewers located along streams must be located outside of the stream bed and sufficiently removed from the stream bed to provide for future possible stream widening and to prevent pollution by siltation during construction.

36.13 Structures

The sewer outfalls, headwalls, manholes, gate boxes, or other structures must be located so they do not interfere with the free discharge of flood flows of the stream.

36.14 Alignment

Sewers crossing streams should be designed to cross the stream as nearly perpendicular to the stream flow as possible and must be free from change in grade. Sewer systems must be designed to minimize the number of stream crossings. Trenchless construction technologies should be considered for stream crossings to avoid the impacts of open cut construction.

36.2 Construction

36.21 Materials

Sewers entering or crossing streams must be constructed so they will remain watertight and free from changes in alignment or grade. The use of a casing pipe to carry the sewer is recommended. Crossings constructed of ductile iron or PVC pipe must have restrained mechanical joints when not encased in concrete. When a casing pipe is not utilized for PVC or HDPE pipe, encasement in concrete is required. Material used to backfill the trench must be stone, coarse aggregate, washed gravel, or other materials that will not readily erode, cause siltation, damage pipe during placement, or corrode the pipe.

36.22 Siltation and Erosion

Construction methods that will minimize siltation and erosion must be used. The design engineer shall include in the project specifications the method(s) to be employed in the installation of sewers in or near streams. Best management practices (BMP's) must be utilized during construction. Such methods must provide adequate control of siltation and erosion by limiting unnecessary excavation, disturbing or uprooting of trees and vegetation, dumping of soil or debris, or pumping of silt-laden water into the stream. Specifications must require that cleanup, grading, seeding and planting or restoration of all work areas begin immediately after the construction has been completed. Exposed areas may not remain unprotected for more than seven days.

Any work proposed in or near streams, wetlands, floodplains, and other water bodies will require permits from the appropriate regulatory authorities. One or more of the following permits may be required: a 124 permit, issued by the Montana Department of Fish, Wildlife and Parks; 318 Authorization issued by DEQ; a 310 Permit issued by the Local Conservation District; a 404 Permit issued by the Corps of Engineers; a Navigable Rivers Land Use License issued by the DNRC; a Floodplain Permit issued by the DNRC or Local Floodplain Administrator. Other permits not listed here may be required.

37. AERIAL CROSSINGS

Sewers supported by piers across ravines or streams will be allowed only when it can be demonstrated that no other practical alternative exists. Such sewers on piers must be constructed in accordance with the requirements in Section 36.21 (Materials). Support must be provided for all joints in pipes utilized for aerial crossings. The supports must be designed to prevent frost heave, overturning, and settlement.

Precautions against freezing, such as insulation and increased slope, must be provided. Expansion jointing must be provided between above ground and below ground sewers. Where buried sewers change to aerial sewers, special construction techniques must be used to minimize frost heaving.

For aerial stream crossings, the impact of flood waters and debris must be considered. The bottom of the pipe and carrying structure must not be lower than the elevation of the 100-year flood. Ductile iron pipe with mechanical joints is recommended.

Where sewers crossing streams are to be attached to bridge structures, the bridge owner must provide written approval that this approach will not structurally impair the bridge or interfere with routine maintenance, and is acceptable to the owner. The sewer must be attached to the bridge in a manner that protects it from vandalism and provides support as defined above for pier crossing systems. This documentation must be provided with the design submittal.

38. PROTECTION OF WATER SUPPLIES

When wastewater sewers are proposed in the vicinity of any water supply facilities, requirements of Circular DEQ 1 must be used to confirm acceptable isolation distances in addition to the following requirements.

38.1 Cross Connections Prohibited

There may not be any physical connections between a public or private potable water supply system and a sewer, or appurtenance thereto which would permit the passage of any wastewater or polluted water into the potable supply. A water pipe may not pass through or come in contact with any part of a sewer manhole.

38.2 Relation to Water Works Structures

Sewer mains may not be located within 100 feet of a public water supply well or within 50 feet of all other wells.

All existing waterworks units, such as basins, wells, or other treatment units, within 100 feet (31 m) of the proposed sewer must be shown on the engineering plans. Documentation must be submitted to the Department from the operating authority of the collection system stating that all waterworks units within 100 feet of the proposed sewer main alignment(s) have been identified and are shown on the project plans.

38.3 Relation to Water Mains

38.31 Horizontal Separation

Sewers must be laid at least 10 feet (3m) horizontally from any existing or proposed water main. The distance must be measured edge to edge.

If the proper horizontal separation as described above cannot be obtained, the design engineer shall submit a request for a deviation along with a description of the problem and justifying circumstances. If the deviation is granted, the sewer must be designed and constructed with the following minimum conditions:

a. Sewers must be constructed of slip-on or mechanical joint pipe complying with public water supply design standards (DEQ 1) and be pressure tested to minimum 150 psi to assure watertightness.

b. Sewer services utilizing in-line fittings and extending to at least property lines must be installed and tested in the area of the encroachment. Saddles are not acceptable.

38.32 Crossings

Sewers crossing water mains must be laid with a minimum vertical distance of 18 inches (457 mm) between the outside of the water main and the outside of the sewer. This must be the case where the water main is either above or below the sewer. The crossing must be arranged so that the sewer joints will be equidistant and as far as possible from the water main joints. Where a water main crosses under a sewer, adequate structural support must be provided for the sewer to maintain line and grade and to prevent damage to the water main.

If the proper vertical separation as described above cannot be obtained, the design engineer may design the crossing with the following minimum conditions:

a. Vertical separation at crossings between water and sewer mains must be at least 6 (six) inches.

b. Sewers must be constructed of slip-on or mechanical joint pipe complying with public water supply design standards (DEQ 1) and be pressure tested to minimum

150 psi to assure watertightness.

c. At crossings, one standard length of new pipe must be centered at approximately a 90 degree angle in respect to the existing pipe.

d. Sewer services utilizing in-line fittings and extending to at least property lines must be installed and tested within 10 feet (3 m) of the crossing. Saddles are not acceptable.

e. Either the water or sewer main must be encased in a watertight carrier pipe which extends 10 feet (3 m) on both sides of the crossing or the mains must be encased in a minimum of 6 inches (152.4 mm) of flowable fill for a minimum of 10 feet (3 m) each side of the crossing pipes.

If the minimum 6 inch (152.4 mm) separation is not viable, the water line must be relocated, and vertical separation at crossings between water and sewer mains must be at least 18 inches (457.2 mm).

39. SEWER SERVICES AND PLUMBING

Sewer services and plumbing must conform to relevant local and state plumbing codes, or to the Uniform Plumbing Code as amended by ARM 24.301.301, or other applicable codes.

The Department discourages the use of shared service lines.

CHAPTER 40

WASTEWATER PUMPING STATIONS

41. GENERAL

41.1 Flooding

Sewage pumping station structures and electrical and mechanical equipment must be protected from physical damage by the 100-year flood. Wastewater pumping stations should remain fully operational and accessible during the 25-year flood. Regulations of state and federal agencies regarding flood plain obstructions must be followed.

41.2 Accessibility and Security

The pumping station must be readily accessible by maintenance vehicles during all weather conditions. The facility should be located off the traffic way of streets and alleys. It is recommended that security fencing and access hatches with locks be provided to prevent unauthorized intrusion.

41.3 Grit

Where it is necessary to pump wastewater prior to grit removal, the design of the wet well and pump station piping must receive special consideration to avoid operational problems from the accumulation of grit.

41.4 Safety

Adequate provisions must be made to effectively protect maintenance personnel from hazards. Equipment for confined space entry in accordance with OSHA, the State of Montana Department of Labor and Industry, and regulatory agency requirements must be provided for all wastewater pumping stations. Also refer to Section 57 (Safety).

42. DESIGN

42.1 Type

Wastewater pumping stations in general use fall into four types: wet well/dry well, submersible, suction lift, and screw pump.

42.2 Structures

42.21 Separation

Dry wells, including their superstructure, must be separated from the wet well. Common walls must be gas tight.

42.22 Equipment Removal

Provisions must be made to facilitate removing pumps, motors, and other mechanical and electrical equipment. Individual pump and motor removal must not interfere with the continued operation of remaining pumps.

42.23 Access and Safety Landings

42.231 Access

Suitable and safe means of access for persons wearing self-contained breathing apparatus must be provided to dry wells, and to wet wells. Access to wet wells containing either bar screens or mechanical equipment requiring inspection or maintenance must conform to

Section 61.13 (Access and Ventilation). Also refer to Section 57 (Safety).

42.232 Safety Landings

For built-in-place pump stations, a stairway or ladder to the dry well must be provided with rest landings at vertical intervals not to exceed 12 feet (3.7 m). For factory-built pump stations over 15 feet (4.6 m) deep, rigidly fixed landings must be provided at vertical intervals not to exceed 10 feet (3 m). Where a landing is used, a suitable and rigidly fixed barrier must be provided to prevent an individual from falling past the intermediate landing to a lower level. A manlift or elevator may be used in lieu of landings in a factory-built station, provided emergency access is included in the design. Where ladders are used, adherence to federal safety standards is mandatory.

42.24 Buoyancy

Where high groundwater conditions are anticipated, buoyancy calculations for the wastewater pumping station structures must be submitted and, if necessary, adequate provisions must be made for protection.

42.25 Construction Materials

Wastewater pumping stations must be constructed with materials that are capable of withstanding prolonged exposure to hydrogen sulfide and other corrosive gases, greases, oils, and other constituents frequently present in wastewater. This is particularly important in the selection of metals and paints. Contact between dissimilar metals should be avoided. If dissimilar metals are used, construction methods must minimize galvanic action through other means.

42.3 Pumps and Pneumatic Ejectors

42.31 Multiple Units

Multiple pumps or ejector units must be provided. Where only two units are provided, they must be of the same size. Units must have capacity such that, with any unit out of service, the remaining units will have capacity to handle the design peak hourly flow.

42.32 Protection Against Clogging

42.321 Combined Wastewater

Pumps handling combined wastewater must be preceded by readily accessible bar racks to protect the pumps from clogging or damage. Bar racks should have clear openings as provided in Section 61.121 (Bar Spacing). Where a bar rack is provided, a mechanical hoist must also be provided. Where the size of the installation warrants, mechanically cleaned and/or duplicate bar racks must be provided. Refer to Sections 42.22 (Equipment Removal), 42.23 (Access and Safety Landings), and 61.13 (Access and Ventilation).

42.322 Separate Sanitary Wastewater

Pumps handling separate sanitary wastewater from 30 inch (762 mm) or larger diameter sewers must be protected by bar racks meeting the above requirements. Appropriate protection from clogging must also be considered for small pumping stations. Refer to Sections 42.23 (Access and Safety Landings) and 61.13 (Access and Ventilation).

42.33 Pump Openings

Pumps handling raw wastewater must be capable of passing spheres of at least 3 inches (76 mm) in diameter, except for grinder pumps, which must be capable of passing spheres of at least 1 inch (25.4 mm) in diameter. Pump suction and discharge openings must be at least 4 inches (102 mm) in diameter, except for grinder pumps, openings must meet the pump manufacturers requirements for the expected wastewater.

42.34 Priming

The pump must be placed so that under normal operating conditions it will operate under a positive suction head, except as specified in Section 43 (Suction Lift Pump Stations).

42.35 Electrical Equipment

Electrical systems and components (e.g., motors, lights, cables, conduits, switch boxes, control circuits, etc.) in raw wastewater wet wells, or in enclosed or partially enclosed spaces where hazardous concentrations of flammable gases or vapors may be present, must comply with the National Electrical Code requirements for Class I, Division 1, Group D, locations. In addition, equipment located in the wet well must be suitable for use under corrosive conditions. Each flexible cable must be provided with watertight seal and separate strain relief. A fused disconnect switch located above ground must be provided for the main power feed for all pumping stations. When such equipment will be exposed to weather, it must meet the requirements for weatherproof equipment in NEMA 3R or 4. A 110 volt power receptacle to facilitate maintenance must be provided inside the control panel for lift stations that have control panels outdoors. Ground fault interruption protection must be provided for all outdoor outlets.

42.36 Intake

Each pump must have an individual intake. Wet well and intake design must avoid turbulence near the intake and prevent vortex formation.

42.37 Dry Well Dewatering

A sump pump equipped with dual check valves must be provided in the dry well to remove leakage or drainage, with discharge above the maximum high water level of the wet well. Water ejectors connected to a potable water supply will not be approved. All floor and walkway surfaces should have an adequate slope to a point of drainage. Pump seal leakage must be piped or channeled directly to the sump. The sump pump must be sized to remove the maximum pump seal water discharge that would occur from a pump seal failure. Refer to Section 46 (Alarm Systems).

42.38 Pumping Rates

The pumps and controls of main pumping stations, especially pumping stations operated as part of the treatment facility, should be selected to operate at varying delivery rates. Insofar as is practicable, such stations should be designed to deliver as uniform a flow as practicable in order to minimize hydraulic surges. The station design peak hourly flow capacity must be determined in accordance with Section 11.24 (Hydraulic Capacity) and should be adequate to maintain a minimum velocity of 2 feet per second (0.61 m/s) in the force main. Refer to Section 49.1 (Velocity and Diameter).

42.4 Controls

Control float tubes, bubbler lines, or other controls should be located so as not to be unduly effected by turbulent flows entering the well or by the turbulent suction of the pumps. Bubbler type level monitoring systems must include dual air compressors. Provision must be made to automatically alternate the pumps in use. Suction lift stations must be designed to alternate pumps daily instead of each pump cycle to extend the life of the priming equipment.

42.5 Valves

42.51 Suction Line

Shutoff valves must be placed on the suction line of dry pit pumps.

42.52 Discharge Line

With the exception of screw pumps and short discharge lines (10 feet or less), shutoff and check valves must be placed on the discharge line of each pump. The check valve must be located between the shutoff valve and the pump. Check valves must be suitable for the material being handled and must be placed on the horizontal portion of discharge piping, except for ball checks, flapper swing check valves, or flexible disk check valves (body seat constructed at an angle of 45 degrees to the flow line), which may be placed in the vertical run. Valves must be capable of withstanding normal pressure and water hammer.

All shutoff and check valves must be operable from the floor level and accessible for maintenance. Outside levers are recommended on swing check valves.

42.6 Wet Wells

42.61 Divided Wells

Where continuity of pumping station operation is critical, consideration should be given to dividing the wet well into two sections, properly interconnected, to facilitate repairs and cleaning.

42.62 Size

Pump stations must be designed to operate under the full range of projected system hydraulic conditions, and should have the flexibility to accommodate project phasing if proposed.

The design fill time and minimum pump cycle time must be considered in sizing the wet well. The effective volume of the wet well must be based on design average flow and a filling time not to exceed 30 minutes unless the facility is designed to provide flow equalization. The pump manufacturer's duty cycle recommendations must be utilized in selecting the minimum cycle time. When the anticipated initial flow tributary to the pumping station is less than the design average flow, provisions should be made so the fill time indicated is not exceeded for initial flows. When the wet well is designed for flow equalization as part of a treatment facility, provisions should be made to prevent septicity.

For constant speed pumps, the minimum volume between pump on and pump off levels can be calculated using Equation (4-1):

$$t = \frac{4V}{Q} \qquad (4\text{-}1)$$

t = minimum time between pump starts (minutes)
V = wet well volume (gallons)
Q = pump capacity (gallons per minute)

42.63 Floor Slope

The wet well floor must have a slope of at least 1 to 1 to the hopper bottom. The horizontal area of the hopper bottom may not be greater than necessary for proper installation and function of the inlet.

42.64 Air Displacement

Covered wet wells must have provisions for air displacement such as an inverted "j" tube or other means which vents to the outside.

42.7 Safety Ventilation

42.71 General

Adequate ventilation must be provided for all pump stations. Where the dry well is below the ground surface, permanent mechanical ventilation is required. If screens or mechanical equipment requiring maintenance or inspection are located in the wet well, permanently installed ventilation is required. There may not be any interconnection between the wet well and dry well ventilation systems.

42.72 Air Inlets and Outlets

In dry wells over 15 feet (4.6 m) deep, multiple inlets and outlets are desirable. Dampers should not be used on exhaust or fresh air ducts and fine screen or other obstructions in air ducts should be avoided to prevent clogging.

42.73 Electrical Controls

Switches for operation of ventilation equipment should be marked and located conveniently. All intermittently operated ventilation equipment must be interconnected with the respective pit lighting system. Consideration should be given also to automatic controls where intermittent operation is used. The manual lighting/ventilation switch must override the automatic controls. For a two-speed ventilation system with automatic switch-over and gas detection equipment, consideration should be given to increasing the ventilation rate automatically in response to the detection of hazardous concentrations of gases or vapors.

42.74 Fans, Heating, and Dehumidification

The fan wheel should be fabricated from non-sparking material. Automatic heating and dehumidification equipment must be provided in all dry wells. The electrical equipment and components must meet the requirements in Section 42.35 (Electrical Equipment).

42.75 Wet Wells

Wet well ventilation may be either continuous or intermittent. Ventilation, if continuous, must provide at least 12 complete air changes per hour; if intermittent, at least 30 complete air changes per hour must be provided. Air must be forced into the wet well by mechanical means rather than exhausted from the wet well. The air change requirements must be based on 100 percent fresh air. Portable ventilation equipment must be provided for use at submersible pump stations and wet wells with no permanently installed ventilation equipment.

42.76 Dry Wells

Dry well ventilation may be either continuous or intermittent. Ventilation, if continuous, must provide at least 6 complete air changes per hour; if intermittent, at least 30 complete air changes per hour must be provided.

A system of two-speed ventilation with an initial ventilation rate of 30 changes per hour for 10 minutes and an automatic switch over to 6 changes per hour may be used to conserve heat. The air change requirements must be based on 100 percent fresh air.

42.8 Flow Measurement and Instrumentation

Suitable devices for measuring wastewater flow should be considered at all pumping stations. Indicating, totalizing and recording flow measurements, and voltage/ampere meters must be provided at pumping stations with a 1200 gpm (76 L/s) or greater design peak flow. Elapsed time meters must be provided for all pumps. Flow meters must be installed as recommended by the manufacturer. A pressure gauge should be provided.

42.9 Water Supply

There may not be any physical connection between any potable water supply and a wastewater pumping station that under any conditions might cause contamination of the potable water supply. If a potable water supply is brought to the station, it must conform to Section 56.23 (Indirect Connections).

43. SUCTION LIFT PUMP STATIONS

Suction lift pumps must be of the self-priming or vacuum-priming type and must meet the applicable requirements of Section 42 (Design).

43.1 Pump Priming and Lift Requirements

Suction-lift pump stations using dynamic suction lifts exceeding the limits outlined in the following sections may be approved upon submission of factory certification of pump performance and detailed calculations indicating satisfactory performance under the proposed operating conditions. Such detailed calculations must include static suction-lift as measured from "lead pump off" elevation to center line of pump suction, friction, and other hydraulic losses of the suction piping, vapor pressure of the liquid, altitude correction, required net positive suction head, and a safety factor of at least 6 feet (1.8 m).

43.11 Self-Priming Pumps

Self-priming pumps must be capable of rapid priming and repriming at the "lead pump on" elevation. Such self-priming and repriming must be accomplished automatically under design operating conditions. Suction piping should not exceed the size of the pump suction and may not exceed 25 feet (7.6 m) in total length. Priming lift at the "lead pump on" elevation must include a safety factor of at least 4 feet (1.2 m) from the maximum allowable priming lift for the specific equipment at design operating conditions. The combined total of dynamic suction lift at the "pump off" elevation and required net positive suction head at design operating conditions may not exceed 22 feet (6.7 m).

43.12 Vacuum-Priming Pumps

Vacuum-priming pump stations must be equipped with dual vacuum pumps capable of automatically and completely removing air from the suction-lift pump. The vacuum pumps must be adequately protected from damage due to wastewater. The combined total of dynamic suction-lift at the "pump off" elevation and required net positive suction head at design operating conditions may not exceed 22 feet (6.7 m).

43.2 Equipment, Wet Well Access, and Valve Location

The pump equipment compartment must be above grade or offset and must be effectively isolated from the wet well to prevent the humid and corrosive sewer atmosphere from entering the equipment compartment. Wet well access may not be through the equipment compartment and must be at least 24 inches (610 mm) in diameter. Gasketed replacement plates must be provided to cover the opening to the wet well for pump units removed for servicing. Valves may not be located in the wet well.

44. SUBMERSIBLE PUMP STATIONS - SPECIAL CONSIDERATIONS

Submersible pump stations must meet the applicable requirements under Section 42 (Design), except as modified in this Section.

44.1 Construction

Submersible pumps and motors must be designed specifically for raw wastewater use, including totally submerged operation during a portion of each pumping cycle, and must meet the requirements of the National Electrical Code for such units. An effective method to detect shaft seal failure or potential seal failure must be provided.

44.2 Pump Removal

Submersible pumps must be readily removable and replaceable without dewatering the wet well or disconnecting any piping in the wet well.

44.3 Electrical Equipment

44.31 Power Supply and Control Circuitry

Electrical supply, control, and alarm circuits must be designed to provide strain relief and to allow disconnection from outside the wet well. Terminals and connectors must be protected from corrosion by location outside the wet well or through use of watertight seals. If located outside, weatherproof equipment must be used.

44.32 Controls

The motor control center must be located outside the wet well, be readily accessible, and be protected by a conduit seal or other appropriate measures meeting the requirements of the National Electrical Code, to prevent the atmosphere of the wet well from gaining access to the control center. The seal must be located so that the motor may be removed and electrically disconnected without disturbing the seal. When such equipment is exposed to weather, it must meet the requirements of weatherproof equipment NEMA 3R or 4.

44.33 Power Cord

Pump motor power cords must be designed for flexibility and serviceability under conditions of extra hard usage and must meet the requirements of the National Electrical Code standards for flexible cords in wastewater pump stations. Ground fault interruption protection must be used to de-energize the circuit in the event of any failure in the electrical integrity of the cable. Power cord terminal fittings must be corrosion-resistant and constructed in a manner to prevent the entry of moisture into the cable, must be provided with strain relief appurtenances, and must be designed to facilitate field connecting.

44.4 Valves

Valves required under Section 42.5 (Valves) must be located in a separate valve chamber. Provisions must be made to remove or drain accumulated water from the valve chamber. Valve pits may be dewatered to a wet well through a drain line with a gas and water tight valve. Check valves that are integral to the pump need not be located in a separate valve chamber provided that the valve can be removed from the wet well in accordance with Section 44.2 (Pump Removal). Access must be provided in accordance with Section 42.231 (Access).

45. SCREW PUMP STATIONS – SPECIAL CONSIDERATIONS

Screw pumps must meet the applicable requirements of Section 42 (Design).

45.1 Covers

Covers should be provided.

45.2 Pump Wells

A positive means of isolating individual screw pump wells must be provided.

45.3 Bearings

Submerged bearings must be lubricated by an automated system without pump well dewatering.

46. ALARM SYSTEMS

Alarm systems with a backup power source must be provided for pumping stations. The alarm must be activated upon power failure, sump pump failure, high and low wet well level, pump failure, unauthorized entry, or any cause of pump station malfunction. Shaft seal failure, moisture and thermal sensors shall be provided on submersible pump motors. Redundant low-level alarms should be considered in high hazard environments. Pumping station alarms, including identification of the alarm condition, must be transmitted (via telemetry) to a municipal facility that is staffed 24 hours a day. If such a facility is not available and a 24-hour holding capacity is not provided, the alarm must be transmitted to municipal offices during normal working hours and to the home of the responsible person(s) in charge of the lift station during off-duty hours. Audio-visual alarm systems with a self-contained power supply may be acceptable in some cases in lieu of a transmitting system outlined above, depending upon location, station holding capacity and inspection frequency.

47. EMERGENCY OPERATION

47.1 Objective

The objective of any emergency operation is to prevent the discharge of raw or partially treated wastewater to any waters and to protect public health by preventing back-up of wastewater and subsequent discharge to basements, streets, and other public and private property.

47.2 Emergency Pumping Capability

Emergency pumping capability is required unless on-system overflow prevention is provided by adequate storage capacity. Emergency pumping capability may be accomplished by connection of the station to at least two independent utility substations, or by use of portable or permanent internal combustion engine equipment which will generate electrical or mechanical energy, or by use of portable pumping equipment. Such emergency standby systems must have sufficient capacity to start up and maintain the total rated running capacity of the station. Regardless of the type of emergency standby system provided, a riser from the force main with rapid connection capabilities and appropriate valving must be provided for all lift stations to hook up portable pumps. Where portable emergency operating equipment is utilized, a separate pump or generator must be provided for each lift station unless adequate justification is provided by the community stating why this is not necessary.

47.3 Emergency High Level Overflows

For use during possible periods of extensive power outages, mandatory power reductions, or emergency conditions, consideration should be given to providing a controlled, high-level wet well overflow, to supplement alarm systems and emergency power generation, in order to prevent backup of wastewater into basements, or other discharges which may cause severe adverse impacts on public interests, including public health and property damage. Where a high level overflow is utilized, it will be necessary to install a storage/detention tank, or basin, which must be made to drain to the station wet well. It is recommended that a minimum of one hour of storage be provided for peak flow conditions. The Department may require different storage requirements based on site specific conditions.

47.4 Equipment Requirements

47.41 General

The following general requirements apply to all internal combustion engines used to drive auxiliary pumps, service pumps through special drives, or electrical generating equipment:

Engine Protection

The engine must be protected from operating conditions that would result in damage to equipment. Unless continuous manual supervision is planned, protective equipment must be capable of shutting down the engine and activating an alarm on site and as provided in Section 46 (Alarm Systems). Protective equipment must monitor for conditions of low oil pressure and overheating, except that oil pressure monitoring is not required for engines with splash lubrication.

Size

The engine must have adequate rated power to start and continuously operate under all connected loads.

Fuel Type

Reliability and ease of starting, especially during cold weather conditions, should be considered in the selection of the type of fuel.

Fuel Storage Tanks

Design and installation of fuel storage tanks and piping must comply with all state and federal standards.

Engine Ventilation

The engine must be located above grade with adequate ventilation of fuel vapors and exhaust gases.

Routine Start-up

All emergency equipment must be provided with instructions indicating the need for regular starting and running of such units at full loads.

Protection of Equipment

Emergency equipment must be protected from damage at the restoration of regular electrical power.

47.42 Engine-Driven Pumping Equipment

Where permanently installed or portable engine-driven pumps are used, the following requirements, in addition to general requirements, apply:

47.421 Pumping Capacity

Engine-driven pump(s) must meet the design pumping requirements unless storage capacity is available for flows in excess of pump capacity. Pumps must be designed for anticipated peak hour operating conditions, including suction lift, if applicable.

47.422 Operation

The engine and pump must be equipped to provide automatic startup and operation of pumping equipment unless manual start-up and operation is justified. Provisions must also be made for manual start-up. Where manual start-up and operation is justified, the storage capacity and alarm system must meet the requirements of Section 47.423 (Portable Pumping Equipment).

47.423 Portable Pumping Equipment

Where part or all of the engine-driven pumping equipment is portable, sufficient storage capacity and an alarm system must be provided to allow time for detection of pump station failure and transportation and hookup of the portable equipment.

47.43 Engine-Driven Generating Equipment

Where permanently installed or portable engine-driven generating equipment is used, the following requirements apply in addition to the general requirements of Section 47.41 (General):

47.431 Generating Capacity

a. Generating unit size must be adequate to provide power for pump motor starting current and for lighting, ventilation, and other auxiliary equipment necessary for safety and proper operation of the lift station.

b. The operation of only one pump during periods of auxiliary power supply must be justified. Such justification may be made on the basis of the design peak hourly flows relative to single-pump capacity, anticipated length of power outage, and storage capacity.

c. Special sequencing controls must be provided to start pump motors unless the generating equipment has capacity to start all pumps simultaneously with auxiliary equipment operating.

47.432 Operation

Provisions must be made for automatic and manual start-up and load transfer unless only manual start-up and operation is justified. The generator must be protected from operating conditions that would result in damage to equipment. Provisions should be considered to allow the engine to start and stabilize at operating speed before assuming the load. Where manual start-up and transfer is justified, storage capacity and alarm system must meet the requirements of Section 47.433 (Portable Generating Equipment).

47.433 Portable Generating Equipment

Where portable generating equipment or manual transfer is provided, sufficient storage capacity and an alarm system must be provided to allow time for detection of pump station failure and transportation and connection of generating equipment. The use of special electrical connections and double throw switches is recommended for connecting portable generating equipment.

47.44 Independent Utility Substations

Where independent substations are used for emergency power, each separate substation and its associated transmission lines must be capable of starting and operating the pump stations at its rated capacity.

48. INSTRUCTIONS AND EQUIPMENT

Wastewater pumping stations and portable equipment must be supplied with a complete set of operational instructions, including emergency procedures, maintenance schedules, tools and such spare parts as may be necessary.

49. FORCE MAINS

49.1 Velocity and Diameter

At design pumping rates, a cleaning velocity of at least 2 feet per second (0.61 m/s) must be maintained. The minimum force main diameter for raw wastewater is 4 inches (102 mm). It is desirable to have cleaning velocities of at least 3 feet per second (0.91 m/s). The maximum velocity shall not exceed 8 feet per second (2.4 m/s) for the design pump rate.

Force mains in small grinder and effluent pump installations must be based on a minimum design flow velocity of 2 feet per second (0.61 m/s) and a minimum pipe diameter of 1.5 inches (31.8 mm).

49.2 Air and Vacuum Relief Valve

An air relief valve must be placed at high points in the force main to prevent air locking. Vacuum relief valves may be necessary to relieve negative pressures on force mains. The force main configuration and head conditions should be evaluated as to the need for and placement of vacuum relief valves.

49.3 Termination

Force mains should enter the gravity sewer system at a point not more than 1 foot (0.3 m) above the flow line of the receiving manhole. Corrosion protection for the receiving manhole must be provided in accordance with Section 34.8 (Corrosion Protection for Manholes).

49.4 Pipe and Design Pressure

Pipe and joints must be equal to water main strength materials suitable for design conditions. The force main, reaction blocking, and station piping must be designed to withstand water hammer pressures and associated cyclic reversal of stresses that are expected with the cycling of wastewater lift stations. Surge protection devices must be evaluated to protect the force main.

49.5 Special Construction

Force main construction near streams or water works structures and at water main crossings must meet applicable provisions of Sections 36 (Sewers in Relation to Streams), 37 (Aerial Crossings), and 38 (Protection of Water Supplies).

49.6 Freeze Prevention

Force mains must be constructed to prevent freezing and must be buried a minimum of 6 feet (1.8 m). Depths greater than 6 feet (1.8 m) may be required where local conditions dictate. If it is impossible to achieve sufficient burial depth, insulation may be used to help prevent freezing. However, when proper depth cannot be obtained, the engineer must submit justification for the lesser depth and heat flow calculations showing that the pipe will not freeze.

49.7 Design Friction Losses

49.71 Friction Coefficient

Friction losses through force mains must be based on the Hazen - Williams formula or other acceptable methods. When the Hazen - Williams formula is used, the value for "C" must be 100 for unlined iron or steel pipe for design. For other smooth pipe materials such as PVC, polyethylene, lined ductile iron, etc., a higher "C" value, not to exceed 120, may be allowed for design.

Both new and old pipe conditions must be evaluated, along with the various combinations of operating pumps and minimum and maximum flows, to determine the highest head and lowest head pumping conditions. The effects of higher discharge rates on selected pumps and downstream facilities must be considered.

49.72 Maximum Power Requirements

When initially installed, force mains will have a significantly higher "C" factor. The effect of the higher "C" factor should be considered in calculating maximum power requirements and duty cycle time to prevent damage to the motor.

49.8 Identification

Where force mains are constructed of material that might cause the force main to be confused with potable water mains, the force main must be appropriately identified.

49.9 Leakage Testing

Leakage tests must be specified including testing methods and leakage limits.

49.10 Maintenance Considerations

Isolation valves must be used where force mains connect into a common force main. Cleanouts at low points and chambers for pig launching and catching should be considered for any force main to facilitate maintenance.

CHAPTER 50

WASTEWATER TREATMENT FACILITIES

51. PLANT LOCATION

51.1 General

Items to be considered when selecting a plant site are listed in Chapter 10 (Engineering Reports and Facility Plans). The layout and siting of wastewater treatment facilities must consider the long-range implications of the State of Montana Nondegradation Rules (ARM 17.30.701), Total Daily Maximum Load (TMDL), and Water Quality Standards necessary to protect public health and to maintain a high level of water quality. Area should be set aside for future facilities that may be required to provide increased levels of treatment.

51.2 Flood Protection

The treatment works structures, and electrical and mechanical equipment must be protected from physical damage by the 100-year flood. Treatment works should remain fully operational and accessible during the 25-year flood. This requirement applies to new construction and to existing facilities undergoing major modification. Flood plain regulations of local, state and federal agencies must be followed.

52. QUALITY OF EFFLUENT

The required degree of wastewater treatment must be based on the effluent requirements and water quality standards established by the Department and/or appropriate federal regulations, including discharge permit requirements. Consideration should be given to future TMDLs and water quality standards as well as the State's Nondegradation Policy.

53. DESIGN

53.1 Type of Treatment

Items that must be considered in the selection of the appropriate type of treatment are presented in Chapter 10 (Engineering Reports and Facility Plans).

The plant design must provide the necessary flexibility to perform satisfactorily within the expected range of waste characteristics and volumes.

53.2 Engineering and Performance Requirements for Innovative Wastewater Treatment Alternatives

The policy of the Department is to encourage rather than discourage development of methods or equipment for treatment or reuse of wastewaters. The lack of inclusion in these standards of some types of wastewater treatment processes or equipment should not be construed as precluding their use. The Department may approve other types of wastewater treatment processes and equipment if the operational reliability and effectiveness of the process or device has been demonstrated with a suitably-sized prototype unit operating at its design load conditions, to the extent required.

To determine that such new processes and equipment or applications have a reasonable and substantial chance of success, the Department may require the following:

a. Monitoring observations, including test results and engineering evaluations, demonstrating the efficiency of such processes;

b. Detailed description of the test methods;

c. Testing, including appropriately-composited samples, under various ranges of strength and flow rates (including diurnal variations) and waste temperatures over a sufficient length of time to demonstrate performance under climatic and other conditions which may be encountered in the area of the proposed installations;

d. Other appropriate information.

The Department may require that appropriate testing be conducted and evaluations be made under the supervision of a competent process engineer other than those employed by the manufacturer or developer.

53.3 Design Period

The design period must be clearly identified in the engineering report or facilities plan as required in Chapter 10 (Engineering Reports and Facility Plans).

53.4 Design Loads

53.41 Hydraulic Design

53.411 Critical Flow Conditions

Flow conditions critical to the design of the treatment plant are described in Chapter 10 (Engineering Reports and Facility Plans).

Initial low flow conditions must be evaluated in the design to minimize operational problems with freezing, septicity, flow measurements and solids dropout. The design peak hourly flows must be considered in evaluating unit processes, pumping, piping, etc.

53.412 Treatment Plant Design Capacity

The treatment plant design capacity must be as described in Chapter 10 (Engineering Reports and Facility Plans). The plant design flow selected must meet the appropriate effluent and water quality standards that are set forth in the discharge permit. The design of treatment units that are not subject to peak hourly flow requirements must be based on the design average flow. For plants subject to high wet weather flows or overflow detention pumpback flows, the design maximum day flows that the plant is to treat on a sustained basis should be specified.

53.413 Flow Equalization

Facilities for the equalization of flows and organic shock load must be considered at all plants that are critically affected by surge loadings. The sizing of the flow equalization facilities should be based on data obtained herein and from Chapter 10 (Engineering Reports and Facility Plans).

53.42 Organic Design

Organic loadings for waste treatment plant design must be based on the information given in Chapter 10 (Engineering Reports and Facility Plans). The effects of accepting septage at the plant must be given consideration and appropriate facilities must be included in the design. Refer to Appendix A (Handling and Treatment of Septage at a Wastewater Treatment Plant).

53.43 Shock Effects

The shock effects of high concentrations and diurnal peaks for short periods of time on the treatment process, particularly for small treatment plants, must be considered.

53.5 Piping and Channels

All piping and channels should be designed to carry the maximum expected flows. The incoming sewer should be designed for unrestricted flow. Bottom corners of the channels must be filleted.

Piping and channels must be designed to avoid creation of pockets and corners where solids can accumulate.

Suitable gates or valves should be placed in channels to seal off unused sections, which might accumulate solids. The use of shear gates, stop plates or stop planks is permitted where they can be used in place of gate valves or sluice gates. Non-corrodible materials must be used for these control gates.

53.6 Arrangement of Units

Component parts of the plant should be arranged for greatest operating and maintenance convenience, flexibility, economy, continuity of maximum effluent quality, and ease of installation of future units.

53.7 Flow Division Control

Flow division control facilities must be provided as necessary to insure organic and hydraulic loading control to plant process units and must be designed for easy operator access, change, observation and maintenance. The use of up flow division boxes equipped with adjustable sharp-crested weirs or similar devices is recommended. The use of valves for flow splitting is not acceptable. Appropriate flow measurement facilities must be incorporated in the flow division control design.

53.8 General Plant Pumping

The Department may require that a rational basis of pump design, pump head calculations, and pump curves be submitted for major pumps and pumps integral to key unit processes. Pump designers should consider the use of variable frequency drives (VFD) or variable speed drives (VSD), and must incorporate spare or redundant pumps where necessary, to maintain treatment capabilities.

54. PLANT DETAILS

54.1 Installation of Mechanical Equipment

The specifications must include the requirement that installation and initial operation of major items of mechanical equipment will be inspected and approved by a representative of the manufacturer.

54.2 Unit Bypasses

54.21 Removal from Service

Properly located and arranged bypass structures and piping must be provided so that each unit of the plant can be removed from service independently. The bypass design must facilitate facility operation during unit maintenance and emergency repair to minimize deterioration of effluent quality and insure rapid process recovery upon return to normal operational mode. The bypass provisions must meet the discharge permit requirements, or other effluent quality requirements of the Department.

Bypassing may be accomplished through the use of duplicate or multiple treatment units in any stage if the design peak instantaneous flow can be handled hydraulically with the largest unit out of service.

The actuation of all bypasses must require manual action by operating personnel. All power-actuated bypasses must be designed to permit manual operation in the event of power failure and be designed so the valve will fail as is, upon failure of the power-actuator.

A fixed high water level bypass overflow should be provided in addition to a manually or power-actuated bypass.

54.22 Unit Bypass During Construction

Unit bypassing during construction must conform to the requirements in Sections 11.29 (i) (Treatment During Construction), 20.15 (Operation During Construction), and Section 21 (Specifications). For facilities with a discharge permit, appropriate personnel in the Department's Permits program should be notified of a planned unit bypass as required in the discharge permit.

54.3 Unit Dewatering, Flotation Protection, and Plugging

Means such as drains or sumps must be provided to completely dewater each unit to an appropriate point in the process. Consideration must be given to the possible need for hydrostatic pressure relief devices to prevent flotation of structures. Pipes subject to plugging must be provided with means for mechanical cleaning or flushing.

54.4 Construction Materials

Due consideration must be given to the selection of materials that are to be used in wastewater treatment facilities because of the possible presence of hydrogen sulfide and other corrosive gases, greases, oils, and similar constituents frequently contained in wastewater. This is particularly important in the selection of metals and paints. Contact between dissimilar metals should be avoided to minimize galvanic action.

54.5 Unit Testing

All water bearing units must be hydraulically tested. The allowable leakage rate for concrete water containment structures, with a side water depth of 25 feet (7.62 m) or less, must not exceed 0.1 percent of the water volume in a 24-hour period (following absorption and stabilization) and must not show any visible leakage or dampness on the exterior walls. Test procedures and results must be submitted to the Department for approval.

54.6 Painting

The use of paints containing lead or mercury must be avoided. To facilitate identification of piping, different lines must be color-coded. The following color scheme is recommended for purposes of standardization.

- Raw sludge line – brown with black bands
- Sludge recirculation suction line – brown with yellow bands
- Sludge draw off line – brown with orange bands
- Sludge recirculation discharge line – brown
- Sludge gas line – orange (or red)
- Natural gas line – orange (or red) with black bands
- Nonpotable water line – blue with black bands
- Potable water line – blue
- Chlorine line – yellow
- Sulfur Dioxide – yellow with red bands
- Sewage (wastewater) line – gray
- Compressed air line – green
- Water lines for heating digesters or buildings – blue with a 6-inch (152 mm) red band spaced 30 inches (762 mm) apart.
- Fuel oil/diesel – red
- Plumbing drains and vents – black
- Polymers – purple

The contents and direction of flow must be stenciled on the piping in a contrasting color.

54.7 Operating Equipment

A complete outfit of tools, accessories and spare parts necessary for the plant operator's use must be provided. Readily accessible storage space and workbench facilities must be provided, and consideration must be given to provision of a garage for large equipment storage, maintenance, and repair.

54.8 Erosion Control Construction

Effective site erosion control must be provided during construction. Permits may be required from the Department for dewatering and storm water control at a construction site.

54.9 Grading and Landscaping

Upon completion of the plant, the ground must be graded and sodded or seeded. All-weather walkways should be provided for access to all units. Where possible, steep slopes should be avoided to prevent erosion. Surface water may not be permitted to drain into any unit. Particular care must be taken to protect trickling filter beds, sludge beds, and intermittent sand filters from stormwater runoff. Provision should be made for landscaping, particularly when a plant must be located near residential areas.

55. PLANT OUTFALLS

55.1 Discharge Impact Control

The outfall sewer must be designed to discharge to the receiving stream in a manner acceptable to the Department. Consideration should be given in each case to the following:

a. Preference for free fall or submerged discharge at the site selected;

b. Utilization of cascade aeration of effluent discharge to increase dissolved oxygen;

c. Limited or complete across-stream dispersion as needed to protect aquatic life movement and growth in the immediate reaches of the receiving stream.

55.2 Protection and Maintenance

The outfall sewer must be constructed and protected against the effects of floodwater, tide, ice, or other hazards as to reasonably insure its structural stability and freedom from stoppage. A manhole should be provided at the shore end of all gravity sewers extended into the receiving waters. Hazards to navigation must be considered in designing outfall sewers.

55.3 Sampling Provisions

All outfalls must be designed so that a sample of the effluent can be safely obtained at a point after the final treatment process and before discharge to or mixing with the receiving waters.

56. ESSENTIAL FACILITIES

56.1 Emergency Power Facilities

56.11 General

All plants must be provided with an alternate source of electric power or pumping capability to allow continuity of operation during power failures, except as noted below. Methods of providing alternate sources include:

a. The connection of at least two independent power sources such as substations. A power line from each substation is recommended, and will be required unless documentation is received and approved by the Department verifying that a duplicate line is not necessary;

b. Portable or in-place internal combustion engine equipment which will generate electrical or mechanical energy;

c. Portable pumping equipment when only emergency pumping is required.

56.12 Power for Aeration

Standby generating capacity normally is not required for aeration equipment used in the activated sludge process. In cases where a history of long-term (4 hours or more) power outages have occurred, auxiliary power for minimum aeration of the activated sludge will be required. Full power generating capacity may be required by the Department for discharges to critical water bodies such as upstream of beaches, public water supply intake or other similar situations.

56.13 Power for Disinfection

Continuous disinfection, where required, must be provided during all power outages. Continuous dechlorination is required for those systems that dechlorinate.

56.2 Water Supply

56.21 General

An adequate supply of potable water under pressure should be provided for use in the laboratory and for general cleanliness around the plant. Piping or other connections may not exist in any part of the treatment works, which, under any conditions, might cause the contamination of a potable water supply. The chemical quality should be checked for suitability for its intended uses such as in heat exchangers, chlorinators, etc.

56.22 Direct Connections

Direct connections between potable water piping and sewer-connected wastes must not exist under any condition in the treatment facility in accordance with Title 17, Chapter 38, Sub-Chapter 3, ARM and the Uniform Plumbing Code as adopted by the State of Montana, particularly Section 603.3.5. An approved backflow prevention assembly must be installed on the service connection (potable water supply line) to any wastewater treatment facility. Potable water from a municipal or separate supply may be used directly at points above grade for the following hot and cold supplies:

a. Lavatory;
b. Water closet;
c. Laboratory sink (with vacuum breaker);
d. Shower;
e. Drinking fountain;
f. Eye wash fountain;
g. Safety shower.

Hot water for any of the above units may not be taken directly from a boiler used for supplying hot water to a sludge heat exchanger or digester heating unit.

56.23 Indirect Connections

Where a potable water supply is to be used for any purpose in a plant other than those listed in Section 56.22 (Direct Connections), backflow due to either back-pressure or back-siphonage must be identified and adequate protection must be provided. An air gap (combination of a break tank, pressure pump, and pressure tank), vacuum breaker, or a backflow preventer assembly must be installed. Air gaps and backflow prevention assemblies must be constructed in accordance with ARM Title 17, Chapter 38, Sub-Chapter 3 and with the Uniform Plumbing Code. If backflow prevention assemblies are used, the plant must have Cross-Connection Control Program approved by the Department. Also, the requirements of Sections 38.1 (Cross Connections Prohibited), and 38.2 (Relation to Water Works Structures) apply.

In break tank systems, water must be discharged to the break tank through an air gap at least 6 inches (152 mm) above the flood line or the spill line of the tank, whichever is higher. Where potable water is discharged to the drainage system and backflow due to back-siphonage may occur, the connection must use an approved air gap. The air gap must be a minimum of two pipe diameters of the supply inlet, but in no case will the air gap be less than 1 inch (25.4 mm).

A sign must be permanently posted at every hose bib, faucet, hydrant or sill cock located on the water system beyond the break tank, or approved backflow prevention assembly to indicate that the water is not safe for drinking.

56.24 Separate Potable Water Supply

Where it is not possible to provide potable water from a public water supply, a separate well may be provided. Location and construction of the well must be in compliance with Circular DEQ 3 and the Montana Board of Water Well Contractors' rules. Requirements governing the use of potable water within a wastewater treatment facility are those contained in this Chapter and within the Uniform Plumbing Code.

56.25 Separate Non-Potable Water Supply

Where a separate non-potable water supply is to be provided, a break tank or an approved backflow prevention assembly will not be necessary, but all system outlets must be posted with a permanent sign indicating the water is not safe for drinking.

56.3 Sanitary Facilities

Toilet, shower, lavatory, and locker facilities should be provided in sufficient numbers and convenient locations to serve the expected plant personnel.

56.4 Floor Slope

Floor surfaces must be sloped adequately to a point of drainage.

56.5 Stairways

Stairways, rather than ladders, must be installed for access to units requiring routine inspection and maintenance, such as digesters, trickling filters, aeration tanks, clarifiers, tertiary filters, etc. Spiral or winding stairs are permitted only for secondary access where dual means of egress are provided.

Stairways must have slopes between 30° and 40° from the horizontal to facilitate carrying samples, tools, etc. Each tread and riser must be of uniform dimension in each flight. Minimum tread run is 9 inches (229 mm). The sum of the tread run and riser may not be less than 17 (432 mm) nor more than 18 inches (457 mm). A flight of stairs may consist of no more than a 12-foot (3.7 m) continuous rise without a platform.

56.6 Flow Measurement

56.61 Location

Flow measurement facilities must be provided to measure the following flows:

a. Plant influent and effluent flow;

b. Excess flow treatment facility discharges;

c. Other flows required to be monitored under the provisions of the discharge permit;

d. Other flows, such as return activated sludge, waste activated sludge, recirculation, and recycle required for plant operational control.

56.62 Facilities

Indicating, totalizing and recording flow measurement devices must be provided for all mechanical plants. Flow measurement facilities for lagoon systems must be at least equivalent to elapsed time meters used in conjunction with pumping rate tests or calibrated weirs or flumes. All flow measurement equipment must be sized to function effectively over the full range of flows expected, must be protected against freezing and must be readily accessible.

56.63 Hydraulic Conditions

Flow measurement equipment including entrance and discharge conduit configuration and critical control elevations must be designed to ensure that the required hydraulic conditions necessary for accurate measurement are provided. Conditions that must be avoided include turbulence, eddy currents, air entrainment, etc., that upset the normal hydraulic conditions necessary for accurate flow measurement.

56.7 Sampling Equipment

Effluent composite sampling equipment must be provided at facilities where necessary to meet discharge permit monitoring requirements. Composite sampling equipment must also be provided as needed for influent sampling and for monitoring plant operations. The influent sampling point must be located prior to any preliminary treatment units and process return flows.

57. SAFETY

57.1 General

Adequate provision must be made to effectively protect plant personnel and visitors from hazards. It is recommended that OSHA and the Montana Department of Labor and Industry Safety and Health Bureau be contacted for safety requirements. At a minimum, and as appropriate, the following must be provided at each facility:

a. Enclosure of the plant with a fence and signs designed to discourage the entrance of unauthorized persons and animals;

b. Hand rails and guards around tanks, trenches, pits, stairwells, and other hazardous structures with the tops of walls less than 42 inches (1070 mm) above the surrounding ground level;

c. Gratings over appropriate areas of treatment units where access for maintenance is required;

d. First aid equipment;

e. "No Smoking" signs in hazardous areas;

f. Protective clothing and equipment, such as self-contained breathing apparatus, gas detection equipment, goggles, gloves, hard hats, safety harnesses, etc.

g. Portable blower and sufficient hose;

h. Portable lighting equipment complying with the National Electrical Code requirements. Suitable lighting must be provided in all work and access areas. Electrical fixtures in areas where hazardous gases may accumulate must meet the requirements of the National Electrical Code for Class I, Division 1, Group D locations;

i. Gas detectors certified for use in Class I, Division 1, Group D, locations;

j. Appropriately-placed floatation devices, warning signs for slippery areas, non-potable water fixtures, low head clearance areas, open service manholes, hazardous chemical storage areas, flammable fuel storage areas, etc.;

k. Adequate ventilation in pump station areas in accordance with Section 42.7 (Safety Ventilation);

l. Provisions for local lockout on stop motor controls, main power source;

m. Provisions for confined space entry in accordance with OSHA, Montana Department of Labor and Industry Safety and Health Bureau, and Department requirements;

n. Adequate vector control which considers customary insects, mammals, rodents and other pests.

57.2 Hazardous Chemical Handling

Follow OSHA Hazard Communication Standard, found in Title 29 Code of Federal Regulations (CFR) Part 1910.1200, or Worker Right to Know Law. In addition, see Uniform Fire Code Article 80.

57.21 Containment Materials

The materials utilized for storage, piping, valves, pumping, metering, splash guards, etc., must be specially selected considering the physical and chemical characteristics of each hazardous or corrosive chemical.

57.22 Underground Storage

Underground storage and piping facilities for fuels, or chemicals such as alum or ferric chloride, must be constructed in accordance with applicable state and federal regulations on underground storage tanks for both fuels and hazardous materials.

57.23 Secondary Containment

Chemical storage areas must be enclosed in dikes or curbs that will contain the stored volume until it can be safely transferred to alternate storage or released to the wastewater at controlled rates that will not damage facilities, inhibit the treatment process, or contribute to stream pollution. Liquid polymer should be similarly contained to reduce areas with slippery floors, especially to protect travelways. Non-slip floor surfaces are desirable in polymer-handling areas.

57.24 Liquefied Gas Chemicals

Properly designed isolated areas must be provided for storage and handling of chlorine and sulfur dioxide and other hazardous gases. Gas detection kits, alarms, controls, safety devices, and emergency repair kits must also be provided.

57.25 Splash Guards

All pumps or feeders for hazardous or corrosive chemicals must have guards that will effectively prevent spray of chemicals into space occupied by personnel. The splash guards are in addition to guards to prevent injury from moving or rotating machinery parts.

57.26 Piping, Labeling, Coupling Guards, Location

All piping containing or transporting corrosive or hazardous chemicals must be identified with labels every ten feet and with at least two labels in each room, closet, or pipe chase. Color-coding may also be used, but is not an adequate substitute for labeling.

All connections (flanged or other type), except those adjacent to storage or feeder areas, must have guards that will direct any leakage away from space occupied by personnel. Pipes containing hazardous or corrosive chemicals should not be located above shoulder level except where continuous drip collection trays and coupling guards will eliminate chemical spray or dripping onto personnel.

57.27 Protective Clothing and Equipment

The following items of protective clothing or equipment must be provided and utilized for all operations or procedures when their use will minimize injury hazard to personnel:

a. Self-contained breathing apparatus recommended for protection against chlorine;

b. Chemical worker's goggles, ultraviolet light safety goggles, or other suitable goggles (safety glasses are insufficient);

c. Face masks or shields for use over goggles;

d. Masks to protect the lungs in dry chemical areas or in areas exposed to aerosols or sprays;

e. Rubber gloves (mandatory for ultraviolet light systems);

f. Rubber aprons with leg straps;

g. Rubber boots (leather and wool clothing should be avoided near caustics);

h. Safety harness and line.

57.28 Warning System and Signs

Facilities must be provided for automatic shutdown of pumps and sounding of alarms when failure occurs in a pressurized chemical discharge line.

Warning signs requiring use of goggles must be located near chemical unloading stations, pumps, and other points of frequent hazard.

57.29 Dust Collection

Dust collection equipment must be provided to protect personnel from dusts injurious to the lungs or skin and to prevent polymer dust from settling on walkways which become slick when wet.

57.30 Eyewash Devices and Safety Showers

Eyewash devices and safety showers must utilize potable water and be fully operable during all weather conditions. Eyewash devices and safety showers are to be as close as practical, and no more than 25 feet (7.6 m) to points of chemical exposure. Eyewash devices and safety showers must be provided in category II (refer to Section 58.3) and category III (refer to Section 58.4) laboratories, and on each floor level or work location involving hazardous or corrosive chemical storage, mixing (or shaking), pumping, metering, or transportation unloading.

The eyewash devices must be supplied with water of moderate temperature, 50° to 90° F (10° to 32° C), suitable to provide 15 minutes to 30 minutes of continuous irrigation of the eyes. The safety showers must be capable of discharging 30 gpm to 50 gpm (1.9 L/s to 3.2 L/s) of water at moderate temperature and at pressures of 20 psi to 50 psi (138 kPa to 345 kPa).

57.31 Hazardous Chemical Container Identification

The identification and hazard warning data included on shipping containers must appear on all containers (regardless of size or type) used to store, carry, or use a hazardous substance. Wastewater and sludge sample containers should be adequately labeled. Below is a suitable label to identify a wastewater sample as a hazardous substance:

RAW SEWAGE WASTEWATER
Sample point No.______
Contains Harmful Bacteria.
May contain hazardous or toxic material.
Do not drink or swallow.
Avoid contact with openings or breaks in the skin.

58. LABORATORY

Follow OSHA Laboratory Safety Standard found in Title 29 CFR Part 1910.1450.

58.1 General

All mechanical treatment facilities must include a laboratory for making the necessary analytical determinations and operating control tests. A laboratory is not required for those facilities that do not require laboratory testing for operational control and where satisfactory off-site laboratory provisions are made to meet the permit monitoring requirements. For facilities where a fully equipped laboratory is not required, the requirements for utilities, fume hoods, etc., may be reduced. The laboratory must have sufficient size, bench space, equipment, and supplies to perform all self-monitoring analytical work required by discharge permits, and to perform the process control tests necessary for good management of each treatment process included in the design.

The facilities and supplies necessary to perform analytical work to support industrial waste control programs will normally be included in the same laboratory. The laboratory arrangement should be sufficiently flexible to allow future expansion should more analytical work be needed. Laboratory instrumentation and size should reflect treatment plant size, staffing requirements, and process complexity. Experience and training of plant operators should also be assessed in determining treatment plant laboratory needs.

Treatment plant laboratory needs may be divided into the following three general categories:

I. Plants performing only basic operational testing; this typically includes pH, temperature, and dissolved oxygen.

II. Plants performing more complex operational and permit laboratory tests including all Category I testing, biochemical oxygen demand, suspended solids, and bacterial analysis (e.g., *E. coli*).

III. Plants performing more complex operational, permit, industrial pretreatment, including all Category II testing, nutrient analysis, metals testing, and multiple plant laboratory testing.

Expected minimum laboratory needs for these three plant classifications are outlined in this section. However, in specific cases laboratory needs may have to be modified or increased due to the industrial monitoring needs or special process control requirements.

58.2 Category I: Plants performing only basic operational testing

58.21 Location and Space

A floor area up to 150 square feet (14 square meters) should be adequate. It is recommended that this be at the treatment site. Another location in the community utilizing space in an existing structure owned by the involved sewer authority may be acceptable.

58.22 Design and Materials

The facility must provide electricity, water, heat, sufficient storage space, a sink, and a bench top. The lab components need not be of industrial grade materials. Laboratory equipment and glassware must be of types recommended by "Standard Methods for the Examination of Water and Wastewater" and the Department.

58.3 Category II: Plants performing more complex operational and permit laboratory tests including biochemical oxygen demand, suspended solids, and bacterial analysis

58.31 Location and Space

The laboratory size should be based on providing adequate room for the equipment to be used. In general, the laboratories for this category of plant should provide a minimum of approximately 300 square feet (28 square meters) of floor space. The laboratory should be located at the treatment site on ground level. The laboratory must be isolated away from vibrating, noisy, high-temperature machinery or equipment, which might have adverse effects on the performance of laboratory staff or instruments.

58.32 Floors

Floor surfaces should be fire resistance, and highly resistant to acids, alkalies, solvents, and salts.

58.33 Cabinets and Bench Tops

Laboratories in this category usually perform both the discharge permit testing and operational control monitoring utilizing "acids" and "bases" in small quantities, such that laboratory grade metal cabinets and shelves are not mandatory. The cabinets and shelves selected may be of wood or other durable materials. Bench tops should be of acid resistant laboratory grade materials for protection of the non-acid proof cabinets. Glass doors on wall-hung cabinets are not required.

One or more cupboard style base cabinets should be provided. Cabinets with drawers should have stops to prevent accidental removal. Cabinets for Category II laboratories are not required to have gas, air, vacuum, and electrical service fixtures. Built-in shelves should be adjustable.

58.34 Fume Hoods, Sinks, and Ventilation

58.341 Fume Hoods

Fume hoods must be provided for laboratories in which required analytical work produces noxious fumes. Air intake should be balanced against all exhaust ventilation to maintain an overall positive pressure relative to atmospheric pressure in the laboratory.

58.342 Sinks

A laboratory grade sink and drain trap must be provided.

58.343 Ventilation

Laboratories should be air conditioned. In addition, separate exhaust ventilation should be provided.

58.35 Balance and Table

An analytical balance of the automated digital readout, single pan 0.1 milligram sensitivity type, must be provided. A heavy special-design balance table, which will minimize vibration of the balance, is recommended. If provided, it must be located as far as possible from windows, doors, or other sources of drafts or air movements, so as to minimize undesirable impacts from these sources upon the balance.

58.36 Equipment, Supplies, and Reagents

The laboratory must be provided with all of the equipment, supplies and reagents that are needed to carry out all of the facility's analytical testing requirements. If any required analytical testing produces malodorous or noxious fumes, the engineer should verify that the in-house analysis is more cost-effective than use of an independent off-site laboratory. Composite samplers may be required to satisfy permit sampling requirements. Discharge permit, process control, and industrial waste monitoring requirements should be considered when specifying equipment needs. References such as Standard Methods for the Examination of Water and Wastewater and the U.S.E.P.A Analytical Procedures Manual should be consulted prior to specifying equipment items.

58.37 Utilities

58.371 Power Supply

Consideration should be given to providing line voltage regulation for power supplied to laboratories using delicate instruments.

58.372 Laboratory Water

Reagent water of a purity suitable for analytical requirements must be supplied to the laboratory. In general, reagent water prepared using an all glass distillation system is adequate. However, some analyses require deionization of the distilled water. Consideration should be given to softening the feed water to the still.

58.38 Safety

At a minimum, laboratories must provide the following: first aid equipment, protective clothing including goggles, gloves, lab aprons, etc., and a fire extinguisher.

58.4 Category III. Plants performing more complex operational, permit, industrial pretreatment and multiple plant laboratory testing

58.41 Location and Space

The laboratory should be located at the treatment site on ground level, with environmental control as an important consideration. It must be located away from vibrating, noisy, high temperature machinery or equipment, which might have adverse effects on the performance of laboratory staff or instruments. The laboratory facility needs for Category III plants should be described in the engineering report or facilities plan. The laboratory floor space and facility layout should be based on an evaluation of the complexity, volume, and variety of sample analyses expected during the design life of the plant including testing for process control, industrial pretreatment control, user charge monitoring, and discharge permit monitoring requirements.

Consideration should be given to the necessity to provide separate (and possibly isolated) areas for some special laboratory equipment, glassware, and chemical storage. The analytical and sample storage areas should be isolated from all potential sources of contamination. It is recommended that the organic chemical facilities be isolated from other facilities. Adequate security must be provided for sample storage areas. Provisions for the proper storage and disposal of chemical wastes must be provided. At large plants, office and administrative space needs should be considered.

For less complicated laboratory needs bench-top working surface should occupy at least 35 percent of the total laboratory floor space. Additional floor and bench space should be provided to facilitate performance of analysis of industrial wastes, as required by the discharge permit and the utility's industrial waste pretreatment program. Ceiling height should be adequate to provide for the installation of wall mounted water stills, deionizers, distillation racks, hoods, and other equipment with extended height requirements.

58.42 Floors and Doors

58.421 Floors

Floor surfaces should be fire resistant, and highly resistant to acids, alkalies, solvents, and salts.

58.422 Doors

Two exit doors should be located to permit a straight egress from the laboratory, preferably at least one to outside the building. Panic hardware should be used. They should have large glass windows for easy visibility of approaching or departing personnel.

Automatic door closers should be installed; swinging doors should not be used.

Flush hardware should be provided on doors if cart traffic is anticipated. Kick plates are also recommended.

58.43 Cabinets and Bench Tops

58.431 Cabinets

Wall-hung cabinets are useful for dust-free storage of instruments and glassware. Units with sliding glass doors are preferable. A reasonable proportion of cupboard style base cabinets and drawer units should be provided.

Drawers should slide out so that entire contents are easily visible. They should be provided with rubber bumpers and with stops, which prevent accidental removal. Drawers should be supported on ball bearings or nylon rollers, which pull easily in adjustable steel channels. All metal drawer fronts should be double-wall construction.

All cabinet shelving should be acid resistant and adjustable. The laboratory furniture must be supplied with adequate water, gas, air, and vacuum service fixtures, traps, strainers, plugs and tailpieces, and all electrical service fixtures.

58.432 Bench Tops

Bench tops should be constructed of materials resistant to attacks from normally used laboratory reagents. Generally, bench-top height should be 36 inches (914 mm). However, areas to be used exclusively for sit-down type operations should be 30 inches

(762 mm) high and include kneehole space. One inch (25.4 mm) overhangs and drip grooves should be provided to keep liquid spills from running along the face of the cabinet. Tops should be furnished in large sections, 1-1/4 inches (32 mm) thick. They should be field-jointed into a continuous surface with acid, alkali, and solvent resistant cements which are at least as strong as the material of which the top is made.

58.44 Hoods

58.441 General

Fume hoods and canopy hoods over heat-releasing equipment must be provided.

58.442 Fume Hoods

a. Location

Fume hoods must be located where air disturbance at the face of the hood is minimal. Air disturbance may be created by persons walking past the hood; by heating, ventilating, or air-conditioning systems; by drafts from opening or closing a door; etc.

Safety factors must be considered in locating a hood. If a hood is situated near a doorway, a secondary means of egress must be provided. Bench surfaces should be available next to the hood so that chemicals need not be carried long distances.

b. Design and Materials

The selection, design, and materials of construction of fume hoods and their appropriate safety alarms must be made by considering the variety of analytical work to be performed. The characteristics of the fumes, chemicals, gases, or vapors that will or may be released by the activities therein must be considered. Special design and construction is necessary if perchloric acid use is anticipated. Consideration must be given to providing more than one fume hood to minimize potential hazardous conditions throughout the laboratory. An overall positive pressure relative to atmospheric must be maintained in the laboratory.

Fume hoods are not appropriate for operation of heat-releasing equipment that does not contribute to hazards, unless they are provided in addition to those needed to perform hazardous tasks.

c. Fixtures

One sink should be provided inside each fume hood. A cup sink is usually adequate.

All switches, electrical outlets, and utility and baffle adjustment handles must be located outside the hood. Light fixtures must be explosion-proof.

d. Exhaust

Twenty-four hour continuous exhaust capability must be provided. Exhaust fans must be explosion-proof. Exhaust velocities must be checked when fume hoods are installed.

58.443 Canopy Hoods

Canopy hoods must be installed over the bench-top areas where hot plate, steam bath, or other heating equipment or heat-releasing instruments are used. The canopy should be constructed of heat and corrosion resistant material.

58.45 Sinks, Ventilation, and Lighting

58.451 Sinks

The laboratory should have a minimum of two sinks (not including cup sinks). At least one of them should be a double-well sink with drainboards. Additional sinks should be provided in separate work areas as needed and identified for the use intended.

Sinks should be made of epoxy resin or plastic materials highly resistant to acids, alkalies, solvents, and salts, and should be abrasion and heat resistant, non-absorbent, and light in weight. Traps should be made of glass, plastic, or lead and easily accessible for cleaning. Waste openings should be located toward the back so that a standing overflow will not interfere.

All water fixtures on which hoses may be used should be provided with reduced zone pressure backflow preventers to prevent contamination of water lines.

58.452 Ventilation

Laboratories should be separately air conditioned, with external air supply for one hundred percent make-up volume. In addition, separate exhaust ventilation should be provided. Ventilation outlet locations should be remote from ventilation inlets. Consideration should be given to providing dehumidifiers.

58.453 Lighting

Good lighting, free from shadows, must be provided for reading dials, meniscuses, etc., throughout the laboratory.

58.46 Balance and Table

An analytical balance of the automatic, digital readout, single pan, 0.1 milligram sensitivity type, must be provided. A heavy special-design balance table that will minimize vibration of the balance is needed. The table must be located as far as practical from windows, doors, or other sources of drafts or air movements, to minimize undesirable impacts from these sources upon the balance.

58.47 Equipment, Supplies, and Reagents

The laboratory must be provided with all of the equipment, supplies, and reagents that are needed to carry out all of the facility's analytical testing requirements. Composite samplers may be required to satisfy permit sampling requirements. Discharge permit, process control, and industrial waste monitoring requirements should be considered when specifying equipment needs. References such as Standard Methods for the Examination of Water and Wastewater and the U.S.E.P.A Analytical Procedures Manual should be consulted prior to specifying equipment items.

58.48 Utilities and Services

58.481 Power Supply

Consideration should be given to providing line voltage regulation for power supplied to laboratories using delicate instruments.

58.482 Laboratory Water

Reagent water of suitable purity for analytical requirements must be supplied to the laboratory. In general, reagent water prepared using an all glass distillation system is adequate. However, some analyses require deionization of the distilled water. Consideration should be given to softening the feed water to the still.

58.483 Gas and Vacuum

Natural or LP gas should be supplied to the laboratory. Digester gas should not be used. An adequately-sized line source of vacuum should be provided with outlets available throughout the laboratory.

58.49 Safety

Laboratories must contain the following: first aid equipment; protective clothing and equipment such as, goggles, safety glasses, full face shields, gloves, etc.; fire extinguishers; chemical spill kits; "No Smoking" signs in hazardous areas; and appropriately placed warning signs for slippery areas, non-potable water fixtures, hazardous chemical storage areas, flammable fuel storage areas, etc.

CHAPTER 60

SCREENING, GRIT REMOVAL, AND FLOW EQUALIZATION

61. SCREENING DEVICES

61.1 Coarse Screens

61.11 When Required

Protection for pumps and other equipment must be provided by trash racks, coarse bar racks, or coarse screens.

61.12 Design and Installation

61.121 Bar Spacing

Clear openings between bars should be no less than 1 inch (25.4 mm) for manually cleaned screens. Clear openings for mechanically cleaned screens may be smaller. Maximum clear openings should be 1 3/4 inches (44.5 mm).

61.122 Slope and Velocity

Manually cleaned screens should be placed on a slope of 30 to 45 degrees from the horizontal.

At design average flow conditions, approach velocities should be no less than 1.25 feet per second (fps) (0.38 m/s), to prevent settling; and no greater than 3.0 fps (0.91 m/s) to prevent forcing material through the openings.

61.123 Channels

Dual channels must be provided and equipped with the necessary gates to isolate flow from any screening unit. Provisions must also be made to facilitate dewatering each unit. The channel preceding and following the screen must be shaped to eliminate stranding and settling of solids.

61.124 Auxiliary Screens

Where a single mechanically cleaned screen is used, an auxiliary manually cleaned screen must be provided. Where two or more mechanically cleaned screens are used, the design must provide for taking any unit out of service without sacrificing the capability to handle the design peak instantaneous flows.

61.125 Invert

The screen channel invert should be 3.0 to 6.0 inches (76 to 152 mm) below the invert of the incoming sewer.

61.126 Flow Distribution

Entrance channels should be designed to provide equal and uniform distribution of flow to the screens.

61.127 Backwater Effect on Flow Metering

Flow measurement devices should be selected for reliability and accuracy. The effect of changes in backwater elevation, due to intermittent cleaning of screens, should be considered in locations of flow measurement equipment.

61.128 Freezing Protection

Screening devices and screening storage areas must be protected from freezing.

61.129 Screenings Removal and Disposal

A convenient and adequate means for removing screenings must be provided. Hoisting or lifting equipment may be necessary depending on the depth of pit and amount of screenings or equipment to be lifted. Washing of screenings is required for screens with 0.5 inch (12.7 mm) openings or less.

Facilities must be provided for handling, storage, and disposal of screenings in a manner acceptable to the Department. Separate grinding of screenings and return to the sewage flow is unacceptable.

Manually cleaned screening facilities must include an accessible platform from which the operator may rake screenings easily and safely. Suitable drainage facilities must be provided for both the platform and the storage area.

61.130 Materials

Due to the corrosive environment, bar racks must be constructed of aluminum, stainless steel, fiberglass, or other non-corrosive material.

61.13 Access and Ventilation

Screens located in pits more than 4 feet (1.2 m) deep must be provided with stairway access. Access ladders are acceptable for pits less than 4 feet (1.2 m) deep, in lieu of stairways.

Screening devices, installed in a building where other equipment or offices are located, must be isolated from the rest of the building, be provided with separate outside entrances, and be provided with separate and independent fresh air supply.

Fresh air must be forced into enclosed screening device areas or into open pits more than 4 feet (1.2 m) deep. Dampers should not be used on exhaust or fresh air ducts and fine screens or other obstructions should be avoided to prevent clogging. Where continuous ventilation is required, at least 12 complete air changes per hour must be provided. Where continuous ventilation would cause excessive heat loss, intermittent ventilation of at least 30 complete air changes per hour must be provided when workers enter the area. The air change requirement must be based on 100 percent fresh air.

Switches for operation of ventilation equipment should be marked and located conveniently. All intermittently operated ventilation equipment must be interconnected with the respective pit lighting system. The fan wheel should be fabricated from non-sparking material. Explosion proof gas detectors must be provided in accordance with Section 57 (Safety).

61.14 Safety and Shields

61.141 Railings and Gratings

Manually cleaned screen channels, must be protected by guard railings and deck gratings, with adequate provisions for removal or opening to facilitate raking.

Mechanically cleaned screen channels, must be protected by guard railings and deck gratings. Consideration should also be given to temporary access arrangements to facilitate maintenance and repair.

61.142 Mechanical Devices

Mechanical screening equipment must have adequate removable enclosures to protect personnel against accidental contact with moving parts and to prevent dripping in multi-level installations.

A positive means of locking out each mechanical device and temporary access for use during maintenance must be provided.

61.143 Drainage

Floor design and drainage must be provided to prevent slippery areas.

61.144 Lighting

Suitable lighting must be provided in all work and access areas. Refer to Section 61.152 (Electrical Equipment, Fixtures, and Controls).

61.15 Electrical Equipment and Control Systems

61.151 Timing Devices

All mechanical units that are operated by timing devices must be provided with auxiliary controls that will set the cleaning mechanism in operation at a preset high water elevation. If the cleaning mechanism fails to lower the high water, a warning must be signaled.

61.152 Electrical Equipment, Fixtures and Controls

Electrical equipment, fixtures and controls in the screening area where hazardous gases may accumulate must meet the requirements of the National Electrical Code for Class I, Division 1, Group D locations.

61.153 Manual Override

Automatic controls must be supplemented by a manual override.

61.16 Servicing

Hosing equipment must be provided to facilitate cleaning. Refer to Section 56.2 (Water Supply).

61.2 Fine Screens

61.21 General

Fine screens have openings less than 0.25 inch (6 mm). The amount of material removed by fine screens is dependent on the waste stream being treated and screen opening size. Automated washing of screenings is required for all fine screens. Fine screens may require close operational attention to function properly.

Fine screens should not be considered equivalent to primary sedimentation, but may be used in lieu of primary sedimentation where subsequent treatment units are designed on the basis of anticipated screen performance and absence of primary sedimentation. Selection of screen capacity should consider flow restriction due to retained solids, gummy materials, frequency of cleaning, and extent of cleaning. Where fine screens are used, additional provision for removal of floatable oils and greases must be considered.

61.22 Design and Installation

Tests should be conducted to determine BOD_5 and suspended solids removal efficiencies at the design maximum day flow and design maximum day BOD_5 loadings. Pilot testing for an extended time is preferred.

A minimum of two parallel fine screens must be provided, each unit being capable of independent operation. Capacity must be provided to treat design peak instantaneous flow with one unit out of service.

Fine screens must be preceded by a coarse bar screening device, unless not required by the fine screen manufacturer. Fine screens must be protected from freezing and located to facilitate maintenance.

61.23 Electrical Equipment, Fixtures and Control

Electrical equipment, fixtures and controls in the screening area where hazardous gases may accumulate must meet the requirements of the National Electrical Code for Class I, Division 1, Group D locations.

61.24 Servicing

Hosing equipment must be provided to facilitate cleaning. Provision must be made for isolating and removing units from their location for servicing.

61.25 Safety and Shields

Hoods must be provided for safety and to contain backwash sprays to reduce operator contact with aerosols and sprays and prevent floors from becoming wet and slippery.

62. COMMINUTORS AND GRINDERS

62.1 General

Provisions for access, ventilation, shields, and safety must conform to Sections 61.13 (Access and Ventilation), 61.14 (Safety and Shields), and 61.15 (Electrical Equipment and Control Systems).

62.2 When Used

Comminutors or grinders may be used in lieu of screening devices to protect equipment. Special consideration must be given to downstream unit process design and operations due to the fact that comminutors and grinders do not remove solids and their use may result in the accumulation of stringy material on downstream equipment.

62.3 DESIGN CONSIDERATIONS

62.31 Location

Comminutors or grinders should be located downstream of any grit removal equipment and should be protected by a coarse screening device. Comminutors or grinders not preceded by grit removal equipment must be protected by a 6 inch (152 mm) deep gravel trap.

62.32 Size

Comminutor or grinder capacity must be adequate to handle design peak hourly flow.

62.33 Installation

A screened bypass channel must be provided. The use of the bypass channel should be automatic for all comminutor or grinder failures.

Gates must be provided in accordance with Sections 61.123 (Channels) and 61.124 (Auxiliary Screens).

62.34 Servicing

Provision must be made to facilitate servicing units in place and removing units from their location for servicing.

62.35 Electrical Controls and Motors

Electrical equipment in comminutor or grinder chambers where hazardous gases may accumulate must meet the requirements of the National Electrical Code for Class I, Division 1, Group D locations. Motors must be protected against accidental submergence.

63. GRIT REMOVAL FACILITIES

63.1 When Required

Grit removal facilities are required for all mechanical wastewater treatment plants, and are required for plants receiving wastewater from combined sewers or from sewer systems receiving substantial amounts of grit. If a plant serving a separate sewer system is designed without grit removal facilities, the design must include provision for future installation. Consideration must be given to possible damaging effects on pumps, comminutors, grinders, and other preceding equipment, and the need for additional storage capacity in treatment units where grit is likely to accumulate.

63.2 Location

63.21 General

Grit removal facilities should be located ahead of pumps and comminuting devices. Coarse bar racks should be placed ahead of grit removal facilities.

63.22 Housed Facilities

63.221 Ventilation

Fresh air must be introduced continuously at a rate of at least 12 air changes per hour, or intermittently at a rate of at least 30 air changes per hour. Odor control facilities may also be warranted. Refer to Section 61.13 (Access and Ventilation).

63.222 Access

Adequate stairway access to above or below grade facilities must be provided.

63.223 Electrical

All electrical work in enclosed grit removal areas where hazardous gases may accumulate must meet the requirements of the National Electrical Code of Class I, Division 1, Group D locations. Explosion-proof gas detectors must be provided in accordance with Section 57 (Safety).

63.23 Outside Facilities

Grit removal facilities located outdoors must be protected from freezing.

63.3 Type and Number of Units

Plants treating wastes from combined sewers should have at least two mechanically cleaned grit removal units, with provisions for bypassing. A single manually cleaned or mechanically cleaned grit chamber with bypass is acceptable for small wastewater treatment plants (average daily flow less than 25,000 gallons per day) serving separate sanitary sewer systems. Minimum facilities for larger plants serving separate sanitary sewers should be at least one mechanically cleaned unit with a bypass.

Facilities other than channel-type must be provided with adequate and flexible controls for velocity and/or air supply devices and with grit collection and removal equipment.

Aerated grit chambers should have air rates adjustable in the range of 3 to 8 cubic feet per minute per foot (0.3 to 0.7 m^3/m) of tank length. Detention time in the tank should be in the range of 3 to 5 minutes at design peak hourly flows. The aerated grit chamber length-to-width ratio should range from 2.5:1 to 5:1. Likewise, the aerated grit chamber width-to-depth ratio should range from1:1 to 5:1.

Horizontal flow grit chambers should have a detention time of 45 to 90 seconds at design peak hourly flows.

63.4 Design Factors

63.41 General

The design effectiveness of a grit removal system must be commensurate with the requirements of the subsequent process units.

63.42 Inlet

Inlet turbulence must be minimized in channel type units.

63.43 Velocity and Detention

Channel-type chambers must be designed to control velocities during normal variations in flow as close as possible to one foot per second (0.30 m/s). The detention period must be based on the size of particle to be removed. All aerated grit removal facilities should be provided with adequate control devices to regulate air supply and agitation.

63.44 Grit Washing

The need for grit washing should be determined by the method of grit handling and final disposal.

63.45 Dewatering

Provision must be made for isolating and dewatering each unit. The design must provide for complete draining and cleaning by means of a sloped bottom equipped with a drain sump.

63.46 Water

An adequate supply of water under pressure must be provided for cleanup in accordance with Section 56.2 (Water Supply).

63.47 Grit Handling

Grit removal facilities located in deep pits should be provided with mechanical equipment for hoisting or transporting grit to ground level. Impervious, non-slip, working surfaces with adequate drainage must be provided for grit handling areas.

Grit transporting facilities must be provided with protection against freezing and loss of material.

64. PRE-AERATION

Pre-aeration of wastewater to reduce septicity may be required in special cases.

65. FLOW EQUALIZATION

65.1 General

Use of flow equalization should be considered where significant variations in organic and hydraulic loadings can be expected.

65.2 Location

Equalization basins must be located downstream of pretreatment facilities such as bar screens, comminutors, and grit chambers.

65.3 Type

Flow equalization can be provided by using separate basins or on-line treatment units, such as aeration tanks. Equalization basins may be designed as either in-line or side-line units. Unused treatment units, such as sedimentation or aeration tanks, may be utilized as equalization basins during the early period of design life.

65.4 Size

Equalization basin capacity should be sufficient to effectively reduce expected flow and load variations to the extent deemed to be economically advantageous. With a diurnal flow pattern, the volume required to achieve the desired degree of equalization can be determined from a cumulative flow plot over a representative 24-hour period.

65.5 Operation

65.51 Mixing

Aeration or mechanical equipment must be provided to maintain adequate mixing. Corner fillets and hopper bottoms with draw-offs must be provided to alleviate the accumulation of sludge and grit.

65.52 Aeration

Aeration equipment must be sufficient to maintain a minimum of 1.0 mg/L of dissolved oxygen in the mixed basin contents at all times. Air supply rates should be a minimum of 1.25 cfm/1000 gallons (0.15 L/s/m^3) of storage capacity. The air supply should be isolated from other treatment plant aeration requirements to facilitate process aeration control, although process air supply equipment may be utilized as a source of standby aeration.

65.53 Controls

Inlets and outlets for all basin compartments must be suitably equipped with accessible external valves, stop plates, weirs, or other devices to permit flow control and the removal of an individual unit from service. Facilities must also be provided to measure and indicate liquid levels and flow rates.

65.6 Electrical

All electrical work in housed equalization basins, where hazardous concentrations of flammable gases or vapors may accumulate, must meet the requirements of the National Electrical Code for Class I, Division 1, Group D locations.

65.7 Access

Suitable access must be provided to facilitate cleaning and the maintenance of equipment.

CHAPTER 70
SETTLING

71. GENERAL

71.1 Number of Units

Multiple units capable of independent operation are desirable and must be provided in all plants where design average flows exceed 100,000 gallons/day (379 m^3/d). Plants not having multiple units must include other provisions to assure continuity of treatment.

71.2 Flow Distribution

Effective flow splitting devices and control appurtenances (i.e., gates, splitter boxes, etc.) must be provided to permit proper proportioning of flow to each unit, throughout the expected range of flows. Valves used for flow proportioning are not acceptable.

72. DESIGN CONSIDERATIONS

72.1 Dimensions

The minimum length of flow from inlet to outlet is 10 feet (3 m) unless special provisions are made to prevent short-circuiting. The vertical side water depths must be designed to provide an adequate separation zone between the sludge blanket and the overflow weirs. The side water depths may not be less than the following values:

Type of Settling Tank	Minimum Side Water Depth (ft.)	(m)
Primary	10	3.0
Secondary tank following activated sludge process*	12	3.7
Secondary tank following fixed film reactor	10	3.0

* Greater side water depths are recommended for secondary clarifiers in excess of 4,000 square feet (372 m^2) surface area (equivalent to 70 feet (21 m) diameter) and for nitrification plants. A minimum side water depth of 16 feet (4.9 m) is recommended for plants that are required to meet stringent TSS and/or phosphorus limits. Depending on required effluent quality, side water depths of less than 12 feet (3.7 m) may be permitted for package plants with a design average flow less than 25,000 gallons per day (95 m^3/d), if justified, based on successful operating experience.

72.2 Surface Overflow Rates

72.21 Primary and Intermediate Settling Tanks

Primary settling tank sizing should reflect the degree of solids removal needed and the need to avoid septic conditions during low flow periods. Liquid detention times should not be greater than 2.5 hours at design average flow. Sizing must be calculated for both design average and design peak hourly flow conditions, and the larger surface area determined must be used. The following surface overflow rates must not be exceeded in the design:

	Surface Overflow Rates* at:	
Type of Settling Tank	Design Avg. Flow gpd/ft^2 (m³/(m²·d))	Design Peak Hourly Flow gpd/ft^2 (m³/(m²·d))
Primary - Tanks not receiving waste activated sludge **	1,000 (41)	1,500 – 3,000 (61 – 122)
Primary - Tanks receiving waste activated sludge		1,200 (49)
Intermediate – Tanks following series units of fixed film reactor processes		1,500 (61)

* Surface overflow rates must be calculated with all flows received at the settling tanks. Primary settling of normal public sewage can be expected to remove approximately 1/3 of the influent BOD when operating at an overflow rate of 1,000 gallons/day/ft^2 [41 m³/(m²·d)] .

** Anticipated BOD removal should be determined by laboratory tests and consideration of the character of the wastes. Significant reduction in BOD removal efficiency will result when the peak hourly overflow rate exceeds 1,500 gallons/day/ft^2 [61 m³/(m²·d)] .

72.22 Final Settling Tanks

Settling tests must be conducted wherever a pilot study of biological treatment is warranted by unusual waste characteristics, treatment requirements, or where proposed loadings go beyond the limits set forth in this Section.

72.221 Final Settling Tanks - Attached Growth Biological Reactors

Surface overflow rates for settling tanks following trickling filters may not exceed 1,200 gallons per day per square foot [49 m³/(m²·d)] based on design peak hourly flow.

72.222 Final Settling Tanks - Activated Sludge

To perform properly while producing a concentrated return flow, activated sludge settling tanks must be designed to meet thickening as well as solids separation requirements. Since the rate of recirculation of return sludge from the final settling tanks to the aeration or reaeration tanks is quite high in activated sludge processes, surface overflow rate and weir overflow rate should be adjusted for the various processes to minimize the problems with sludge loadings, density currents, inlet hydraulic turbulence, and occasional poor sludge settleability. The size of the settling tank must be based on the larger surface area determined for surface overflow rate and solids loading rate. The following design criteria shall not be exceeded:

Treatment Process	Surface Overflow Rate at Design Peak Hourly Flow* gallons/day/ft² [m³/(m²·d)]	Peak Solids Loading Rate*** lb/day/ft² [kg/(m²·d)]
Conventional, Step Aeration, Complete Mix Contact Stabilization, Carbonaceous Stage of Separate Stage Nitrification	1,200** (49)	50 (244)
Extended Aeration Single Stage Nitrification	1,000 (41)	35 (171)
2 Stage Nitrification	800 (33)	35 (171)
Activated Sludge with Chemical Addition to Mixed Liquor for Phosphorus Removal	900**** (37)	As Above

* Based on influent flow only.

** Plants needing to meet 20 mg/l or less suspended solids should reduce surface overflow rate to 1,000 gallons per day per square foot 41 $m^3/(m^2 \cdot d)$)

*** Clarifier peak solids loading rate must be computed based on the design maximum day flow rate plus the design maximum return sludge rate requirement and the design MLSS under aeration.

**** When phosphorus removal to a concentration of less than 1.0 mg/l is required.

72.3 Inlet Structures

Inlets should be designed to dissipate the inlet velocity, to distribute the flow equally both horizontally and vertically and to prevent short-circuiting. Channels must be designed to maintain a velocity of at least one foot per second (0.3 m/s) at one-half of the design average flow. Corner pockets and dead ends must be eliminated and corner fillets or channeling must be used where necessary. Provisions must be made for elimination or removal of floating materials in inlet structures.

72.4 Weirs

72.41 General

Overflow weirs must be readily adjustable over the life of the structure to correct for differential settlement of the tank. Launders and weirs must be accessible for cleaning.

72.42 Location

Overflow weirs must be located to optimize actual hydraulic detention time, and minimize short-circuiting. Peripheral weirs must be placed at least one foot from the wall.

72.43 Design Rates

Weir loadings should not exceed:

Average Plant Capacity	Loading Rate at Design Peak Hourly Flow - gallons/day/lin ft [m^3/(m·d)]
Equal to or less than 1 MGD (3785 m^3/d)	20,000 (250)
Greater than 1 MGD (3785 m^3/d)	30,000 (375)

If pumping is required, the pumps must be operated as continuously as possible. Also, weir loadings should be related to pump delivery rates to avoid short-circuiting.

72.44 Weir Troughs

Weir troughs must be designed to prevent submergence at design peak hourly flow, and to maintain a velocity of at least one foot per second (0.3 m/s) at one-half design average flow. Submerged weirs may be allowed for biological nutrient removal facilities to minimize the introduction of oxygen.

72.5 Submerged Surfaces

The tops of troughs, beams, and similar submerged construction elements must have a slope of at least 1.4 vertical to 1 horizontal; the underside of these elements must have a slope of 1 to 1 to prevent the accumulation of scum and solids.

72.6 Unit Dewatering

Unit dewatering features must conform to the provisions outlined in Section 54.3 (Unit Dewatering, Flotation Protection, and Plugging). The bypass design must also provide for distribution of the plant flow to the remaining units.

72.7 Freeboard

Walls of settling tanks must extend at least 6 inches (152 mm) above the surrounding ground surface and must provide at least 12 inches (304 mm) freeboard. Additional freeboard or the use of wind screens is recommended where larger settling tanks are subject to high velocity wind currents that would cause tank surface waves and inhibit effective scum removal.

72.8 Baffles

Incline baffles, which reduce short-circuiting caused by density currents, should be installed in final settling basins where settling performance must be optimized in order to meet stringent TSS and/or phosphorus limits.

73. SLUDGE AND SCUM REMOVAL

73.1 Scum Removal

Full surface mechanical scum collection and removal facilities, including baffling, must be provided for all settling tanks. The unusual characteristics of scum that may adversely affect pumping, piping, sludge handling and disposal, must be considered in design. Provisions may be made for the discharge of scum with the sludge; however, other special provisions for disposal may be necessary.

73.2 Sludge Removal

Mechanical sludge collection and withdrawal facilities must be designed to assure rapid removal of the sludge. Suction withdrawal should be provided for activated sludge clarifiers over 60 feet (18 m) in diameter, especially for activated sludge plants that nitrify.

Each settling tank must have its own sludge withdrawal lines to insure adequate control of sludge wasting rate for each tank.

73.21 Sludge Hopper

The minimum slope of the side walls must be 1.7 vertical to 1 horizontal. Hopper wall surfaces should be made smooth with rounded corners to aid in sludge removal. Hopper bottoms may not have a maximum dimension of greater than 2 feet (610 mm). Extra depth sludge hoppers for sludge thickening are not acceptable.

73.22 Cross Collectors

Cross collectors serving one or more settling tanks may be useful in place of multiple sludge hoppers.

73.23 Sludge Removal Piping

Each hopper must have an individually valved sludge withdrawal line at least six inches (152 mm) in diameter, except for Sequencing Batch Reactor (SBR) and Membrane Bioreactor (MBR) plants in which the withdrawal line may be 4 inches (102 mm) in diameter. The static head available for withdrawal of sludge must be 30 inches (762 mm) or greater, as necessary to maintain a three foot per second (0.91 m/s) velocity in the withdrawal pipe. Clearance between the end of the withdrawal line and the hopper walls must be sufficient to prevent "bridging" of the sludge. Adequate provisions must be made for rodding or back-flushing individual pipe runs. Provisions must be made to allow for visual confirmation and sampling of return sludge. Piping must be provided to return sludge for further processing.

73.24 Sludge Removal Control

Separate settling tank sludge lines may drain to a common sludge well.

Sludge wells equipped with telescoping valves or other appropriate equipment must be provided for viewing, sampling, and controlling the rate of sludge withdrawal. A means of controlling and measuring the sludge removal rate must be provided for each clarifier. The air-lift type of sludge removal will not be approved for removal of primary sludges and are discouraged for secondary sludge removal where stringent TSS or phosphorous limits are required.

74. PROTECTIVE AND SERVICE FACILITIES

74.1 Operator Protection

All settling tanks must be equipped to enhance safety for operators. Such features must include machinery covers, life lines, stairways, walkways, handrails, and slip-resistant surfaces.

74.2 Mechanical Maintenance Access

The design must provide for convenient and safe access to routine maintenance items such as gear boxes, scum removal mechanisms, baffles, weirs, inlet stilling baffle areas, and effluent channels.

74.3 Electrical Fixtures and Controls

Electrical equipment, fixtures and controls in enclosed settling basins and scum tanks, where hazardous concentrations of flammable gases or vapors may accumulate, must meet the requirements of the National Electrical Code for Class I, Division 1, Group D locations, with the exception of secondary clarifiers following extended aeration activated sludge treatment plants. Unless hazardous gasses are known to be present, enclosed secondary clarifiers following extended aeration processes are not classified as an explosive environment. In all cases, adequate ventilation must be provided.

The fixtures and controls must be located so as to provide convenient and safe access for operation and maintenance. Adequate area lighting must be provided.

74.4 Covering

Covering of final settling tanks for extended aeration facilities or nitrogen removal facilities must be considered to prevent freezing of the water surface. Covers must be designed to facilitate all necessary maintenance. Adequate ventilation and corrosion control must be provided for enclosed tanks.

CHAPTER 80

SLUDGE PROCESSING, STORAGE, AND DISPOSAL

81. GENERAL

Facilities for processing sludge must be provided at all mechanical wastewater treatment plants. Handling equipment must be capable of processing sludge to a form suitable for ultimate disposal unless provisions acceptable to the Department are made for processing the sludge at an alternate location.

The Department must be contacted if sludge unit processes not described in this Chapter are being considered or are necessary to meet state or federal sludge disposal requirements.

82. PROCESS SELECTION

The selection of sludge handling unit processes should be based upon at least the following considerations:

a. Local land use;

b. System energy requirements;

c. Cost effectiveness of sludge thickening and dewatering;

d. Equipment complexity and staffing requirements;

e. Adverse effects of heavy metals and other sludge components upon the unit processes;

f. Sludge digestion or stabilization requirements; including appropriate residence time and temperature requirements for pathogen and vector attraction reduction according to 40 CFR Part 503 regulations;

g. Sidestream or return flow treatment requirements (e.g., digester or sludge storage facilities supernatant, dewatering unit filtrate, wet oxidation return flows);

h. Sludge storage requirements;

i. Methods of ultimate disposal emphasizing beneficial use indicating compliance with local, state and federal sludge disposal regulations;

j. Back-up techniques of sludge handling and disposal.

83. SLUDGE THICKENERS

83.1 Design Considerations

Sludge thickeners to reduce the volume of sludge should be considered. The design of thickeners (gravity, dissolved-air flotation, centrifuge, and others) should consider the type and concentration of sludge, sludge stabilization processes, storage requirements, method of ultimate sludge disposal, chemical needs, and cost of operation. The use of gravity thickening tanks for unstabilized sludges is not recommended because of problems due to septicity unless provisions are made for adequate control of process operational problems and odors at the gravity thickener and any following unit processes.

Particular attention should be given to the pumping and piping of the concentrated sludge and possible onset of anaerobic conditions.

83.2 Prototype Studies

Process selection and unit process design parameters should be based on prototype studies. The Department will require such studies where the sizing of other plant units is dependent on performance of the thickeners. Refer to Section 53.2 (Engineering and Performance Requirements for Innovative Wastewater Treatment Alternatives) for any new process determination.

84. ANAEROBIC SLUDGE DIGESTION

84.1 General

84.11 Multiple Units

Multiple units or alternate methods of sludge processing must be provided. Facilities for sludge storage and supernatant separation in an additional unit may be required, depending on raw sludge concentration and disposal methods for sludge and supernatant.

84.12 Depth

If process design provides for supernatant withdrawal, the proportion of depth to diameter should be such as to allow for the formation of a reasonable depth of supernatant liquor. A minimum side water depth of 20 feet (6.1 m) is recommended.

84.13 Design Maintenance Provisions

To facilitate emptying, cleaning and maintenance, the following features are required, where applicable.

84.131 Slope

The tank bottom must slope to drain toward the withdrawal pipe. For tanks equipped with a suction mechanism for sludge withdrawal, a bottom slope not less than 1 to 12 is recommended. Where the sludge is to be removed by gravity alone, 1 to 4 slope is recommended.

84.132 Access Manholes

At least two access manholes not less than 30 inches (760 mm) in diameter should be provided in the top of the tank in addition to the gas dome. There should be stairways to reach the access manholes.

A separate side wall manhole must be provided that is large enough to permit the use of mechanical equipment to remove grit and sand. The side wall access manhole should be low enough to facilitate heavy equipment handling and may be buried in the earthen bank insulation.

84.133 Safety

Non-sparking tools, rubber-soled shoes, safety harness, gas detectors for flammable and toxic gases, and at least two self-contained breathing units must be provided for emergency use. Refer to other safety items as appropriate in Section 57 (Safety).

84.14 Toxic Materials

If the anaerobic digestion process is proposed, the basis of design must be supported by wastewater analyses to determine the presence of undesirable materials, such as high concentrations of sulfates and inhibitory concentrations of heavy metals.

84.2 Sludge Inlets, Outlets, Recirculation, and High Level Overflow

84.21 Multiple Inlets and Draw-Offs

Multiple sludge inlets and draw-offs and, where used, multiple recirculation suction and discharge points to facilitate flexible operation and effective mixing of the digester contents, must be provided unless adequate mixing facilities are provided within the digester.

84.22 Inlet Configurations

One inlet should discharge above the liquid level and be located at approximately the center of the tank to assist in scum breakup. The second inlet should be opposite to the suction line at approximately the 2/3 diameter point across the digester.

84.23 Inlet Discharge Location

Raw sludge inlet discharge points should be so located as to minimize short circuiting to the digested sludge or supernatant draw-offs.

84.24 Sludge Withdrawal

Sludge withdrawal to disposal should be from the bottom of the tank. The bottom withdrawal pipe should be interconnected with the necessary valving to the recirculation piping, to increase operational flexibility in mixing the tank contents.

84.25 Emergency Overflow

An unvalved vented overflow must be provided to prevent damage to the digestion tank and cover in case of accidental overfilling. This emergency overflow must be piped to an appropriate point and at an appropriate rate in the treatment process or sidestream treatment facilities to minimize the impact on process units.

84.3 Tank Capacity

84.31 Rational Design

The total digestion tank capacity must be determined by rational calculations based upon such factors as: volume of sludge added, percent solids and character; the temperature to be maintained in the digesters; the degree or extent of mixing to be obtained; the degree of volatile solids reduction required; the solids retention time at peak loadings; method of sludge disposal, and the size of the installation with appropriate allowances for gas, scum, supernatant, and digested sludge storage. Secondary digesters of two-stage series digestion systems that are utilized for digested sludge storage and concentration may not be credited in the calculations for volumes required for sludge digestion. Calculations must be submitted to justify the basis of design with consideration given to ultimate disposal of sludge.

84.32 Standard Design

When such calculations are not submitted to justify the design based on the above factors, the minimum digestion tank capacity outlined below will be required. Such requirements assume that the raw sludge is derived from ordinary public sewage, a digestion temperature is to be maintained in the range of 85° to 95° F (29° C to 35° C), 40 to 50 percent volatile matter in the digested sludge, and that the digested sludge will be removed frequently from the process (See also Sections 84.11 (Multiple Units) and 89.11 (General).)

84.321 Completely Mixed Systems

For digestion systems providing for intimate and effective mixing of the digester contents, the system may be loaded up to 80 pounds of volatile solids per 1000 cubic feet (1.3 kg/m^3) of volume per day in the active digestion units.

84.322 Moderately Mixed Systems

For digestion systems where mixing is accomplished only by circulating sludge through an external heat exchanger, the system may be loaded up to 40 pounds of volatile solids per 1000 cubic feet of volume per day (0.65 kg/m^3) in the active digestion units. This loading may be modified upward or downward depending upon the degree of mixing provided.

84.323 Multistage Systems

For digestion systems utilizing two stages (primary and secondary units), the first stage (primary) may be either completely mixed or moderately mixed and loaded in accordance with Sections 84.321 (Completely Mixed Systems) or 84.322 (Moderately Mixed Systems). The second stage (secondary) is to be designed for sludge storage, concentration, and gas collection and may not be credited in the calculations for volumes required for sludge digestion.

84.324 Digester Mixing

Facilities for mixing the digester contents must be provided where required for proper digestion by reason of loading rates or other features of the system. Where sludge recirculation pumps are used for mixing, they must be provided in accordance with appropriate requirements of Section 87.1 (Sludge Pumps).

84.4 Gas Collection, Piping and Appurtenances

84.41 General

All portions of the gas system including the space above the tank liquor, storage facilities, and piping must be designed so that under all normal operating conditions, including sludge withdrawal, the gas will be maintained under pressure. All enclosed areas where any gas leakage might occur must be adequately ventilated.

84.42 Safety Equipment

All necessary safety facilities must be included where gas is produced. Pressure and vacuum relief valves and flame trap, together with automatic safety shut off valves must be provided and protected from freezing. Water seal equipment may not be installed. Safety equipment and gas compressors should be housed in a separate room with an exterior door.

84.43 Gas Piping and Condensate

Gas piping must have a diameter of at least 4 inches (102 mm). A smaller diameter pipe at the gas production meter is acceptable. Gas piping must slope to condensation traps at low points. The use of float-controlled condensate traps is not permitted. Condensation traps must be protected from freezing.

Tightly fitted self-closing doors should be provided at connecting passageways and tunnels, which connect digestion facilities to other facilities to minimize the spread of gas. Piping galleries must be ventilated in accordance with Section 84.47 (Ventilation).

84.44 Gas Utilization Equipment

Gas burning boilers, engines, etc., must be located in well-ventilated rooms. Such rooms would not ordinarily be classified as a hazardous location if isolated from the digestion gallery or ventilated in accordance with Section 84.47 (Ventilation). Gas lines to these units must be provided with suitable flame traps.

84.45 Electrical Equipment, Fixtures, and Controls

Electrical equipment, fixtures and controls, in places enclosing and adjacent to anaerobic digestion appurtenances, where hazardous gases may accumulate, must comply with the National Electrical Code for Class 1, Division 1, Group D locations. Refer to Section 84.47 (Ventilation).

84.46 Waste Gas

84.461 Location

Waste gas burners must be readily accessible and should be located at least 50 feet (15.2 m) away from any plant structure. Waste gas burners must be of sufficient height and so located to prevent injury to personnel due to wind or downdraft conditions.

84.462 Pilot Light

All waste gas burners must be equipped with automatic ignition such as a pilot light or a device using a photoelectric cell sensor. Consideration should be given to the use of natural or propane gas to insure reliability of the pilot.

84.463 Gas Piping Slope

Gas piping must be sloped at a minimum of 2 percent up to the waste gas burner with a condensate trap provided in a location not subject to freezing.

84.47 Ventilation

Any underground enclosures connecting with digestion tanks or containing sludge or gas piping or equipment must be provided with forced ventilation for dry wells in accordance with Sections 42.71 (General) through 42.74 (Fans, Heating and Dehumidification) and 42.76 (Dry Wells). The ventilation rate for Class I, Division 2, Group D locations including enclosed areas without a gas tight partition from the digestion tank or areas containing gas compressors, sediment traps, drip traps, gas scrubbers, or pressure regulating and control valves, if continuous, must be at least 12 complete air changes per hour.

84.48 Meter

A gas meter with bypass must be provided, to meter total gas production for each active digestion unit. Total gas production for two-stage digestion systems operated in series may be measured by a single gas meter with proper interconnected gas piping.

Where multiple primary digestion units are utilized with a single secondary digestion unit, a gas meter must be provided for each primary digestion unit. The secondary digestion unit may be interconnected with the gas measurement unit of one of the primary units. Interconnected gas piping must be properly valved with gas tight gate valves to allow measurement of gas production from either digestion unit or maintenance of either digestion unit.

Gas meters may be of the orifice plate, turbine, or vortex type. Positive displacement meters should not be utilized. The meter must be specifically designed for contact with corrosive and dirty gases.

84.5 Digestion Tank Heating

84.51 Insulation

Wherever possible digestion tanks should be constructed above ground water level and must be suitably insulated to minimize heat loss. Maximum utilization of earthen bank insulation should be used.

84.52 Heating Facilities

Sludge may be heated by circulating the sludge through external heaters or by units located inside the digestion tank. Refer to Section 84.522 (Other Heating Methods).

84.521 External Heating

Piping must be designed to provide for the preheating of feed sludge before introduction into the digesters. Provisions must be made in the layout of the piping and valving to facilitate heat exchanger tube removal and cleaning of the lines. Heat exchanger sludge piping should be sized for peak heat transfer requirements. Heat exchangers should have a heating capacity of 130 percent of the calculated peak heating requirement to account for the occurrence of sludge tube fouling.

84.522 Other Heating Methods

a. The use of hot water heating coils affixed to the walls of the digester, or other types of internal heating equipment that require emptying the digester contents for repair, are not acceptable.

b. Other systems and devices have been developed recently to provide both mixing and heating of anaerobic digester contents. These systems will be reviewed on their own merits. Operating data detailing their reliability, operation, and maintenance characteristics will be required. Refer to Section 53.2 (Engineering and Performance Requirements for Innovative Wastewater Treatment Alternatives).

84.53 Heating Capacity

84.531 Capacity

Sufficient heating capacity must be provided to consistently maintain the design sludge temperature considering insulation provisions and ambient cold weather conditions. Where digester tank gas is used for other purposes, an auxiliary fuel may be required. The design operating temperature should be in the range of 85° to 100 °F (29° to 38°C) where optimum mesophilic digestion is required.

84.532 Standby Requirements

The provision of standby heating capacity or the use of multiple units sized to provide the heating requirements must be considered unless acceptable alternative means of handling raw sludge are provided for the extended period that digestion process outage is experienced due to heat loss.

84.54 Hot Water Internal Heating Controls

84.541 Mixing Valves

A suitable automatic mixing valve must be provided to temper the boiler water with return water so that the inlet water to the removable heat jacket or coil in the digester can be held below a temperature at which caking will be accentuated. Manual control should also be provided by suitable bypass valves.

84.542 Boiler Controls

The boiler must be provided with suitable automatic controls to maintain the boiler temperature at approximately 180° F (82° C) to minimize corrosion and to shut off the main gas supply in the event of pilot burner or electrical failure, low boiler water level, low gas pressure, or excessive boiler water temperature or pressure.

84.543 Boiler Water Pumps

Boiler water pumps must be sealed and sized to meet the operating conditions of temperature, operating head, and flow rate. Duplicate units must be provided.

84.544 Thermometers

Thermometers must be provided to show inlet and outlet temperatures of the sludge, hot water feed, hot water return, and boiler water.

84.545 Water Supply

The chemical quality should be checked for suitability for this use. Refer to Section 56.23 (Indirect Connections) for required break tank for indirect water supply connections.

84.55 External Heater Operating Controls

All controls necessary to ensure effective and safe operation are required. Provision for duplicate units in critical elements should be considered.

84.6 Supernatant Withdrawal

Where supernatant separation is to be used to concentrate sludge in the digester units and increase digester solids retention time, the design must provide for ease of operation and positive control of supernatant quality.

84.61 Piping Size

Supernatant piping should not be less than 6 inches (152 mm) in diameter.

84.62 Withdrawal Arrangements

84.621 Withdrawal Levels

Piping should be arranged so that withdrawal can be made from 3 or more levels in the tank. An unvalved vented overflow must be provided. The emergency overflow must be piped to an appropriate point and at an appropriate rate in the treatment process or side stream treatment units to minimize the impact on process units.

84.622 Withdrawal Selection

On fixed cover tanks the supernatant withdrawal level should preferably be selected by means of interchangeable extensions at the discharge end of the piping.

84.623 Supernatant Selector

A fixed screen supernatant selector or similar type device may be used only in an unmixed secondary digestion unit. If such supernatant selector is provided, provisions must be made for at least one other draw-off level located in the supernatant zone of the tank, in addition to the unvalved emergency supernatant draw-off pipe. High pressure back-wash facilities must be provided.

84.63 Sampling

Provisions must be made for sampling at each supernatant draw-off level. Sampling pipes should be at least 1 1/2 inches (38 mm) in diameter and should terminate at a suitably sized sampling sink or basin.

84.64 Supernatant Disposal

Supernatant return and disposal facilities should be designed to alleviate adverse hydraulic and organic effects on plant operations. If nutrient removal (e.g., phosphorus, ammonia) must be accomplished at a plant, then a separate supernatant side stream treatment system should be provided.

84.7 Anaerobic Digestion Sludge Production

For calculating design sludge handling and disposal needs, sludge production values from a two-stage anaerobic digestion process shall be based on a maximum solids concentration of 5 percent without additional thickening. The solids production values on a dry weight basis must be based on the following for the listed processes:

Primary plus waste activated sludge – at least 0.12 lb/P.E./day [0.05 kg/ (P.E.·d)].
Primary plus fixed film sludge – at least 0.09 lb/P.E./day [0.04 kg/P.E.·d)].
where P.E. = Population Equivalent

85. AEROBIC SLUDGE DIGESTION

85.1 General

The aerobic sludge digestion system must include provisions for digestion, supernatant separation, sludge concentration, and any necessary sludge storage. These provisions may be accomplished by separate tanks or processes, or in the digestion tanks.

85.2 Multiple Units

Multiple digestion units capable of independent operation are desirable and must be provided in all plants where the design average flow exceeds 100,000 gallons per day (379 m^3/d). Plants not having multiple units must provide alternate sludge handling and disposal methods.

85.3 Tank Capacity

85.31 Volume Required

The following digestion tank capacities are based on a solids concentration of 2 percent with supernatant separation performed in a separate tank. If supernatant separation is performed in the digestion tank, a minimum of 25 percent additional volume is required. These capacities must be provided unless sludge thickening facilities (refer to Section 83 (Sludge Thickeners) are utilized to thicken the feed solids concentration to greater than 2 percent. If such thickening is provided, the digestion volumes may be decreased proportionally.

Sludge Source	Volume/Population Equivalent (P.E.)
	ft^3/P.E. (m^3/P.E.)
Waste activated sludge -- no primary settling	4.5 (0.13)*
Primary plus waste activated sludge	4.0 (0.11)*
Waste activated sludge exclusive of primary sludge	2.0 (0.06)*
Extended aeration activated sludge	3.0 (0.09)
Primary plus fixed film reactor sludge	3.0 (0.09)

** These volumes also apply to waste activated sludge from single stage nitrification facilities with less than 24-hours detention time based on design average flow.

85.32 Effect of Temperature on Volume

The volumes in Section 85.31 (Volume Required) are based on digester temperatures of 59° F (15° C) and a solids retention time of 27 days. Aerobic digesters must be covered to minimize heat loss or these volumes must be increased for colder temperature applications. Refer to Section 85.9 (Digested Sludge Storage Volume) for necessary sludge storage. Additional volume may be required if the land application disposal method is used in order to meet applicable federal regulatory requirements.

85.4 Mixing

Aerobic digesters must be provided with mixing equipment that can maintain solids in suspension and ensure complete mixing of the digester contents. Energy requirements for mixing with mechanical aeration equipment must not be less than 0.75 horsepower per 1000 cu. ft. of digester capacity. Refer to Section 85.5 (Air Requirements).

85.5 Air Requirements

Sufficient air must be provided to keep the solids in suspension and maintain dissolved oxygen between 1 and 2 milligrams per liter (mg/L). For minimum mixing and oxygen requirements, an air supply of 30 cfm per 1000 cubic feet (0.5 L/s/m^3) of tank volume must be provided with the largest blower out of service. If diffusers are used, the non-clog type is recommended and they should be designed to permit continuity of service. If mechanical turbine aerators are utilized, at least two turbine aerators per tank must be provided to permit continuity of service. Mechanical aerators are not recommended for use in aerobic digesters where freezing conditions will cause ice build-up on the aerator and support structures.

85.6 Supernatant Separation and Scum and Grease Removal

85.61 Supernatant Separation

Facilities must be provided for effective separation or decanting of supernatant. Separate facilities are recommended; however, supernatant separation may be accomplished in the digestion tank provided additional volume is provided per Section 85.3 (Tank Capacity). The supernatant draw-off unit must be designed to prevent recycle of scum and grease back to plant process units. Provisions should be made to withdraw supernatant from multiple levels of the supernatant withdrawal zone.

85.62 Scum and Grease Removal

Facilities must be provided for the effective collection of scum and grease from the aerobic digester for final disposal and to prevent its recycle back to the plant process and to prevent long term accumulation and potential discharge in the effluent.

85.7 High Level Emergency Overflow

An unvalved high level overflow and any necessary piping must be provided to return digester overflow back to the head of the plant or to the aeration process in case of accidental overfilling. Design considerations related to the digester overflow must include waste sludge rate and duration during the period the plant is unattended, potential effects on plant process units, discharge location of the emergency overflow, and potential discharge of suspended solids in the plant effluent.

85.8 Aerobic Digestion Sludge Production

For calculating design sludge handling and disposal needs, sludge production values from aerobic digesters must be based on a maximum solids concentration of 2 percent without additional thickening. The solids production values on a dry weight basis must be based on the following for the listed processes:

Primary plus waste activated sludge - at least 0.16 lbs./P.E./day (0.07 kg/P.E./d.).
Primary plus fixed film sludge - at least 0.12 lbs./P.E./day (0.05 kg/P.E./d.).
where P.E. – Population Equivalent

85.9 Digested Sludge Storage Volume

85.91 Sludge Storage Volume

Sludge storage must be provided in accordance with Section 89 (Sludge Storage and Disposal) to accommodate daily sludge production volumes and as an operational buffer for unit outage and adverse weather conditions. Designs utilizing increased sludge age in the activated sludge system as a means of storage are not acceptable.

85.92 Liquid Sludge Storage

Liquid sludge storage facilities must be based on the following values unless digested sludge thickening facilities are utilized (refer to Section 83 Sludge Thickeners) to provide solids concentrations of greater than 2 percent.

Sludge Source	Volume/Population Equivalent (P.E.)
	ft^3/P.E./day (m^3/P.E./day)
Waste activated sludge - no primary settling, primary plus waste activated sludge, extended aeration activated sludge	0.13 (0.004)
Waste activated sludge exclusive of primary sludge	0.06 (0.002)
Primary plus fixed film reactor sludge	0.10 (0.003)

86. HIGH pH STABILIZATION

86.1 General

Alkaline material may be added to liquid primary or secondary sludges for sludge stabilization in lieu of digestion facilities; to supplement existing digestion facilities; or for interim sludge handling. There is no direct reduction of organic matter or sludge solids with the high pH stabilization process. There is an increase in the mass of dry sludge solids. Without supplemental dewatering, additional volumes of sludge will be generated. The design must account for the increased sludge quantities for storage, handling, transportation, and disposal methods and associated costs.

86.2 Operational Criteria

Sufficient alkaline material must be added to liquid sludge to produce a homogeneous mixture with a minimum pH of 12 after 2 hours of vigorous mixing without further alkali addition. The pH of the sludge must remain above 11.5 for an additional 22 hours. Facilities for adding supplemental alkaline material must be provided to maintain the pH of the sludge during interim sludge storage periods.

86.3 Odor Control and Ventilation

Odor control facilities must be provided for sludge mixing and treated sludge storage tanks when located within 1/2 mile (0.8 km) of residential or commercial areas. Ventilation is required for indoor sludge mixing, storage or processing facilities. See Section 42.71 (General) through 42.74 (Fans, Heating and Dehumidification) and 42.76 (Dry Wells) for ventilation requirements.

86.4 Mixing Tanks and Equipment

86.41 Tanks

Mixing tanks may be designed to operate as either a batch or continuous flow process. A minimum of two tanks must be provided of adequate size to provide a minimum 2 hours contact time in each tank. The following items must also be factored into the determination of the number, configuration and size of tanks:

a. peak sludge flow rates;

b. storage between batches;

c. dewatering or thickening performed in tanks;

d. repeating sludge treatment due to pH decay of stored sludge;

e. sludge thickening prior to sludge treatment;

f. type of mixing device used and associated maintenance or repair requirements.

86.42 Equipment

Mixing equipment must be designed to provide vigorous agitation within the mixing tank, maintain solids in suspension and provide for a homogeneous mixture of the sludge solids and alkaline material. Mixing may be accomplished either by diffused air or mechanical mixers. If diffused aeration is used, an air supply of 30 cfm per 1000 cubic feet (0.5 $L/s/m^3$) of mixing tank volume must be provided with the largest blower out of service. When diffusers are used, the non-clog type is recommended, and they should be designed to permit continuity of service. If mechanical mixers are used, the impellers must be designed to minimize fouling with debris in the sludge and consideration must be given to providing continuity of service during freezing weather conditions.

86.5 Chemical Feed and Storage Equipment

86.51 General

Alkaline material is caustic in nature and can cause eye and tissue injury. Equipment for handling or storing alkaline material must be designed for adequate operator safety. Refer to Section 57 (Safety) for proper safety precautions. Storage, slaking, and feed equipment should be sealed as airtight as practical to prevent contact of alkaline materials with atmospheric carbon dioxide and water vapor and to prevent the escape of dust material. All equipment and associated transfer lines or piping must be accessible for cleaning.

86.52 Feed and Slaking Equipment

The design of the feeding equipment must be based on the treatment plant size, type of alkaline material used, slaking required, and operator requirements. Equipment may be either of batch or automated type. Automated feeders may be of the volumetric or gravimetric type depending on accuracy, reliability, and maintenance requirements. Manually operated batch slaking of quicklime (CaO) should be avoided unless adequate protective clothing and equipment are provided. At small plants, use of hydrated lime [$Ca(OH)_2$] is recommended over quicklime due to safety and labor-saving reasons. Feed and slaking equipment must be sized to handle a minimum of 150 percent of the peak sludge flow rate including sludge that may need to be retreated due to pH decay. Duplicate units must be provided.

86.53 Chemical Storage Facilities

Alkaline materials may be delivered either in bag or bulk form depending upon the amount of material used. Material delivered in bags must be stored indoors and elevated above floor level. Bags should be of the multi-wall moisture-proof type. Dry bulk storage containers must be as airtight as practical and must contain a mechanical agitation mechanism. Storage facilities must be sized to provide a minimum of a 30-day supply.

86.6 Sludge Storage

Refer to Section 89 (Sludge Storage and Disposal) for general design considerations for sludge storage facilities. The design must incorporate the following considerations for the storage of high pH stabilized sludge.

86.61 Liquid Sludge

Liquid high pH stabilized sludge may not be stored in a pond. This sludge must be stored in a tank or vessel equipped with rapid sludge withdrawal mechanisms for sludge disposal or retreatment. Provisions must be made for adding alkaline material in the storage tank. Mixing equipment in accordance with Section 86.42 (Equipment) above must also be provided in all storage tanks.

86.62 Dewatered Sludge

On-site storage of dewatered high pH stabilized sludge should be limited to 30 days. Provisions for rapid retreatment or disposal of dewatered sludge stored on-site must also be made in case of sludge pH decay.

86.63 Off-Site Storage

There may not be any off-site storage of high pH stabilized sludge unless specifically permitted by the Department.

86.7 Disposal

Immediate sludge disposal methods and options are recommended to be utilized in order to reduce the sludge inventory on the treatment plant site and amount of sludge that may need to be retreated to prevent odors if sludge pH decay occurs. If the land application option is utilized for high pH stabilized sludge, the sludge should be incorporated into the soil during the same day of delivery to the site and application must comply with applicable state and federal disposal regulations.

87. SLUDGE PUMPS AND PIPING

87.1 Sludge

87.11 Capacity

Pump capacities must be adequate but should not be excessive. Provision for varying pump capacity is desirable. A rational basis of design must be provided with the plan documents. Variability in sludge mass and volume must be considered in pump selection.

87.12 Duplicate Units

Duplicate units must be provided at all installations.

87.13 Type

Plunger pumps, screw feed pumps, or other types of pumps with demonstrated solids handling capability must be provided for handling raw sludge. Where centrifugal pumps are used, a parallel positive displacement pump must be provided as an alternate to pump heavy sludge concentrations, such as primary or thickened sludge, that may exceed the pumping head of the centrifugal pump.

87.14 Minimum Head

A minimum positive head of 24 inches (610 mm) must be provided at the suction side of centrifugal type pumps and is desirable for all types of sludge pumps. Maximum suction lifts should not exceed 10 feet (3 m) for plunger pumps.

87.15 Sampling Facilities

Unless sludge sampling facilities are otherwise provided, quick-closing sampling valves must be installed at the sludge pumps. The size of valve and piping should be at least 1 1/2 inches (38 mm) and terminate at a suitably sized sampling sink or floor drain.

87.16 Safety

High pressure shut off switches and alarms must be used on positive displacement pumps to prevent dangerous conditions.

87.2 Sludge Piping

87.21 Size and Head

Digested sludge withdrawal piping should have a minimum diameter of 8 inches (203 mm) for gravity withdrawal and 6 inches (152 mm) for pump suction and discharge lines. Where withdrawal is by gravity, the available head on the discharge pipe should be at least 4 feet (1.2 m) and preferably more. Undigested sludge withdrawal piping must be sized in accordance with Section 73.23 (Sludge Removal Piping).

87.22 Slope and Flushing Requirements

Gravity piping should be laid on uniform grade and alignment. Slope on gravity discharge piping should not be less than 3 percent for primary sludges and all sludges thickened to greater than 2 percent solids. Slope on gravity discharge piping should not be less than 2 percent for aerobically digested sludge or waste activated sludge with less than 2 percent solids. Cleanouts must be provided for all gravity sludge piping. Provisions must be made for draining and flushing discharge lines. All sludge pipes must be suitably located or otherwise adequately protected to prevent freezing.

87.23 Supports

Special consideration must be given to the corrosion resistance and permanence of supporting systems for piping located inside the digestion tank.

88. SLUDGE DEWATERING

88.1 General

On-site sludge dewatering facilities must be provided for all plants. The sludge production values presented in Sections 84.7 (Anaerobic Digestion Sludge Production) and 85.8 (Aerobic Digestion Sludge Production) may be reduced, if justified, with on-site liquid sludge storage facilities or approved off-site sludge disposal.

For calculating design sludge handling and disposal needs for sludge stabilization processes other than those described in Sections 84.7 and 85.8, a rational basis of design for sludge production values must be developed and provided to the Department for approval on a case-by-case basis.

88.2 Sludge Drying Beds

88.21 Applicability

Sludge drying beds may be used for dewatering well digested sludge from either the anaerobic or aerobic process. Due to the large volume of sludge produced by the aerobic digestion process, consideration should be given to using a combination of dewatering systems or other means of ultimate sludge disposal.

88.22 Unit Sizing

Sludge drying bed area must be calculated on a rational basis with the following items considered:

a. The volume of wet sludge produced by existing and proposed processes;

b. Depth of wet sludge drawn to the drying beds. For design calculation purposes, a maximum depth of 8 inches (203 mm) must be utilized. For operational purposes, the depth of sludge placed on the drying bed may increase or decrease from the design depth based on the percent solids content and type of digestion utilized;

c. Total digester volume and other wet sludge storage facilities;

d. Degree of sludge thickening provided after digestion;

e. The maximum drawing depth of sludge, which can be removed from the digester or other sludge storage facilities without causing process or structural problems;

f. The time required on the bed to produce a removable cake. Adequate provision must be made for sludge dewatering and/or sludge disposal facilities for those periods of time during which outside drying of sludge on beds is hindered by weather. Drying during the winter months should not be anticipated in sizing beds;

g. Capacities of auxiliary dewatering facilities.

88.23 Percolation Type Bed Components

88.231 Gravel

The lower course of gravel around the underdrains should be properly graded and should be 12 inches (305 mm) in depth, extending at least 6 inches (152 mm) above the top of the underdrains. It is desirable to place this in 2 or more layers. The top layer of at least 3 inches (76 mm) should consist of gravel 1/8 to 1/4 inch (3 to 6 mm) in size.

88.232 Sand

The top level should consist of 6 to 9 inches (152 to 229 mm) of clean, washed, course sand. The effective size of the sand should be in the range of 0.8 to 1.5 millimeter. The finished sand surface should be level.

88.233 Underdrains

Underdrains should be at least 4 inches (102 mm) in diameter laid with open joints. Perforated pipe may also be used. Underdrains should be spaced no more than 20 feet (6.1 m) apart and sloped at a minimum of 1 percent. Lateral tiles should be spaced at 8 to 10 feet (2.4 to 3.0 m). Various pipe materials may be selected provided the pipe is corrosion resistant and appropriately bedded to ensure that the underdrains are not damaged by sludge removal equipment.

88.234 Additional Dewatering Provisions

Consideration must be given to providing a means of decanting supernatant of sludge placed on the sludge drying beds. More effective decanting of supernatant may be accomplished with polymer treatment of sludge.

88.235 Seal

The bottom must be sealed in a manner approved by the Department.

88.24 Walls

Walls should be water-tight and extend 18 inches (457 mm) above and at least 9 inches (230mm) below the surface of the bed. Outer walls should be extended at least 4 inches (102 mm) above the outside grade elevation to prevent soil from washing on to the beds.

88.25 Sludge Removal

Each bed must be constructed so as to be readily and completely accessible to mechanical cleaning equipment. Concrete runways spaced to accommodate mechanical equipment must be provided. Special attention should be given to assure adequate access to the areas adjacent to the sidewalls. Entrance ramps down to the level of the sand bed must be provided. These ramps should be high enough to eliminate the need for an entrance end wall for the sludge bed.

88.3 Mechanical Dewatering Facilities

88.31 General

Provision must be made to maintain sufficient continuity of service so that sludge may be dewatered without accumulation beyond storage capacity. The number of vacuum filters, centrifuges, filter presses, belt filters, or other mechanical dewatering facilities should be sufficient to dewater the sludge produced with the largest unit out of service. Unless other standby wet sludge facilities are available, adequate storage facilities of at least 4 days production volume must be provided. Documentation must be submitted justifying the basis of design of mechanical dewatering facilities.

88.32 Water Supply Protection

Provisions for water supply to mechanical dewatering facilities must be in accordance with Section 56.23 (Indirect Connections).

88.33 Auxiliary Facilities for Vacuum Filters

Back-up vacuum and filtrate pumps must be provided. It is permissible to have uninstalled back-up vacuum and filtrate pumps for every three or less vacuum filters, provided that the installed units can easily be removed and replaced. At least one filter media replacement unit must be provided.

88.34 Ventilation

Adequate facilities must be provided for ventilation of the dewatering area. The exhaust air should be properly conditioned to avoid odor nuisance. Ventilation must be provided in accordance with Section 42.7 (Safety Ventilation).

88.35 Chemical Handling Enclosures

Lime-mixing facilities should be completely enclosed to prevent the escape of lime dust. Chemical handling equipment should be automated to eliminate the manual lifting requirement. Refer to Section 57 (Safety).

88.4 Drainage and Filtrate Disposal

Drainage from beds, pond supernatant and filtrate from dewatering units must be returned to the wastewater treatment process at appropriate points and rates. See also Sections 56.7 (Sampling Equipment) and 84.64 (Supernatant Disposal).

88.5 Other Dewatering Facilities

If dewatering sludge is proposed by other methods, a detailed description of the process and design data must accompany the plans. Refer to Section 53.2 (Engineering and Performance Requirements for Innovative Wastewater Treatment Alternatives) for any new process determinations.

89. SLUDGE STORAGE AND DISPOSAL

89.1 Storage

89.11 General

Sludge storage facilities must be provided at all mechanical treatment plants. Appropriate storage facilities may consist of any combination of drying beds, ponds, separate tanks, additional volume in sludge stabilization units, pad areas or other means to store either liquid or dried sludge. Refer to Sections 88.2 (Sludge Drying Beds) and 89.2 (Sludge Storage Ponds) for drying bed and pond design criteria respectively.

The design must provide for odor control in sludge storage tanks and sludge ponds, including aeration, covering or other appropriate means.

89.12 Volume

Calculations justifying the number of days of storage to be provided must be submitted and must be based on the total sludge handling and disposal system. Refer to Sections 84.7 (Anaerobic Digestion Sludge Production) and 85.8 (Aerobic Digestion Sludge Production) for digested sludge production values. Sludge production values for other stabilization processes should be justified in the basis of design. If land application is the only means of sludge disposal utilized at a treatment plant, sludge storage provisions must be based on the following factors:

a. Inclement weather effects on access to the application land;

b. Temperatures including frozen ground and stored sludge cake conditions;

c. Haul road restrictions including spring thawing conditions;

d. Area seasonal rainfall patterns;

e. Cropping practices on available land, including nutrient requirements;

f. Potential for increased sludge volumes from industrial sources during the design life of the plant;

g. Available area for expanding sludge storage;

h. Appropriate pathogen reduction and vector attraction reduction requirements.

A minimum of 180 days storage should be provided for the design life of the plant where land application is the only means of disposal, unless a different period is approved by the Department. Refer to Section 89.33 (Land Application) for other sludge land application considerations.

89.2 Sludge Storage Ponds

89.21 General

Sludge storage ponds will be permitted only upon proof that the character of the digested sludge and the design mode of operation are such that offensive odors will not result. Where sludge ponds are permitted, adequate provisions must be made for other sludge dewatering facilities or sludge disposal in the event of upset or failure of the sludge digestion process. Sludge must be removed from the storage pond within 2 years or it must meet the surface disposal requirements in Federal 40 CFR Part 503 Sludge Disposal regulations.

89.22 Location

Sludge ponds must be located as far as practicable from inhabited areas or areas likely to be inhabited during the lifetime of the structures. The distance between the design high water mark of the sludge pond and any water well must meet the setback distance as established in ARM 17.30.1702.

89.23 Seal

Adequate provisions must be made to seal the sludge pond bottoms and embankments in accordance with Section 93.422 (Seal) to prevent leaching into adjacent soils or groundwater. The seal must be protected to prevent damage from sludge removal activities. Testing methodology and results must be approved by the Department.

89.24 Access

Provisions must be made for pumping or heavy equipment access for sludge removal from the sludge pond on a routine basis.

89.25 Supernatant Disposal

A method of decanting must be provided. Pond supernatant must be returned to the wastewater treatment process at appropriate points and rates. See also Sections 56.7 (Sampling Equipment) and 84.64 (Supernatant Disposal).

89.3 Disposal

89.31 General

Drainage facilities for sludge vehicle transfer stations must be provided to allow any spillage or washdown material to be collected and returned to the wastewater treatment plant or sludge storage facility.

89.32 Sanitary Landfilling

Sludge and sludge residues may be disposed of in approved Class II sanitary landfills under the terms and conditions of the Department. Typically sludges must pass a Toxicity Characteristic Leaching Procedure (TCLP) test and be capable of passing a paint filter test to be suitable for disposal in an approved landfill. Documentation must be submitted to the Department from the operating authority of the landfill indicating that they are licensed and willing to accept sewage sludge. The Federal 40 CFR Part 258 - Criteria for Municipal Solid Waste Landfills regulations govern the placement of sludge in landfills.

89.33 Land Application

The beneficial use of sludge is encouraged in all cases. The Department should be contacted for specific design and approval requirements governing land application of municipal sludges. Additional operating criteria may be obtained from applicable federal regulations. Sludge may be utilized as a soil conditioner for agricultural, horticultural, or reclamation purposes. Important design considerations include, but are not necessarily limited to: sludge stabilization process, appropriate pathogen and vector attraction reduction, sludge characteristics including the presence of inorganic and organic chemicals, application site characteristics (soil, groundwater elevations, setback distance requirements, etc.), local topography and hydrology, cropping practices, spreading and incorporation techniques, population density and odor control, local groundwater quality and usage.

Sludge mixing equipment or other provisions to assist in the monitoring of land applied sludge should be considered in the design of sludge handling and storage facilities.

Due to inclement weather and cropping practices, alternative sludge disposal options are recommended to ensure the sludge is properly managed.

Sludge must not be applied to land which is used for growing food crops to be eaten raw, such as leafed vegetables and root crops.

The Federal 40 CFR Part 503 Sludge Disposal regulations govern the application of sludge to land. A sludge disposal permit from EPA must be obtained by the Owner before any sludge can be applied to any land application site. The land application of sludge (including abandonment in place) will only be approved by the Department in situations where it is clearly demonstrated that impacts to groundwater or surface water will not occur. In some cases, a solid waste permit may be required.

89.34 Sludge Ponds for Disposal

The utilization of ponds for ultimate disposal of sludge is not allowed.

89.35 Other Disposal Methods

If disposal of sludge by other methods is proposed, a detailed description of the technique and design data must accompany the plans. Refer to Section 53.2 (Engineering and Performance Requirements for Innovative Wastewater Treatment Alternatives) for any new process determinations

CHAPTER 90

BIOLOGICAL TREATMENT

91. TRICKLING FILTERS

91.1 General

Trickling filters may be used for treatment of wastewater amenable to treatment by aerobic biologic processes. Trickling filters must be preceded by effective settling tanks equipped with scum and grease collecting devices, or other suitable pretreatment facilities.

Filters must be designed to provide for reduction in carbonaceous and/or nitrogenous oxygen demand in accordance with water quality standards and objectives for the receiving waters as established by the Department, or to properly condition the wastewater for subsequent treatment processes. Multi-stage filters should be considered if needed to meet more stringent effluent standards.

91.2 Hydraulics

91.21 Distribution

91.211 Uniformity

The wastewater may be distributed over the filter by rotary distributors or other suitable devices which will ensure uniform distribution to the surface area. At design average flow, the deviation from a calculated uniformly distributed volume per square foot (m^2) of the filter surface may not exceed plus or minus 10 percent at any point. All hydraulic factors involving proper distribution of wastewater on the filters must be carefully calculated. Such calculations must be submitted to the Department.

For rotary distributors, reverse reaction nozzles, hydraulic brakes or motor driven distributor arms must be provided to not exceed the maximum speed recommended by the distributor manufacturer and to attain the desired media flushing rate.

91.212 Head Requirements

For reaction type distributors, a minimum head of 24 inches (610 mm) between low water level in the siphon chamber and center of the arms is required. Similar allowance in design must be provided for added pumping head requirements where pumping to the reaction type distributor is used.

91.213 Clearance

A minimum clearance of 12 inches (305 mm) between media and distributor arms must be provided.

91.22 Dosing

Wastewater may be applied to the filters by siphons, pumps or by gravity discharge from preceding treatment units when suitable flow characteristics have been developed. Application of the wastewater must be practically continuous. The piping system must be designed for recirculation.

91.23 Piping System

The piping system, including dosing equipment and distributor, must be designed to provide capacity for the design peak hourly flow rate, including recirculation required under Section 91.55 (Recirculation).

91.3 Media

91.31 Quality

The media may be crushed rock, slag, or manufactured material. The media must be durable, resistant to spalling or flaking and relatively insoluble in wastewater. The top 18 inches (457 mm) may not have a loss by the 20 cycle, sodium sulfate soundness test of more than 10 percent, as prescribed by ASCE Manual of Engineering Practice, Number 13. The balance must pass a 10 cycle test using the same criteria. Slag media must be free from iron or other leachable materials that will adversely affect the process or effluent quality. Manufactured media must be resistant to ultraviolet degradation, disintegration, erosion, aging, all common acids and alkalies, organic compounds, and fungus and biological attack. This media must be structurally capable of supporting a person's weight or a suitable access walkway must be provided to allow for distributor maintenance.

91.32 Depth

Trickling filter media must have a depth of at least 6 feet (1.8 m) above the underdrains. Rock and/or slag filter media depths should not exceed 10 feet (3 m) and manufactured filter media depths may not exceed the recommendations of the manufacturer. Forced ventilation should be considered in accordance with Section 91.43 (Ventilation).

91.33 Size, Grading and Handling of Media

91.331 Rock, Slag, and Similar Media

Rock, slag, and similar media may not contain more than 5 percent by weight of pieces with the longest dimension three times the least dimension. They must be free from thin, elongated and flat pieces, dust, clay, sand or fine material and must conform to the following size and grading when mechanically graded over a vibrating screen with square openings.

Passing 4 1/2 inch (114 mm) screen - 100% by weight
Retained on 3 inch (76 mm) screen - 95-100% by weight
Passing 2 inch (51 mm) screen - 0-2% by weight Passing
1 inch (25 mm) screen - 0-1% by weight

91.332 Manufactured Media

Suitability will be evaluated on the basis of experience with installations handling similar wastes and loadings. To insure sufficient void clearances, media with specific surface areas of no more than 30 square feet per cubic foot (100 m^2/m^3) are acceptable for filters employed for carbonaceous reduction, and 45 square feet per cubic foot (150 m^2/m^3) for second stage ammonia reduction.

91.333 Handling and Placing of Media

Material delivered to the filter site must be stored on wood-planked or other approved clean, hard-surfaced areas. All material must be rehandled at the filter site and no material may be dumped directly into the filter. Crushed rock, slag, and similar media must be washed and rescreened or forked at the filter site to remove all fines. This material must be placed by hand to a depth of 12 inches (305 mm) above the tile underdrains. The remainder of material may be placed by means of belt conveyors or equally effective methods approved by the engineer. All material must be carefully placed so as not to damage the underdrains. Manufactured media must be handled and placed as approved by the engineer. Trucks, tractors, and other heavy equipment may not be driven over the filter during or after construction.

91.4 Underdrain System

91.41 Arrangement

Underdrains with semicircular inverts or equivalent should be provided and when provided, the underdrain system must cover the entire floor of the filter. Inlet openings into the underdrains must have an unsubmerged gross combined area equal to at least 15 percent of the surface area of the filter.

91.42 Hydraulic Capacity

The underdrains must have a slope of at least 1 percent. Effluent channels must be designed to produce a velocity of at least 2 feet per second (0.61 m/s) at design average flow rates of application to the filter including recirculated flows. Refer to Section 91.43 (Ventilation).

91.43 Ventilation

The underdrain system, effluent channels and effluent pipe must be designed to permit free passage of air. The size of drains, channels, and pipe should be such that not more than 50 percent of their cross-sectional area will be submerged under the design peak instantaneous flow, including proposed or possible future recirculated flows.

Forced ventilation should be provided for covered trickling filters to insure adequate oxygen for process requirements. Windows or simple louvered mechanisms arranged to ensure air distribution throughout the enclosure must be provided. The design of the ventilation facilities must provide for operator control of air flow in accordance with outside seasonal temperature. Design computations showing the adequacy of air flow to satisfy process oxygen requirements must be submitted.

91.44 Flushing

Provision should be made for flushing the underdrains unless high rate recirculation is utilized. In small rock and slag filters, use of a peripheral head channel with vertical vents is acceptable for flushing purposes. Inspection facilities should be provided.

91.5 Special Features

91.51 Flooding

Appropriate valves, sluice gates, or other structures must be provided to enable flooding of filters comprised of rock or slag media for filter fly control.

91.52 Freeboard

A freeboard of 4 feet (1.2 m) or more should be provided for tall, manufactured filters to contain windblown spray. Provide at least 6 foot (1.8 m) headroom for maintenance of the distributor on covered filters.

91.53 Maintenance

All distribution devices, underdrains, channels, and pipes must be installed so that they may be properly maintained, flushed or drained.

91.54 Winter Protection

Covers must be provided to maintain operation and treatment efficiencies when climatic conditions are expected to result in problems due to cold temperatures.

91.55 Recirculation

The piping system must be designed for recirculation as required to achieve the design efficiency or effluent quality. The recirculation rate must be variable and subject to plant operator control at the range of 0.5:1 up to 4:1 (ratio of recirculation rate versus design average flow). A minimum of two recirculation pumps must be provided.

91.56 Recirculation Measurement

Devices must be provided to permit measurement of the recirculation rate. Elapsed time meters and pump head recording devices are acceptable for facilities treating less than 1 MGD (3785 m^3/d). The design of the recirculation facilities must provide for both continuity of service and the range of recirculation ratios. Reduced recirculation rates for periods of brief pump outages may be acceptable depending on water quality requirements.

91.6 Rotary Distributor Seals

Mercury seals are not permitted. Ease of seal replacement must be considered in the design to ensure continuity of operation.

91.7 Unit Sizing

Required volumes of filter media must be based upon pilot testing with the particular wastewater or any of the various empirical design equations that have been verified through actual full scale experience. Such calculations must be submitted if pilot testing is not utilized. Pilot testing is recommended to verify performance predictions based upon the various design equations, particularly when significant amounts of industrial wastes are present.

Trickling filter design must consider peak organic load conditions including the oxygen demands due to recycle flows (i.e. heat treatment supernatant, vacuum filtrate, anaerobic digester supernatant, etc.) due to high concentrations of BOD_5 and TKN associated with such flows. The volume of media determined from either pilot plant studies or use of acceptable design equations must be based upon the design maximum day BOD_5 organic loading rate rather than the design average BOD_5 rate. Refer to Section 11.251 (Organic Load Definitions and Identification).

92. ACTIVATED SLUDGE

92.1 General

92.11 Applicability

92.111 Biodegradable Wastes

The activated sludge process and its various modifications may be used where wastewater is amenable to biological treatment.

92.112 Operational Requirement

This process requires close attention and competent operating supervision, including routine laboratory control. These requirements must be considered when proposing this type of treatment.

92.113 Energy Requirements

This process requires major energy usage to meet aeration demands. Energy costs and potential mandatory emergency public power reduction events in relation to critical water quality conditions must be carefully evaluated. Capability of energy usage phasedown, while still maintaining process viability, both under normal and emergency energy availability conditions must be included in the activated sludge design.

92.12 Specific Process Selection

The activated sludge process and its several modifications may be employed to accomplish varied degrees of removal of suspended solids and reduction of carbonaceous and/or nitrogenous oxygen demand. Choice of the process most applicable will be influenced by the degree and consistency of treatment required, type of waste to be treated, proposed plant size, anticipated degree of operation and maintenance, and operating and capital costs. All designs must provide for flexibility in operation and should provide for operation in various modes, if feasible.

Extended aeration and oxidation ditch treatment facilities may be prone to the growth of filamentous organisms which can adversely impact treatment efficiency. The design of extended aeration and oxidation ditch facilities must consider this potential problem, and should provide a means for control of filamentous organisms.

92.13 Winter Protection

In severe climates, protection against freezing should be incorporated into the design to ensure continuity of operation and performance. Insulation of the tanks by earthen banks should be considered.

92.2 Pretreatment

Where primary settling tanks are not used, effective removal or exclusion of grit, debris, excessive oil or grease, and screening of solids must be accomplished prior to the activated sludge process. Screening devices with clear openings of ¼ inch (6 mm) or less must be provided.

Where primary settling is used, provision must be made for discharging screened raw wastewater directly to the aeration tanks to facilitate plant start-up and operation during the initial stages of the plant's design life.

92.3 Aeration

92.31 Capacities and Permissible Loadings

The size of the aeration tank for any particular adaptation of the process must be determined by full scale experience, pilot plant studies, or rational calculations based mainly on solids retention time, food to microorganism ratio and mixed liquor suspended solids levels. Other factors, such as size of treatment plant, diurnal load variations, and degree of treatment required, must also be considered. In addition, temperature, pH and reactor dissolved oxygen must be considered when designing for nitrification (see Section 95.31 Nitrification).

Calculations should be submitted to justify the basis for design of aeration tank capacity. Calculations using values differing substantially from those in the accompanying table should reference actual operational plants. Mixed liquor suspended solids levels greater than 5000 mg/L may be allowed providing adequate data is submitted showing the aeration and clarification system capable of supporting such levels.

When process design calculations are not submitted, the aeration tank capacities and permissible loadings for the several adaptations of the processes shown in the following table must be used. These values apply to plants receiving diurnal load ratios of design peak hourly BOD_5 to design average BOD_5 ranging from about 2:1 to 4:1. Thus, the utilization of flow equalization facilities to reduce the diurnal design peak hourly BOD_5 organic load may be considered by the Department as justification to approve organic loading rates that exceed those specified in the table.

PERMISSIBLE AERATION TANK CAPACITIES AND LOADINGS			
Process	******Aeration Tank Organic Loading lbs. BOD_5/d/1000 ft^3 ($kg/d/m^3$)*****	**F/M Ratio lb. BOD_5/day per lb. MLVSS *****	**MLSS* mg/L**
Conventional Step Aeration Complete Mix	40 (0.64)	0.2-0.5	1000-3000
Contact Stabilization	50** (0.8)	0.2-0.6	1000-3000
Extended Aeration Single Stage Nitrification	15 (0.24)	0.05-0.1	3000-5000

* MLSS values are dependent upon the surface area provided for sedimentation and the rate of sludge return as well as the aeration process.

** Total aeration capacity, includes both contact and re-aeration capacities. Normally the contact zone equals 30 to 35% of the total aeration capacity.

*** Refer to 11.251(a) for definition of BOD.

**** Loadings are based on the organic load influent to the aeration tank at plant design average BOD5.

92.32 Arrangement of Aeration Tanks

a. Dimensions

The dimensions of each independent mixed liquor aeration tank or return sludge re-aeration tank must be such as to maintain effective mixing and utilization of air. Ordinarily, liquid depths should not be less than 10 feet (3 m) or more than 30 feet (9 m) except in special design cases. An exception is that horizontally mixed aeration tanks must have a depth of at least 5.5 feet (1.7 m).

b. Short-circuiting

For very small tanks or tanks with special configuration, the shape of the tank, the location of the influent and sludge return, and the installation of aeration equipment must provide for positive control to prevent short-circuiting through the tank.

92.321 Number of Units

Total aeration tank volume must be divided among two or more units, capable of independent operation, when required by the Department to meet applicable effluent limitations and reliability guidelines.

92.322 Inlets and Outlets

a. Controls

Inlets and outlets for each aeration tank unit must 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.

The effluent weir for a horizontally mixed aeration tank system must be easily adjustable by mechanical means and must be sized based on the design peak instantaneous flow plus the maximum return sludge flow. Refer to Section 92.41 (Return Sludge Rate). The hydraulic properties of the system must permit the design peak instantaneous flow to be carried with any single aeration tank unit out of service.

b. Conduits

Channels and pipes carrying liquids with solids in suspension must be designed to maintain self-cleansing velocities or must be agitated to keep such solids in suspension at all rates of flow within the design limits. Adequate provisions should be made to drain segments of channels which are not being used due to alternate flow patterns.

92.323 Freeboard

All aeration tanks should have a freeboard of not less than 18 inches (457 mm). However, if a mechanical surface aerator is used, the freeboard should be not less than 3 feet (914 mm) to protect against windblown spray freezing on walkways, etc.

92.33 Aeration Equipment

92.331 General

Oxygen requirements generally depend on maximum diurnal organic loading (design peak hourly BOD_5 as described in Section 11.251(a)(3)), degree of treatment, and level of suspended solids concentration to be maintained in the aeration tank mixed liquor. For nitrogen removal plants, the diurnal peak TKN loading (as described in 11.251(b)(2) must also be taken into account.

Aeration equipment must be capable of maintaining a minimum of 2.0 mg/l of dissolved oxygen in the mixed liquor at all times and provide thorough mixing of the mixed liquor. In the absence of experimentally determined values, the design oxygen requirements for all activated sludge processes must be 1.1 lbs. O_2/lb. design peak hourly BOD_5 (1.1 kg O_2/kg design peak hourly BOD_5) applied to the aeration tanks, with the exception of the extended aeration process, for which the value must be 1.5 to include endogenous respiration requirements.

In the case of nitrification, the oxygen requirement for oxidizing ammonia must be added to the above requirement for carbonaceous BOD_5 removal and endogenous respiration requirements. The nitrogen oxygen demand (NOD) must be taken as 4.6 times the diurnal peak TKN content of the influent. In addition, the oxygen demands due to recycle flows (i.e., heat treatment supernatant, vacuum filtrate, elutriates, etc.) must be considered due to the high concentrations of BOD_5 and TKN associated with such flows. See Section 95.31 (Nitrification) for additional design considerations.

Careful consideration should be given to maximizing oxygen utilization per unit power input. Unless flow equalization is provided, the aeration system should be designed to match the diurnal organic load variation while economizing on power input. Refer to Section 92.31 (Capacities and Permissible Loadings).

92.332 Diffused Air Systems

The diffused air system that provides the oxygen must be designed according to either of the two methods described below in (a) and (b), augmented as required by consideration of items (c) through (h):

a. Having determined the oxygen requirements under Section 92.331 (General), air requirements for a diffused air system must be determined by use of any of the well known equations incorporating such factors as:

1. Tank depth;
2. Alpha factor of waste;
3. Beta factor of waste;
4. Certified aeration device transfer efficiency;
5. Minimum aeration tank dissolved oxygen concentration;
6. Critical wastewater temperature;
7. Altitude of plant.

In the absence of experimentally determined alpha and beta factors, wastewater transfer efficiency must be assumed to be not greater than 50 percent of clean water efficiency for plants treating primarily (90 percent or greater) public sewage. Treatment plants where the waste contains higher percentages of industrial wastes must use a correspondingly lower percentage of clean water efficiency and must submit calculations justifying a lower percentage. The design transfer efficiency should be included in the specifications.

b. Normal air requirements for all activated sludge processes except extended aeration (assuming equipment capable of transmitting to the mixed liquor the amount of oxygen required in Section 92.331(General)) must be considered to be 1500 cubic feet at standard conditions of pressure, temperature, and humidity per pound of BOD_5 tank loading (94 m^3/kg of BOD_5). For the extended aeration process the value must be 2050 cubic feet per pound of BOD_5 (128 m^3/kg of BOD_5).

c. Air required for channels, pumps, aerobic digesters, filtrate, and supernatant or other air-use demand must be added to the air requirements calculated above.

d. The specified capacity of blowers or air compressors, particularly centrifugal blowers, should take into account that the air intake temperature may reach 115°F (46°C) or higher and the pressure may be less than normal. The specified capacity of the motor drive should also take into account that the intake air may be -20°F (-29°C) or less and may require over-sizing of the motor or a means of reducing the rate of air delivery to prevent overheating or damage to the motor.

e. The blowers must 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 must also provide for varying the volume of air delivered in proportion to the load demand of the plant. Aeration equipment must be easily adjustable in increments and must maintain solids suspension within these limits.

f. Diffuser systems must be capable of providing for 200 percent of the design average day oxygen demand. The air diffusion piping and diffuser system must be capable of delivering normal air requirements with minimal friction losses.

g. Air piping systems should be designed such that total head loss from blower outlet (or silencer outlet where used) to the diffuser inlet does not exceed 0.5 psi (3.4 kPa) at average operating conditions.

h. The spacing of diffusers should be in accordance with the oxygen requirements through the length of the channel or tank, and should be designed to facilitate adjustment of their spacing without major revisions to air header piping.

i. All plants having less than four independent aeration tanks must be designed to incorporate removable diffusers that can be serviced and/or replaced without dewatering the tank.

j. Individual assembly units of diffusers must be equipped with control valves, preferably with indicator markings for throttling, or for complete shutoff. Diffusers in any single assembly must have substantially uniform pressure loss.

k. Air filters must be provided in numbers, arrangements, and capacities to continuously furnish an air supply sufficiently free from dust to prevent damage to blowers and clogging of the diffuser system used.

92.333 Mechanical Aeration Systems

a. Oxygen Transfer Performance

The mechanism and drive unit must be designed for the expected conditions in the aeration tank in terms of the power performance. Certified testing must be provided to verify mechanical aerator performance. Refer to applicable provisions of Section 93.332 (Diffused Air Systems). In the absence of specific design information, the oxygen requirements must be calculated using a transfer rate not to exceed 2 pounds of oxygen per horsepower per hour (1.22 kg O2/kw/hr) in clean water under standard test conditions. Design transfer efficiencies must be included in the specifications.

b. Design Requirements

The design requirements of a mechanical aeration system must accomplish the following:

1. Maintain a minimum of 2.0 mg/L of dissolved oxygen in the mixed liquor at all times throughout the tank or basin;

2. Maintain all biological solids in suspension (for a horizontally mixed aeration tank system an average velocity of 1 foot per second [0.3 m/sec] must be maintained);

3. Meet maximum oxygen demand and maintain process performance with the largest unit out of service;

4. Provide for varying the amount of oxygen transferred in proportion to the load demand on the plant;

5. Provide that motors, gear housing, bearings, grease fittings, etc., be easily accessible and protected from inundation and spray as necessary for proper functioning of the unit.

c. Winter Protection

Where extended cold weather conditions occur, the aerator mechanism and associated structure must be protected from freezing due to splashing. Due to high heat loss, subsequent treatment units must be protected from freezing.

92.4 Return Sludge Equipment

92.41 Return Sludge Rate

The minimum permissible return sludge rate of withdrawal from the final settling tank is a function of the concentration of suspended solids in the mixed liquor entering it, the sludge volume index of these solids, and the length of time these solids are retained in the settling tank. Since undue retention of solids in the final settling tanks may be deleterious to both the aeration and sedimentation phases of the activated sludge process, the rate of sludge return expressed as a percentage of the design average daily flow (ADF) of wastewater should generally be variable between the limits set forth as follows:

Type of Process	% ADF Minimum	% ADF Maximum
Conventional, Step Aeration or Complete Mix	15	100
Carbonaceous Stage of Separate Stage Nitrification	15	100
Single Stage Nitrification	50	150
Contact Stabilization	50	150
Extended Aeration	50	150
Nitrification Stage of Separate Stage Nitrification	50	200
Biological Nutrient Removal	70	120

The rate of sludge return must be varied by means of variable speed motors, drives, or timers (small plants) to pump sludge at the above rates. All designs must provide for flexibility in operation and should provide for operation in various process modes, if feasible.

92.42 Return Sludge Pumps

If motor driven return sludge pumps are used, the maximum return sludge capacity must be obtained with the largest pump out of service. A positive head should be provided on pump suctions. Pumps should have at least 3 inch (76 mm) suction and discharge openings.

If air lifts are used for returning sludge from each settling tank hopper, no standby unit will be required provided the design of the air lifts facilitates their rapid and easy cleaning and provided other suitable standby measures are provided. Air lifts should be at least 3 inches (76 mm) in diameter.

92.43 Return Sludge Piping

Discharge piping should be at least 4 inches (102 mm) in diameter and should be designed to maintain a velocity of not less than 2 feet per second (0.61 m/s) when return sludge facilities are operating at normal return sludge rates. Suitable devices for observing, sampling, and controlling return activated sludge flow from each settling tank hopper must be provided, as outlined in Section 73.24 (Sludge Removal Control).

92.44 Waste Sludge Facilities

Waste sludge control facilities should have a capacity of at least 25 percent of the design average rate of wastewater flow and function satisfactorily at rates of 0.5 percent of design average wastewater flow or a minimum of 10 gallons per minute (0.63 L/s), whichever is larger. Means for observing, measuring, sampling, and controlling waste activated sludge flow must be provided. Waste sludge may be discharged to the concentration or thickening tank, primary settling tank, sludge digestion tank, vacuum filters, or any practical combination of these units.

92.5 Measuring Devices

Devices must be installed in all plants for indicating flow rates of raw wastewater or primary effluent, return sludge, and air to each tank unit. For plants designed for design average wastewater flows of 1 MGD (3785 m^3/d) or more, these devices must totalize and record, as well as indicate flows. Where the design provides for all return sludge to be mixed with the raw wastewater (or primary effluent) at one location, then the mixed liquor flow rate to each aeration unit must be measured.

93. WASTEWATER TREATMENT PONDS

93.1 General

This Section deals with generally used variations of treatment ponds capable of achieving secondary treatment including controlled-discharge pond systems, flow-through pond systems and aerated pond systems. Ponds utilized for equalization, percolation, and sludge storage are not discussed in this Section.

93.2 Location

93.21 Distance from Habitation

A pond site should be located as far as practicable, with a recommended minimum of 1/4 mile (0.4 km), from human habitation or from any area that may be built up within the foreseeable future. Consideration should be given to site specifics including but not limited to vector transport, odor, public safety, topography, prevailing winds, and forest.

93.22 Surface Runoff

Adequate provision must be made to divert stormwater runoff around the ponds and protect pond embankments from erosion.

93.23 Soil Borings

Data from soil borings conducted by an independent soil testing laboratory to determine subsurface soil characteristics and groundwater characteristics (including elevation and flow) of the proposed site and their effect on the construction and operation of a pond must be provided.

93.24 Groundwater Separation

A minimum separation of 4 feet (1.2 m) between the bottom of the pond and the maximum groundwater elevation should be maintained.

93.25 Bedrock Separation

A minimum separation of 10 feet (3.0 m) between the pond bottom and any bedrock formation is recommended.

93.26 Water Well Separation

The distance between the design high water mark of the sewage pond (including those used for the storage of effluent) and any water well must meet the setback distance as established in ARM 17.30.1702.

93.3 Basis of Design

93.31 Area and Loadings for Continuous and Controlled-Discharge Facultative Treatment Pond Systems

See Table 93-1 for facultative pond design criteria.

93.32 Aerated Treatment Pond Systems

For the development of final design parameters, it is recommended that actual experimental data be developed; however the aerated treatment pond system design for minimum detention time may be estimated using the following formula applied separately to each aerated cell:

$$t = \frac{E}{2.3K_1 \times (100-E)}$$

t = detention time, days
E = percent of BOD_5 to be removed in an aerated pond
K_1 = reaction coefficient, aerated pond, base 10. For normal public sewage, the K_1 value may be assumed to be 0.12/day at 68° F (20° C) and 0.06/day at 34° F (1° C)

The reaction rate coefficient for public sewage, which includes some industrial wastes, other wastes, and partially treated wastewater, must be determined experimentally for various conditions which might be encountered in the aerated ponds. Conversion of the reaction rate coefficient at other temperatures must be made based on experimental data.

Raw wastewater strength should also consider the effect of any return sludge. Also, additional storage volume should be considered for sludge, and in northern climates, ice cover.

Design should consider recirculation within the system.

Oxygen requirements generally will depend on the design average BOD_5 loading, the degree of treatment, and the concentration of suspended solids to be maintained. Aeration equipment must be capable of maintaining a minimum dissolved oxygen level of 2 mg/L in the ponds at all times and should also be capable of increasing the dissolved oxygen level for periodic upsets. Suitable protection from weather must be provided for electrical controls.

See Table 93-2 for partially mixed aerated pond design criteria.

See Section 92.33 (Aeration Equipment) for details on aeration equipment.

93.33 Industrial Wastes

Consideration must be given to the type of industrial wastes and effects on the treatment process. In some cases it may be necessary to pretreat industrial or other discharges.

Industrial wastes may not be discharged to ponds without assessment of the effects these substances may have upon the treatment process or discharge requirements in accordance with state and federal laws.

93.34 Number of Cells Required

At a minimum, a wastewater treatment pond system should consist of 3 cells designed to facilitate both series and parallel operations. The maximum size of a pond cell should be 40 acres (16 ha). Two-cell systems may be utilized in very small installations (approximately 25,000 gallons/day or less).

All systems must be designed with piping flexibility to permit isolation of any cell without affecting the transfer and discharge capabilities of the total system. In addition, the ability to discharge the influent waste load to a minimum of two cells and/or all primary cells in the system must be provided.

93.35 Pond Shape

The shape of all cells should be such that there are no narrow or elongated portions. Rectangular ponds (length not exceeding three times the width) are considered most desirable. Islands, peninsulas and coves are not permitted. Dikes should be rounded at corners to minimize accumulations of floating materials. Common-wall dike construction, wherever possible, is strongly encouraged.

93.36 Pond Design Criteria

The following tables summarize the criteria for facultative and aerated ponds.

TABLE 93-1
FACULTATIVE POND DESIGN CRITERIA

	Disposal Method			
	Continuous Discharge	Controlled Discharge	Land Application	Total Retention[6]
Primary Cells				
Minimum Number[1]	2	2	1	1
BOD_5 Loading lb/acre/day	15-35	15-35	15-35	15-35
Operating Range Limits[2], feet	2-6	2-6	2-6	4 -6
Detention Time, days	40-80	40-80	40-80	40-80
Maximum Seepage Rate[2] inches/year	6	6	6	6
Secondary or Storage Cells				
Minimum Number	1	1	1	1
Maximum Depth without Aeration, ft	8	8	8	8
Minimum Depth, ft	2	2	1	1
Maximum Seepage Rate, inches/year	6	6	6	6
Overall System				
Maximum BOD_5 Loading, lb/acre/day	20	20	20	20
Minimum Detention Time, days[2]	180	180	90-120	Total Retention[4,5]
Emergency or Winter Storage	N/A	N/A	60-150[3,4]	

1. All primary cells must be approximately equal in size.
2. Primary cell detention times must be based on volume between the 2 foot level and maximum depth. Secondary and storage cell detention times may be based on volume between the 1- foot level and maximum depth.
3. Shorter time periods for infiltration/percolation disposal and longer time periods for irrigation.
4. An annual month-by-month water balance must be submitted for land application and total retention.
5. Net evaporation rate must be calculated by using mean annual lake evaporation rate and the 10-year precipitation return period for annual precipitation and distribute it monthly based on the ratio of average monthly to average annual precipitation.
6. Total retention systems must be designed for at least 2 cells, and the primary cell must be designed to remain full within the 4 to 6-foot water surface level at minimum expected flows.

TABLE 93-2 PARTIALLY MIXED AERATED POND DESIGN CRITERIA			
	Disposal Method		
	Continuous Discharge	**Controlled Discharge**	**Land Application**
Minimum Number of Aerated Cells[1]	3	3	1-2[2]
Recommended Mode of Aeration[3]	Tapered	Tapered	Equal
Minimum System Oxygen Requirements, lbs 0_2 / lb BOD_5 removed[4]	2.5	2.5	2.5
Minimum Dissolved Oxygen, mg/l[5]	2.0	2.0	2.0
Depth, feet	10-15	10-15	10-15
Minimum Detention Time Under Aeration, days[6]	20	20	15
Maximum Seepage Rate, inches/year	6	6	6
Emergency Storage for Infiltration/ Percolation, days	N/A	N/A	30-90
Winter Storage for Irrigation	N/A	N/A	See footnote 7
Mixing in Aerated Cells, Hp/MG	5-10	5-10	5-10

1. The outlet area of all final cells must have a quiescent zone of at least one to two days hydraulic detention time for settling solids.
2. One aeration cell if large storage cell is proposed. Two aeration cells if infiltration/percolation is proposed.
3. If first cell is out of service, sufficient oxygen must be dispersed in remaining cells to keep cells aerobic.
4. Criteria for Primary Cells: Oxygen supplied must be sufficient to meet the organic, nitrogenous, benthic and algal demands in the pond.
5. Measured two feet below the surface of the pond.
6. Base design on provisions of Section 93.32. Detention time must be sufficient to provide adequate BOD reduction to meet waste discharge requirements. Volume calculated from two feet from bottom to maximum depth. Time not inclusive of quiescent zone. Waste load and climatic conditions may require more stringent criteria.
7. An annual month-by-month water balance must be submitted with each land application plan to determine winter storage.

93.4 Pond Construction Details

93.41 Embankments and Dikes

Material

Dikes must be constructed of relatively impervious soil and compacted to at least 95 percent of maximum dry density as determined by AASHTO T99 or ASTM D698, or as recommended by a geotechnical engineer, to form a stable structure. Vegetation and other unsuitable materials must be removed from the area where the embankment is to be placed.

Top Width

The minimum dike width is 8 feet (2.4 m) to permit access for maintenance vehicles.

Maximum Slopes

Inner and outer dike slopes may not be steeper than 1 vertical to 3 horizontal (1:3).

Minimum Slopes

Inner slopes should not be flatter than 1 vertical to 4 horizontal (1:4). Flatter slopes can be specified for larger installations because of wave action but have the disadvantage of added low areas being conducive to emergent vegetation. Outer slopes must be sufficient to prevent surface runoff from entering the ponds.

Freeboard

Freeboard must be at least 3 feet (914 mm), except for small systems (25,000 gpd or less) where 2 feet (610 mm) may be acceptable.

Erosion Control

All ponds must be protected from erosion caused by wave action, weather and flooding. A justification and detailed discussion of the method of erosion control which encompasses all relative factors such as pond location and size, seal material, topography, prevailing winds, cost breakdown, application procedures, etc., must be provided. Ponds with proposed uncovered synthetic liners must include provisions to reduce the hazard associated with the slick surface.

a. Seeding

The dikes must have a cover layer of at least 4 inches (102 mm) of fertile topsoil to promote establishment of an adequate vegetative cover wherever riprap or synthetic liner is not utilized. Perennial-type, low-growing, spreading grasses that minimize erosion and can be mowed are most satisfactory for seeding on dikes. Alfalfa and other long-rooted crops should not be used for seeding since the roots of this type are apt to impair the water-holding efficiency of the dikes.

b. Additional Erosion Protection

Riprap or some other acceptable method of erosion control is required as a minimum around all piping entrances and exits and on interior dike slopes of all ponds utilizing soil liners. Riprap, or an acceptable equal, must be placed from one foot above the high water mark to two feet below the low water mark (measured on the vertical). For aerated cells the design should ensure erosion protection on the slopes and bottoms in the areas where turbulence will occur. Additional erosion control may also be necessary on the exterior dike slope to protect the embankment from erosion due to severe flooding of a watercourse.

93.42 Pond Bottom

93.421 Soil

Soil used in constructing the pond bottom (not including the seal) and dike cores must be tight and compacted at or up to 4 percent above the optimum water content to at least 95 percent of maximum dry density as determined by AASHTO T99 or ASTM D698, or as recommended by a geotechnical engineer.

93.422 Seal

Ponds must be sealed so that seepage loss through the seal is as low as practicably possible. Seals consisting of soils, bentonite, or synthetic liners may be considered provided the permeability, durability, and integrity of the proposed material can be satisfactorily demonstrated for anticipated conditions. The proposed hydraulic testing procedure must be included in the project specifications. The test must take place at the maximum operating depth and must be a minimum of 14 days in length. The liner is considered watertight if leakage is less than 0.23 inches (5.8 mm) in a 14-day period (6 inches (152.4 mm) per year). The effects of evaporation and precipitation during the testing period must be considered. Testing results that substantiate the adequacy of the proposed seal must be submitted to the Department. In the event of a failed test, the lagoon cell shall be drained, patched, and retested.

The use of the following equipment and testing method (or equivalent) is recommended:

> Equipment and method: Two 12-inch (304.8 mm), minimum diameter PVC pipes shall be securely placed vertically (and temporarily) to the floor or sidewall of the pond being tested. The top of each pipe shall be at least 12 inches (304.8 mm) above the water surface. Both pipes shall be open to the atmosphere and must have a waterproof scale secured to the interior of the pipe near the water surface in increments no less than 1/16” (1.6 mm). One pipe (control pipe) shall be water tight below the water surface and filled to the level of the basin at the start of the testing period. The second pipe shall have holes below the water surface to allow a hydraulic connection between the inside of the pipe and the water in the basin. The leakage through the liner is the difference between the two levels over the testing period.

To achieve an adequate seal in systems using soil, bentonite, or other seal materials, the coefficient of permeability (k) in centimeters per second specified for the seal may not exceed the value derived from the following expression:

$$\mathbf{k = 2.6 \times 10^{-9} L}$$

Where L equals the thickness of the seal in centimeters, the "k" obtained by the above expression corresponds to a percolation rate of pond water of less than 450 gallons per day per acre (4.22 m^3/ha/d) at a water depth of 6 feet (1.8 m) and a liner thickness of 1 foot (0.3 m), using the Darcy’s law equation. For a seal consisting of a synthetic liner, seepage loss through the liner may not exceed the quantity equivalent to seepage loss through an adequate soil seal.

93.423 Uniformity

Finished elevations for soil and bentonite liners may not vary more than 3 inches (76 mm) from the average elevation of the bottom and should be as level as possible. Sloped pond bottoms are allowed for synthetic liners; however, they must be uniformly sloped.

93.424 Prefilling

Prefilling the pond should be considered in order to protect the liner, to prevent weed growth, to reduce odor, and to maintain the moisture content of soil liners However, the dikes must be completely prepared as described in Sections 93.416 (Erosion Control) (a) and (b) before the introduction of water.

93.43 Influent Lines

Material

Generally accepted material for underground sewer construction will be given consideration for the influent line to the pond. Corrugated metal pipe must not be used due to corrosion problems. In material selection, consideration must be given to the characteristics of the wastes, exceptionally heavy external loadings, abrasion, soft foundations, and similar problems.

Manhole

A manhole or vented clean-out wye must be installed prior to entrance of the influent line into the primary cell and must be located as close to the dike as topography permits. Its invert must be at least 6 inches (152 mm) above the maximum operating level of the pond and provide sufficient hydraulic head without surcharging the manhole.

Flow Distribution

Flow distribution structures must be designed to effectively split hydraulic and organic loads equally to primary cells.

Placement

Influent lines must be located along the bottom of the pond (above the required sludge storage depth) and be adequately supported.

Point of Discharge

All primary cells must have individual influent lines which terminate approximately at the midpoint of the width and at approximately 10 feet (3 m) from the toe of the dike slope and be located as far as possible from the outlet structure to minimize short-circuiting.

All aerated cells must have influent lines that distribute the load within the mixing zone of aeration equipment.

Influent Discharge Apron

The influent line must discharge onto a concrete apron.

The end of the discharge line must rest on a suitable concrete apron large enough to prevent the terminal influent velocity at the end of the apron from causing soil erosion. A minimum size apron of 25 square feet (7.6 square meters) must be provided.

93.44 Control Structures and Interconnecting Piping

93.441 Structure

Facility design must consider the use of multipurpose control structures to facilitate normal operational functions such as drawdown and flow distribution, flow and depth measurement, sampling, pumps for recirculation, chemical additions and mixing, and minimization of the number of construction sites within the dikes.

At a minimum, control structures must be: (a) accessible for maintenance and adjustment of controls; (b) adequately ventilated for safety and to minimize corrosion; (c) locked to discourage vandalism; (d) contain controls to permit water level and flow rate control, and complete shutoff; (e) constructed of non-corrodible materials (metal-on-metal contact in controls should be of similar alloys to discourage electrochemical reactions); and (f) located to minimize short-circuiting within the cell and avoid freezing and ice damage.

Recommended devices to regulate water level are valves, slide tubes or dual slide gates. Stop logs are not to be used to regulate water levels. Regulators should be designed so that they can be preset to prevent the pond surface elevation from dropping below the desired operational level.

93.442 Piping

All piping must be of ductile iron, PVC or other acceptable material. Pipes should be anchored with adequate erosion control. All interpond piping and takeoffs must be submerged.

a. Drawdown Structure Piping

1. Single Takeoffs for the Final Treatment Pond

For ponds designed with operating depths that are 6 feet or less, single takeoffs are allowed. The intake of the takeoff must be located 10 feet (3.0 m) from the toe of the dike and a minimum of 2 feet (610 mm) above the bottom of the pond, and must employ vertical withdrawal.

2. Multi-Level Takeoffs for the Final Treatment Pond

For ponds that are variable in depth or designed deep enough to permit stratification of pond content, multiple takeoffs are required. Three withdrawal pipes at different elevations are recommended. The bottom pipe must be located 10 feet (3.0m) from the toe of the dike, 2 feet (610mm) above the bottom of the pond, and must employ vertical withdrawal. The other pipes must be located a minimum of 2 feet (610 mm) from the edge of the dike and should utilize horizontal entrance. Adequate structural support must be provided for all piping.

3. Irrigation Storage Ponds

The use of multiple takeoffs or a floating pump is recommended. The bottom pipe must be located 10 feet (3.0 m) from the toe of the dike, 1 foot (305 mm) above the bottom of the pond, and must employ vertical withdrawal.

4. Emergency Overflow

To prevent overtopping of dikes, emergency overflow must be provided with capacity to carry the peak instantaneous flow expected.

b. Hydraulic Capacity

The hydraulic capacity for continuous discharge structures and piping must allow for a minimum of 250 percent of the design maximum day flow of the system. The hydraulic capacity for controlled-discharge systems must permit transfer of water at a minimum rate of 6 inches (152 mm) of pond water depth per day at the available head.

93.5 Miscellaneous

93.51 Fencing

The pond area must be enclosed with an adequate fence to prevent entering of livestock and discourage trespassing. Chain link fencing or equivalent should be seriously considered for ponds near urban areas. Fencing should not obstruct maintenance vehicle traffic on top of the dikes. A vehicle access gate of sufficient width to accommodate mowing equipment must be provided. All access gates must be secured with locks.

93.52 Access

An all-weather access road must be provided to the pond site to allow year-round maintenance of the facility.

93.53 Warning Signs

Appropriate permanent signs must be provided along the fence around the pond to designate the nature of the facility and advise against trespassing. At least one sign must be provided on each side of the site and one for every 500 feet (150 m) of its perimeter.

93.54 Flow Measurement

Flow measurement requirements are presented in Section 56.6 (Flow Measurement.) Effective weather protection must be provided for the recording equipment.

93.55 Groundwater Monitoring

An approved system of wells or lysimeters may be required around the perimeter of the pond site to facilitate groundwater monitoring. The need for such monitoring will be determined on a case-by-case basis.

93.56 Pond Level Gauges

Pond level gauges must be provided.

93.57 Service Building

A service building for laboratory and maintenance equipment must be provided if required in Section 58 (Laboratory).

93.58 Sulfate Content of Water Supply

Non-aerated ponds should not be used if excessive sulfate is present in the wastewater.

94 ROTATING BIOLOGICAL CONTACTORS

94.1 General

94.11 Applicability

The Rotating Biological Contactor (RBC) process may be used where sewage is amenable to biological treatment. The process may be used to accomplish carbonaceous and/or nitrogenous oxygen demand reductions. Design standards, operating data and experience for this process will vary according to site-specific conditions. Therefore, expected performance of RBC's must be based upon experience at similar full scale installations or thoroughly documented pilot testing with the particular wastewater.

94.12 Winter Protection

Wastewater temperature affects rotating contactor performance. Year-round operation in colder climates requires that rotating contactors be covered to protect the biological growth from cold temperatures and the excessive loss of heat from the wastewater with the resulting loss of performance.

Enclosures must be constructed of a suitable corrosion resistant material. Windows or simple louvered mechanisms that can be opened in the summer and closed in the winter must be installed to provide adequate ventilation. To minimize condensation, the enclosure should be adequately insulated and/or heated.

94.2 Required Pretreatment

RBC's must be preceded by effective settling tanks equipped with scum and grease collecting devices unless substantial justification is submitted for other pretreatment devices which provide for effective removal of grit, debris and excessive oil or grease prior to the RBC units. Bar screening or comminution are not suitable as the sole means of pretreatment.

94.3 Unit Sizing

Unit sizing must be based on experience at similar full-scale installations or thoroughly documented pilot testing with the particular wastewater. In determining design loading rates, expressed in units of volume per day per unit area of media covered by biological growth, the following parameters must be considered:

a. Design flow rate and influent waste strength;

b. Percentage of BOD to be removed;

c. Media arrangement, including number of stages and unit area in each state;

d. Rotational velocity of the media;

e. Retention time within the tank containing the media;

f. Wastewater temperature;

g. Percentage of influent BOD which is soluble.

In addition to the above parameters, loading rates for nitrification will depend upon influent total Kjeldahl nitrogen (TKN), pH, and the allowable effluent ammonia nitrogen concentration.

94.4 Design Safety Factor

Effluent concentrations of ammonia nitrogen from the RBC process designed for nitrification are affected by diurnal load variations. Therefore, it may be necessary to increase the design surface area proportional to the ammonia nitrogen diurnal peaking rates to meet effluent limitations. An alternative is to provide flow equalization sufficient to ensure process performance within the required effluent limitations.

95. BIOLOGICAL NUTRIENT REMOVAL (BNR)

95.1 General

BNR is an advanced form of activated sludge treatment where processes are manipulated to encourage the biochemical removal of nitrogen and/or phosphorus from the wastewater.

BNR facilities must be designed to allow for flexibility with respect to all recycle streams, recycle inputs and wasting rates. A BNR system should be designed with locations for chemical inputs to enhance settling, nutrient removal or other chemically enhanced options, even if not proposed with the planned operation mode. These potential chemical enhancements should be supported with the appropriate sizing of tanks and basins to allow for effective chemical enhancement should that level of treatment become necessary in the future. Designs should include flexibility for start-up (i.e. low flow conditions) and seasonal adjustments with swing zones and recycle piping.

In addition to the requirements of this section, applicable portions of Section 92 (Activated Sludge) must be considered in the design of BNR systems.

95.11 Design Report

BNR system design must be based on experience at comparable facilities under similar climatic locations and must provide for accessibility and flexibility in operation. A design report must be submitted, which at a minimum, addresses the following:

a. The engineer must indicate how the modes of operation were selected and configured to achieve the treatment goals and produce a finished effluent that will meet all applicable requirements.

b. A nutrient removal analysis (i.e., modeling) must be provided (including seasonal variations) to justify system design. The analysis must consider maximum month flow and the lowest anticipated wastewater temperature.

c. Design flow and water quality parameters must be based on 1 year of actual plant influent wastewater data, if available. This data should include temperature, alkalinity, pH, BOD_5, COD, TSS, total phosphorus, ortho-phosphate, total nitrogen, ammonia, total Kjeldahl nitrogen (TKN), volatile fatty acid (VFA), and seasonal flow variations. Other data may be required by the Department depending on the treatment process proposed, or if there is a relevant discharge permit or total maximum daily load (TMDL) issue specific to the discharge.

95.12 Full Scale Plant Data and Pilot Studies

Full-scale plant data or pilot studies may be required by the Department on a case-by-case basis, particularly if the system will treat industrial wastewater. The Department encourages the use of pilot studies in advance of selecting a BNR alternative as a means of comparing performance and ease of operation and maintenance.

95.2 Phosphorus Removal

When low TP effluent levels (around 0.3 mg/L) are needed, chemical removal and effluent filtration may be required and must be designed in accordance with Chapter 110 (Supplemental Treatment Processes).

95.21 Biological Phosphorus Removal

To enhance the microbial uptake of soluble phosphorus (P), the treatment system must contain an anaerobic zone and a simple carbon source (e.g., VFAs) for P release, and an aerobic zone for P uptake.

a. The anaerobic zone(s) must be designed to prevent the introduction of dissolved oxygen, nitrate, or sulfate. Designs should utilize interzone baffles incorporating a hydraulic drop in the water surface across the top of the baffle to prevent the backflow of water high in nitrates or dissolved oxygen.

b. An influent $cBOD_5$:TP ratio of 20:1 or greater, or a COD:TP ratio of 45:1 or greater to the anaerobic zone is necessary to achieve a final effluent level of 1 mg/L or less phosphorus. This ratio should take into account all recycle loads and removal in the primary clarifiers, if provided. When this ratio is not met, provisions to add short chain carbon compounds (e.g., VFAs) to the anaerobic zone should be considered.

c. Depending on the BNR process utilized and the availability of VFAs, the anaerobic basin(s) should have a solids retention time (SRT) of 0.5 to 2 days and a hydraulic retention time (HRT) of approximately 0.5 hours to 2 hours. The longer retention times may be required when VFAs are produced in the anaerobic basin. A swing zone, to adjust the anaerobic zone volume, should be considered.

d. Adequate mixing must be provided in the anaerobic zone to keep solids in suspension (1 ft/sec) but must be designed to prevent turbulence or vortexing that will introduce oxygen from the atmosphere. A mixing energy of 0.1 to 0.2 Hp/1000 ft^3 should be adequate.

e. Dissolved oxygen concentrations of approximately 1 mg/L to 2 mg/L in the aeration zone are sufficient for phosphorus uptake to occur.

f. The aerobic zone design should have a solids retention time (SRT) of 2 to 5 days and a hydraulic retention time of (HRT) of 2 to 6 hours (temperature dependent). For systems designed for both phosphorus removal and nitrification, the latter will determine the aerobic zone sizing requirements (see section 95.31 Nitrification). In any case, the minimum required SRT and HRT to achieve the performance goals should be utilized since longer retention times can lead to phosphorus release.

g. The aeration basin should be designed with tapered aeration so adequate oxygen is available at the head of the tank for phosphorus uptake.

h. The pH should be > 7.0 in the aerobic zone with the optimal pH range being 7.5 to 8.0.

i. Consideration must be given to sludge handling processes. If the sludge becomes anaerobic, phosphorus can be released and returned in a recycle stream.

95.22 Fermenters

If a fermenter is utilized to generate the VFAs necessary for phosphorus release the design engineer should keep in mind that the fermentation process can reduce the amount of gas produced in anaerobic digesters by 30 to 40 percent. A fermenter is essentially the acid stage of digestion and functions much like an anaerobic digester without gas production. Therefore, in addition to the information provided below, the fermenter must be designed in accordance with applicable parts of Section 84 (Anaerobic Sludge Digestion) and Section 87 (Sludge Pumps and Piping).

a. Approximately 7 to 10 mg/L of VFA should be provided for each mg/L of P to be removed.

b. An SRT of 3 to 8 days, depending on wastewater temperature, is recommended. SRTs longer than this can lead to gas production.

c. The HRT of the fermenter is typically 12 to 36 hours.

d. Elutriate water from the secondary clarifier is recommended to increase VFA removal from the fermenter and to maintain optimal oxidation/reduction potential (ORP) conditions of the fermenter. Primary effluent or dissolved-air-floatation (DAF) underflow can be used as elutriate water as well.

e. Sludge in the fermenter should be continually pumped (recirculated) to prevent thickened sludge from developing at the bottom of the fermenter which can plug piping. Positive displacement pumps are recommended.

f. A back-up chemical feed system for VFA addition should be provided in the case of fermenter failure.

g. The use of ORP and pH probes is strongly encouraged to optimize and monitor the fermentation process. If ORP is not utilized in the design, another method of monitoring the fermentation process must be provided which is acceptable to the Department.

h. Odor control for the fermenter is strongly recommended.

i. The internal components and tank covers must be constructed with materials that are capable of withstanding prolonged exposure to a corrosive environment.

95.3 Nitrogen Removal

This section discusses biological nitrogen removal. For chemical nitrogen removal see Chapter 110 (Supplemental Treatment Processes).

95.31 Nitrification

The following criteria are recommended for facilities designed to optimize nitrification:

a. If industrial wastewater is to be treated, an effective pretreatment program must be provided to minimize the possibility of toxins (e.g., certain heavy metals, halogenated solvents, cyanide, etc.) upsetting the biological process.

b. System design must prevent short-circuiting. Basins must be designed to optimize plug flow, with consideration given to dividing the basin into a series of compartments by installing dividers across the basin width, and ports through the dividers. At least two stages are needed to assure year-round nitrification.

c. The aeration basin(s) must be designed in accordance with Section 92.3 (Aeration). For systems with complete denitrification, oxygen requirements for nitrification can be based on 2.5 lbs O_2 rather than the 4.6 lbs O_2/ lb of diurnal peak TKN required for nitrification-only facilities.

In order to balance seasonal oxygen requirements, provisions to adjust one or more of the following must be included: (1) sludge age; (2) basin pH; (3) volume in service, or (4) oxygen supply to the basin.

d. For systems with denitrification, aeration system design should incorporate a decrease in residual dissolved oxygen levels (0.8 mg/L to 1.0 mg/L) at the end of the aeration zone to minimize the transfer of oxygen to the anoxic zone. A post aeration zone may be required to meet effluent dissolved oxygen requirements.

e. The SRT should be 8 to 15 days, depending on wastewater temperature.

f. The food to mass ratio (F/M) should be approximately 0.25 or less.

g. A MLVSS concentration of 2000 to 5000 mg/L is recommended in the aeration zone.

h. System pH must be maintained between 7.4 and 8.6, (optimum 8.2 to 8.6).

i. Nitrification destroys 7.2 lbs of alkalinity as $CaCO_3$ per pound of NH_4-N oxidized. Designs must include an evaluation of the potential need to add alkalinity to maintain a neutral effluent pH and residual alkalinity of 30 to 50 mg/L of alkalinity after complete nitrification. The analysis must presume that the system will achieve complete nitrification whether required or not. If the wastewater is deficient in alkalinity, alkaline feed and pH control must be provided. When alkalinity addition is required, designs must identify the preferred alkalinity source or mix of chemicals which supplies carbonate ions.

j. For combined carbon oxidation/nitrification, the BOD_5/TKN ratio should be 5:1or greater. For separate stage nitrification the ratio can be less than 5:1.

k. The dissolved oxygen concentration in the aeration basin must be designed for 2.0 mg/L during average flow conditions and at least 1.0 mg/L during peak flow conditions, based on critical wastewater temperature.

l. The HRT of the aeration zone for nitrification should be 4 to 12 hours depending on wastewater temperature.

m. Where performance data or pilot plant data are not available, the following nitrification rates may be employed in the design of the aeration basin. These rates are established for optimum pH. If the design is based on a pH range other than the optimum range, the nitrification rates should be reduced.

Temperature °F (°C)	Nitrification rate (lbs NH_4-N nitrified/day/lb MLVSS)
41 (5)	0.04
50 (10)	0.08
59 (15)	0.13
68 (20)	0.18
77 (25)	0.24
86 (30)	0.31

n. Consideration must be given to side stream flows from sludge handling processes since some sludge conditioning chemicals used for sludge dewatering can inhibit nitrification.

95.32 Denitrification

The following criteria are recommended for facilities designed to optimize denitrification:

a. Basin design must prevent short-circuiting. Basins must be designed to optimize plug flow, with consideration given to dividing the basin into a series of compartments by installing dividers across the basin width, and ports through the dividers.

b. The anoxic zone(s) must be designed to minimize the introduction of dissolved oxygen from the aerobic zone.

c. A supplemental organic substrate feed (e.g., methanol) may be required to achieve denitrification if the influent and recycled flows from the mainstream process do not provide a sufficient amount of substrate.

If chemical feed equipment for substrate is proposed, duplicate feed pumps must be provided. The feed rate of the organic substrate must be closely controlled to avoid residual BOD in the effluent. A means of pacing the feed to the incoming nitrate concentration must be provided. Feed rates based on flow pacing are not acceptable, due to varying nitrate concentrations.

d. Complete denitrification may require at least two anoxic stages with a total HRT of 1 to 3 hours. A shorter HRT is appropriate if a simple carbon source (i.e., methanol) is provided while a longer HRT is required if endogenous respiration is needed to provide the carbon source.

e. An aeration zone should follow the final anoxic zone to control BOD and/or increase the dissolved oxygen level in the final effluent.

f. An SRT of 8 to 15 days should be provided depending on wastewater temperature.

g. A MLVSS concentration of 2000 to 5000 mg/L in the anoxic zone is recommended.

h. System pH must be maintained between 6.5 and 8.5, (optimum 7.0).

i. Denitrification produces 3.6 lbs of alkalinity as $CaCO_3$ per pound of NO_3-N reduced.

j. Dual internal recycle pumps must be provided, each with the capacity to return 100 to 400 percent of the average daily flow, from the end of the system's main aeration zone to the main anoxic zone.

j. Adequate mixing must be provided in the anoxic zone(s) to keep solids in suspension (1 ft/sec) but must be designed to prevent turbulence or vortexing that will introduce oxygen from the atmosphere. A mixing energy of 0.1 to 0.2 Hp/1000 ft^3 should be adequate.

k. Ponds utilized for denitrification should be covered to retain heat and prevent wind mixing and photosynthetic oxygen production, which reduce denitrification rates.

95.4 Instrumentation and Controls

95.41 Automation

A programmable logic controller (PLC) unit that automatically controls much of the routine operation of BNR facilities must be provided. Typical automated functions must include blower operations, recirculation pumping, and flow routing in some systems. Design must provide operators with the ability to alter set-points as treatment goals change or if operator experience indicates a need for process adjustments. BNR systems must be able to run in a full manual mode in the event the PLC system fails. An uninterruptible power supply, with electrical surge protection, must be provided for each PLC to retain program memory through a power loss.

The PLC system should be tied into the facility's Supervisory Control and Data Acquisition (SCADA) or Human Machine Interface (HMI) software system to enable continuous monitoring of all system components and modes of operation from the main office

95.42 Monitoring and Alarms

Typical trend data monitored for automated process control include: dissolved oxygen, ORP, pH, alkalinity, nitrate, ammonia, ortho-phosphate, VFAs, and MLSS. Continuous monitoring of these parameters should be provided as necessary, with outputs connected to a common PLC to control aerator output, recycle rates, chemical additions, etc.

Alarm conditions that must be monitored include, but are not necessarily limited to: high/low water levels, failure of automatically operated valves, blower failure (including low pressure and high temperature), and pump failure (including high temperature and seal leakage).

95.5 Performance Sampling

Convenient and safe access for the sampling of each treatment basin must be provided so that system performance can be determined and needed process control and operational modifications can be made. Consideration must be given to the types of parameters that should be monitored.

In addition to the monitoring requirements within the facility's discharge permit, the Department may require BNR facilities to perform additional monitoring as a condition of approval.

96. SEQUENCING BATCH REACTOR (SBR)

96.1 General

SBR systems are a fill and draw activated sludge wastewater treatment system that utilizes a single basin for treatment and clarification. To provide continuous treatment, SBR systems typically contain two basins that are operated with alternating cycles. SBRs generally contain the following phases of operation: fill, react, settle, decant and idle.

SBRs rely on the use of automatic controls and motor-operated control valves; therefore, coordination of the controls, process design, and equipment must be carefully considered. This typically leads to SBR systems designed as complete packages by a single manufacturer.

Since individual SBR equipment manufacturers often provide proprietary control system and process components, early identification of a preferred SBR manufacturer may be necessary for plant design. Pre-selection or pre-qualification of an SBR system must follow applicable federal and state procurement laws.

Depending on treatment goals, in addition to the requirements of this section, applicable portions of Section 92 (Activated Sludge) and/or Section 95 (Biological Nutrient Removal (BNR)) will be applied to the design of SBR systems.

96.11 Design Report

SBR system design must be based on experience at comparable facilities under similar climatic locations and must provide for accessibility and flexibility in operation. A design report must be submitted which at a minimum addresses the following:

a. The engineer must justify how the modes of operation were selected and configured to achieve the treatment goals and produce a finished effluent that will meet all applicable water quality requirements.

b. The engineer must evaluate proprietary system designs and document how the system will meet the criteria of this section. This analysis must include the calculations needed to support any performance claims.

c. At a minimum, designs must identify the following parameters: food to mass (F/M) ratio, oxygen demand/supply, high and low water levels, mixing energy, sludge residence time, cycle times at various flow conditions, and basin dimensions.

d. Design flow and water quality parameters must be based on 1 year of actual data, if available. This data should include raw wastewater alkalinity, pH, temperature, BOD_5, TSS, total phosphorus, total nitrogen, ammonia, and total Kjeldahl nitrogen (TKN) concentrations. Other data may be required by the Department if it is relevant to a discharge permit, or total maximum daily load (TMDL) issue specific to the discharge.

96.2 Pretreatment

Pretreatment of wastewater must be provided in accordance with Chapter 60 (Screening, Grit Removal, and Flow Equalization), or as recommended by the manufacturer if more stringent.

The use of a grinder on the influent flow is discouraged since a neutral buoyancy portion of masticated plastic or other material can accumulate in the tank and get passed out with each decant.

96.3 Design Flow Rate

The SBR system must be designed to handle all expected flow scenarios. A minimum peaking factor of 2 will be applied to the average daily flow to determine the maximum day flow unless flow data indicates otherwise.

The engineer must consider existing flows at the time of installation and base SBR sizing on the ability to treat the range of flows expected after start-up. Should these "start-up" flows be substantially less than the 20-year design flows, multiple units must be planned. The Department may allow for installation of additional basins at a later date as the capacity of the initial set of SBRs is reached, as long as the design allows for this growth with respect to equalization capacity, available land area, and discharge constraints.

96.4 Process Characteristics

96.41 Solids Retention Time (SRT)

Basin sizing must be based on SRT and mass balance calculations reflecting that solids removal will allow the effluent to meet design and permit criteria throughout the design life. Designs must provide sufficient tank volume to operate with an "oxic" sludge age of approximately 8 to 15 days depending on wastewater temperature. The "oxic" sludge age equals the SRT multiplied by the proportion of time the tank is in the aeration phase. Designs must assess the need for longer sludge ages if basins will operate below 59 ºF (15 ºC).

96.42 Food to Mass (F/M) Ratio

Where nutrient removal is required, the F/M ratios typically range from (0.05 to 0.1) lb BOD_5/day/lb MLSS at the design average daily loading rate. For conventional treatment, the F/M ratios typically range from (0.15 to 0.4) lb BOD_5/day/lb MLSS at the design average daily loading rate. The basin mass (lb MLSS) should be calculated at the high-water level.

96.43 Mixed Liquor Suspended Solids (MLSS) Concentrations

Typical MLSS concentrations range from 2,000 to 4,500 mg/L at the high water level. The engineer must provide operating examples to support design MLSS concentrations outside the range presented above.

96.44 Mass Loading Rate

Designs should provide adequate tank volume to limit the mass loading rate to approximately 15 lb BOD_5/d/1000 ft^3 (0.24 kg BOD_5/d/m^3). This criterion should be evaluated using the tank volume at the low-water level and the average loading for BOD_5.

96.5 Basin Design

a. Adequate space must be provided for equipment access (e.g., cranes) for the removal of grit, debris or equipment from each basin.

b. Each basin must be provided with an overflow to the other basin(s) or to pre-equalization tank(s).

c. Common basin walls must be structurally designed for liquid forces on one side of wall only.

d. Designs should provide stub-outs for additional basins to accommodate system expansion.

96.51 Minimum Number of Basins

A minimum of two fully-functional basins are required. A pre-equalization basin is recommended, and when provided must be designed in accordance with Section 65 (Flow Equalization). The Department may require the installation of a pre-equalization basin based on project-specific conditions.

Designs must allow the operator to isolate, replace, or service a malfunctioning component with little or no reduction in treatment capacity. Such functionality typically requires the installation of an adequately sized equalization basin, or the installation of retrievable components (diffuser grids, mixers, etc.) that can be removed without dewatering the basin. Designs must provide backup for all proprietary equipment including; major assemblies, motors, pumps, valves, blowers, and control logic. In addition, provisions must be made that allow the basins to operate in a continuous flow-through mode during emergency operations.

96.52 Emergency Operation

a. Two basin systems must be designed for operating each basin as a flow through unit if one basin is out of service. The distance between the inlet pipe and decanter must be maximized horizontally and vertically to minimize short-circuiting. This includes extending the inlet pipe two to three feet from the bottom of the basin(s) or installing a baffle wall in the inlet area at the opposite end of the decanter location.

b. The average horizontal velocities through each SBR or through baffle wall opening should not exceed 1 ft/sec (0.3 m/s).

c. Rectangular basins are recommended as they encourage plug flow and therefore are an advantage during flow through operations.

96.6 Influent Lines

Gravity influent lines must enter the SBR basin above the high water level to prevent the backflow of water into the SBR basin with the lowest water level. Pressure influent lines must contain provisions for backflow protection.

96.7 Minimum Operating Levels

The low water level of each basin must not be less than 10 feet (3 m) to allow for adequate separation of solids from the wastewater. Where simultaneous fill and decant may occur (i.e., no equalization) the low water level must not be less than 12 feet (3.6 m) unless additional treatment is provided.

96.8 Decantable Volume and Decanter Sizing

The decantable volume should not exceed one-third of the total tank volume.
The decantable volume and decanter capacity of the SBR system, with the largest basin out of service, must be sized to pass at least 75 percent of the design maximum day flow for systems that nitrify, or 50 percent of the design maximum flow for systems that provide secondary treatment only, on a continuous basis without changing cycle times.

96.81 Decanter Details

a. Each decanter must draw treated effluent from below the water surface and provide a means of excluding scum during the decant phase. An adequate zone of separation between the sludge blanket and the decanter(s) must be maintained at all times during the decant phase. The decanter must be designed with an entrance velocity that is less than 1.0 ft/sec to prevent floatables and sludge from being drawn into the decanter.

b. A means of excluding solids from entering the decanter during a reaction phase must be provided.

c. Decanters must fail in the closed position. It is recommended that the decanter have a “fail safe” feature where at least two independent control signals or valves must open.

d. Floating decanters must have a physical restraint that prevents continued lowering if a drain valve fails.

e. Fixed decanters should not be used in basins where simultaneous fill and decant may occur.

f. Fixed decanters should only be utilized when preceded by equalization facilities or followed by final clarifiers/filtration. Added settling time before a discharge must be considered for SBRs with fixed decanters.

96.9 Mixing Equipment

a. Mechanical mixing independent of aeration must be provided for all basins where biological nutrient removal is required, with mixing equipment sized to thoroughly mix the entire basin from a settled condition within 5 minutes, without aeration. Mixing may be accomplished via the same equipment that performs aeration, but the equipment must be able to function separately as an aeration device, as a mixing device, and as a combined aeration/mixing device to provide operational flexibility.

b. Floating mixers must be accessible, adequately moored, and protected from excessive icing.

96.10 Aeration Equipment

a. The aeration equipment must be able to quickly achieve and sustain a dissolved oxygen concentration of at least 2 mg/L throughout the basin. This analysis must be based on the average water depth between the low and maximum water levels of the basin. SBRs that utilize mixers as the sole air source must also meet these aeration requirements.

b. The oxygen demand must be designed in accordance with section 92.331 (General) where pounds of BOD_5 and TKN are based on 2 times the average daily concentrations unless monitoring data indicates otherwise. For facilities designed to completely nitrify and denitrify, the oxygen requirements for nitrification can be based on 2.5 lbs O_2/ lb of peak diurnal TKN.

96.101 Blower and Diffuser System Requirements

a. Design discharge pressure of blowers must be established at the maximum water depth. Blower discharge pressure (psig) = (diffuser depth (ft.) at high water level x 0.4335) + line losses (psig).

b. Multiple blowers must be provided and meet the maximum air demand in the aerated portions of the SBR with the single largest blower out of service.

c. A segment of the air supply line must be placed above the high water level of the basin to prevent water from flowing back to the blowers when off.

d. Self sealing medium to fine bubble diffusers should be specified for SBR processes. Ceramic diffusers are not recommended due to clogging.

e. Provisions to easily remove aeration diffusers without dewatering the basin are recommended to permit maintenance and repair without interrupting operation of the basin or inhibiting operation of the other aeration equipment. For fixed diffuser systems, an alternate method of cleaning or back-flushing the diffusers should be provided. In systems with only two basins, the engineer must configure diffusers in multiple banks that can be independently isolated and repaired.

f. Aeration equipment must allow for varying water depths and cyclical operation. Positive displacement blowers should be used to handle wastewater level variations in the basin.

g. Oxygen transfer rates from the aerators must be designed in accordance with Section 92.332 (Diffused Air Systems). The engineer must provide the basis for selected factors. Site specific data should be used.

96.12 Solids Wasting

a. A separate piping and pumping system must be provided for sludge wasting in each SBR basin.

b. Sludge wasting should be automated to ensure performance stability of the system.

c. All sludge transfer and wasting pumps must be accessible for maintenance without dewatering the basin.

d. To maximize the removal of solids, the waste sludge pump or suction pipe must extend to the bottom of the basin. The basin floor must slope towards waste sludge pumps or suction pipe.

e. The capability to transfer sludge between basins must be provided.

96.13 Post Equalization Basin

A post equalization basin is recommended to dampen flows for downstream operations such as disinfection and filtering units. If post equalization is not provided, then downstream units and piping must be sized to handle the peak discharge rate of the decanter.

Post-SBR flow equalization should be designed to meet the following criteria:

a. Store a minimum of one design capacity decantable volume;

b. If effluent pumps are utilized, at least two must be provided with each sized to empty the post equalization basin before the next decant starts.

c. If required in the facility’s discharge permit, aeration may be required to increase the dissolved oxygen level in the final effluent.

96.14 Freezing Protection

SBR basins and components must be protected from freezing. The engineer must indicate how an outdoor installation, if proposed, will not cause operational and maintenance issues during freezing conditions.

For facilities that require nutrient removal, the SBR basins should be housed in a heated structure to maintain wastewater temperature. For covered SBR basins, consideration must be given to the need and means for equipment removal. Electrical equipment, fixtures and controls must comply with the National Electrical Code for Class I, Division 2, Group D locations.

96.15 Freeboard

All open basin SBRs must have a minimum freeboard of 18 inches (457.2 mm) to serve as storage in emergency situations and to handle resultant foaming.

96.16 Foam and Scum Control

Scum removal features such as telescoping valves or scum troughs, must be provided in the SBR basins. Where designs employ scum troughs, they may either be fixed or floating (e.g., attached to the decant boom). Entrainment by mixing must not be the sole means of scum control in the SBR basin.

Designs must include spray bars or manual spray hose connections supplied with chlorinated non-potable water for foam suppression and facilitation of scum collection.

96.17 Instrumentation and Controls

96.171 Automation

A programmable logic controller (PLC) unit that automatically controls much of the routine operation of SBR facilities must be provided. Typical automated functions include: valve positioning, oxygen delivery, decant operations, and sludge wasting. Design must provide operators with the ability to alter set points as influent flows vary, treatment goals change, or operator experience indicates a need for process adjustments. SBR systems must be able to run in a full manual mode in the event the PLC system fails. An uninterruptible power supply, with electrical surge protection, must be provided for each PLC to retain program memory through a power loss.

The PLC system should be tied into the facility's Supervisory Control and Data Acquisition (SCADA) or Human Machine Interface (HMI) software system to enable continuous monitoring of all system components and modes of operation from the main office.

96.172 Controls and Alarms

a. SBR controls must at a minimum allow for the following modes of operation: static fill, mixed fill, aerated fill, react, settle, decant, sludge waste and idle.

b. Designs must include automatically controlled, motor-operated (or hydraulic cylinder-operated) valves for influent, decant, and air control. All motor-operated valves must have the ability to be manually operated should the electronics fail, or the design must include a manual backup valve. Both automatic and manual controls must allow independent operation of each basin.

c. Motor control centers should be located in close proximity to the process and a view of the basins is highly recommended.

d. Data typically monitored for automated process control include, but is not limited to: dissolved oxygen, oxidation/reduction potential (ORP), pH, alkalinity, nitrate, ammonia, ortho-phosphate, and MLSS. Continuous monitoring of these parameters should be provided as necessary, with outputs connected to a common PLC to control aerator output, cycle times, chemical additions, etc.

e. Pressure transducers and floats may be used as tank level sensors. Floats must be shielded from prevailing winds and adequately protected from freezing. Bubbler systems must not be used.

f. Visual display and recording of instantaneous and totalized flow rates, both influent, as well as discharge, must be provided.

g. Designs must address the operational strategy for high flow situations. The control system should automatically and progressively adjust cycle times when influent flows exceed what "normal" cycle times can handle. Designs must include a level-based high water alarm and cycle structure override.

Under all operational strategies, a minimum settling time of at least 20 minutes between the react and decant phases must be maintained.

h. Alarm conditions that must be monitored include, but are not necessarily limited to: high and low water level in each basin, failure of all automatically operated valves, decanter failure, mixer failure, blower failure (including low pressure and high temperature), sludge pump failure (including high temperature and seal leak).

96.18 Performance Sampling

Convenient and safe access for the sampling of each treatment basin must be provided so that system performance can be determined and needed process control and operational modifications can be made. Consideration must be given to the types of parameters that should be monitored.

In addition to the monitoring requirements within the facility's discharge permit, the Department may require SBR facilities to perform additional monitoring as a condition of approval.

97. MEMBRANE BIOREACTOR (MBR)

97.1 General

MBR systems combine suspended growth activated sludge with membrane filtration to provide wastewater treatment. Low-pressure membranes, generally classified as microfiltration or ultrafiltration, are commonly used for MBR systems and are the filtration units defined within this section.

It is generally accepted that the design of MBR systems is manufacturer-specific; therefore, consideration must be given to the proprietary nature of the selected product. A comparison of various types of MBR systems should be evaluated during the preliminary design process with consideration given to the future dependency on a specific manufacturer for parts, technical assistance, and support. Early identification of a preferred MBR manufacturer may be necessary for plant design. Pre-selection or pre-qualification of an MBR system must follow applicable federal and state procurement laws for publicly-owned facilities.

Depending on treatment goals, in addition to the requirements of this section, applicable portions of Section 92 (Activated Sludge) and/or Section 95 (Biological Nutrient Removal (BNR)) will need to be applied to the design of MBR systems.

97.11 Design Report

MBR system design must be based on experience at comparable facilities under similar climatic locations and must provide for accessibility and flexibility in operation. A design report must be submitted which at a minimum addresses the following:

a. The engineer must justify how the modes of operation were selected and configured to achieve the treatment goals and produce a finished effluent that will meet all applicable water quality requirements.

b. The engineer must evaluate proprietary system designs and document how the system will meet the criteria of this section. This analysis must include the calculations needed to support any performance claims.

c. Designs must identify the following: flux rates (average and peak instantaneous); mixed liquor concentrations; recycle rate and flexibility; transmembrane pressures (TMPs); air scour demand and effect on recycle streams; flow scenarios (considering seasonal variations with corresponding minimum water temperature); life expectancy of membranes and components; and cleaning requirements as specified by the manufacturer.

d. Design flows (including average day, peak day, maximum month, and peak hourly) and water quality parameters must be identified (based on 1 year of actual plant influent data, if available). This data should include temperature, alkalinity, pH, BOD_5, COD, TSS, total phosphorus, total nitrogen, ammonia, total Kjeldahl nitrogen (TKN), and seasonal flow variations. Other data may be required by the Department depending on the treatment process proposed, or if there is a relevant discharge permit or total maximum daily load (TMDL) issue specific to the discharge.

97.12 Full Scale Plant Data and Pilot Studies

Full-scale plant data or pilot studies may be required by the Department on a case-by-case basis, particularly if the system will treat industrial wastewater. The Department encourages the use of pilot studies in advance of selecting an MBR alternative as a means of comparing performance and ease of operation and maintenance. Pilot testing must be performed at systems treating industrial wastewater.

97.2 Pretreatment

In addition to the requirements listed in Chapter 60 (Screening, Grit Removal, and Flow Equalization), fine screens with maximum openings of 0.5 mm to 3.0 mm (perforated plate), or as recommended by the MBR manufacturer, must be provided. Fine screens must not be bypassed; therefore, full redundancy must be provided.

In addition to the use of fine screens, the use of either primary clarification and/or grit removal is strongly recommended. If required by the manufacturer, a means for the removal of fat, oil, and grease (FOG) from the wastewater must be provided.

97.3 MBR Process Design Characteristics

97.31 Mixed Liquor Suspended Solids (MLSS) Concentrations

The activated sludge portion of an MBR system typically operates with an MLSS concentration in the range of 6,000 to 18,000 mg/L. MLSS concentrations greater than 18,000 mg/L require justification from the MBR manufacturer.

In order to control the concentration of mixed liquor in the membrane tank, a minimum recycle rate (typically between 200 and 400 percent of the average daily flow) is required to maintain a maximum MLSS concentration of 18,000 mg/L in the membrane tank during peak hour conditions.

Depending on treatment goals, the recommended sludge retention time (SRT) for MBR systems ranges from 10 to 50 days.

97.32 Membrane Flux Rates

Flux rates used in design must be based on manufacturer-specific data that takes into account the full range of flow conditions expected, allowable transmembrane pressure (TMP), MLSS concentration, and minimum water temperature. Cleaning intervals and durations must be considered in determining net flux rates. Average net flux rates for public sewage typically range from 8 to 20 gfd at 68 ^{o}F (20 ^{o}C).

Sufficient justification must be provided to show that flux rates and number of membrane modules are practical and reasonable. Spare space should be provided in the membrane tanks for future additional membrane modules. When one membrane tank is out of service for maintenance procedures, the remaining tanks must still operate within the manufacturer's recommended net flux requirements.

97.33 Transmembrane Pressure (TMP)

The TMP range must be provided by the membrane manufacturer and must be used in the design of appropriate permeate pumping equipment and automated cleaning cycles at the established flux rates.

97.4 Pumping Requirements

Major pumps must be designed in accordance with Section 53.8 (General Plant Pumping).

Hollow fiber designs should consider using reversible rotary-lobe pumps to serve the dual option of permeate forward flow and back pulse reverse flow.

97.5 Cleaning and Chemical Feed Systems

Designs must incorporate manufacturer's on-line and off-line cleaning strategies to restore membrane permeability during operation

Designs must provide for recovery cleaning within an isolated section of the membrane basin or with membrane removal to a dedicated recovery cleaning tank. Special considerations must be given to the disposal of cleaning chemicals (e.g., sodium hypochlorite, oxalic acid, citric acid, hydrochloric acid, etc.) so that they do not disrupt biological processes. When equalization or storage basins are available, this waste stream may be returned to the headworks of the facility to be diluted and processed with the influent wastewater.

Basin or tank walls that will be exposed to membrane cleaning chemicals (bleach, acid, etc.) must be lined to protect against corrosion or constructed of a corrosion resistant material.

97.6 Aeration

Designs must ensure that sufficient aeration and diffuser arrangements will be provided to meet all biological and membrane scouring needs. Aeration systems for MBR applications must be based on criteria similar to Section 92.33 (Aeration Equipment) or Section 95.31 (Nitrification), depending on treatment goals. Designs must take into account lower oxygen transfer due to higher MLSS concentrations. Increased MLSS concentrations and mixed liquor viscosities result in decreased alpha (α) values for fine bubble diffusers (typically 0.3 to 0.4). The design must provide clear rationale to support the choice of the α-value used for the proposed project.

The use of coarse bubble diffusers for membrane scouring may affect the overall aeration requirements of the system.

Designs may use the oxygen in the RAS to offset air needs in the aeration tanks. In claiming this "oxygen credit", designs must provide a reasonable accounting of the oxygen balance within the system and justify that sufficient aeration capacity will exist. This credit can only be counted when RAS is directed into the aerobic tank(s).

In cases where the recycle stream is directed to the anoxic or anaerobic zone, designs must incorporate features to limit the introduction of dissolved oxygen from the RAS. Features may include, but are not limited to, use of a de-aeration basin, mixing with the influent, or inclusion of a larger anoxic or anaerobic basin. Oxygen concentration in membrane basins should be monitored to aid in managing oxygen transfer in recycle flows.

97.7 Freezing Protection

Membrane tanks and components must be protected from freezing. The engineer must indicate how an outdoor installation, if proposed, will not cause operational and maintenance issues during freezing conditions.

97.8 Freeboard

All system tanks must have freeboard of 18 inches (457.2 mm) or more to serve as storage in emergency situations and to handle resultant foaming.

97.9 Membrane Removal

A means to remove the membranes from service, such as a bridge crane or monorail, must be provided. A membrane maintenance area with a drain capable of handling drainage waste from out-of-service membranes must be provided.

The crane/hoist lifting power must be designed for the membrane cassette wet weight plus additional weight of the solids accumulated on the membranes.

97.10 Foam and Scum Control

Design must include a means to remove foam and scum from the basins (e.g., surface wasting). Spray-down nozzles or hose bibs must be provided to assist in foam control and wash down.

97.11 Instrumentation and Controls

97.111 Automation

A programmable logic controller (PLC) unit that automatically controls much of the routine operation of MBR facilities must be provided. Typical automated functions must include all cleaning cycles, except for recovery cleaning (large facilities may choose to include automated recovery cleaning), blower operations, recirculation and permeate pumping, and flow routing in some systems. Design must provide operators with the ability to alter set-points as treatment goals change or if operator experience indicates a need for process adjustments. A redundant PLC system must be provided to ensure system reliability unless the design allows for manual mode operation and sufficient on-site storage is available. An uninterruptible power supply, with electrical surge protection, must be provided for each PLC to retain program memory through a power loss.

The PLC system should be tied into the facility's Supervisory Control and Data Acquisition (SCADA) or Human Machine Interface (HMI) software system to enable continuous monitoring of all system components and modes of operation from the main office.

97.112 Monitoring and Alarms

The ability to detect and isolate membrane failures must be a provision of the design or the manufacturer's equipment. Membrane permeate turbidimeters with continuous recording equipment must be installed to monitor effluent quality.

Integrated sensors and control valves must be connected to a common PLC. Typical trend data monitored for automated process control include: TMP, turbidity, dissolved oxygen, filtrate flow/flux rate, temperature, and permeability. Continuous monitoring of these parameters should be provided as necessary, with outputs connected to a common PLC to control aerator output, cleaning cycles, chemical additions, etc.

To protect membranes from catastrophic damage, control systems such as manual override capability, automatic high-pressure TMP shutdown, or other manufacturer requirements must be provided.

Alarm conditions that must be monitored include, but are not necessarily limited to: high effluent turbidity, transmembrane pressure (outside of normal set points), failure of automatically operated valves, blower failure (including low pressure and high temperature), and pump failure (including high temperature and seal leakage).

97.113 Flow Control

Designs should allow placing individual membrane trains into standby when influent flow is low. When influent flows increase, the design should include automatic controls to remove individual trains from standby as needed and abort cleaning operations, if necessary. If the engineer provides automated controls with the ability to abort cleaning operations, the design must have appropriate safeguards to ensure proper disposal of cleaning chemicals.

97.12 Performance Sampling

Convenient and safe access for the sampling of each treatment basin must be provided so that system performance can be determined and needed process control and operational modifications can be made. Consideration must be given to the types of parameters that should be monitored.

In addition to the monitoring requirements within the facility's discharge permit, the Department may require MBR facilities to perform additional monitoring as a condition of approval.

98. OTHER BIOLOGICAL SYSTEMS

Biological treatment processes not included in these standards may be considered in accordance with Section 53.2 (Engineering and Performance Requirements for Innovative Wastewater Treatment Alternatives).

CHAPTER 100
DISINFECTION

101. GENERAL

Disinfection of the effluent must be provided as necessary to meet applicable standards. The design must meet both the bacterial standards and the disinfectant residual limit in the effluent. The disinfection process should be selected after due consideration of waste characteristics, type of treatment process provided prior to disinfection, waste flow rates, pH of waste, disinfectant demand rates, current technology application, cost of equipment and chemicals, power cost and maintenance requirements.

Chlorine is the most commonly used chemical for wastewater disinfection. The forms most often used are liquid chlorine and calcium or sodium hypochlorite. Other disinfectants, including chlorine dioxide, ozone, bromine, or ultraviolet disinfection, may be accepted by the Department in individual cases. If halogens are utilized, it may be necessary to dehalogenate if the residual level in the effluent exceeds limitations or would impair the natural aquatic habitat of the receiving stream.

Municipalities are encouraged to investigate the use of ultraviolet disinfection due to safety and toxicity benefits.

Where a disinfection process other than the processes included in this Chapter is proposed, supporting data from pilot plant installations or similar full scale installations may be required as a basis for the design of the system. Refer to Section 53.2 (Engineering and Performance Requirements for Innovative Wastewater Treatment Alternatives).

102. CHLORINE DISINFECTION

102.1 Type

Chlorine is available for disinfection in gas, liquid (hypochlorite solution), and pellet (hypochlorite tablet) form. The type of chlorine should be carefully evaluated during the facility planning process. The use of chlorine gas or liquid will be most dependent on the size of the facility and the chlorine dose required. Large quantities of chlorine, such as are contained in ton cylinders and tank cars, can present a considerable hazard to plant personnel and to the surrounding area, should such containers develop leaks. Both monetary costs and the potential public exposure to chlorine should be considered when making the final determination.

102.2 Dosage

For disinfection, the capacity must be adequate to produce an effluent that will meet the applicable bacterial limits specified by the regulatory agency for that installation. Required disinfection capacity will vary, depending on the uses and points of application of the disinfection chemical. The chlorination system must be designed on a rational basis and calculations justifying the equipment sizing and number of units must be submitted for the whole operating range of flow rates for the type of control to be used. System design considerations must include the controlling wastewater flow meter (sensitivity and location), telemetering equipment and chlorination controls. For normal public sewage, the following may be used as a guide in sizing chlorination facilities:

Type of Treatment	Dosage
Fixed film plant effluent	10 mg/L
Activated sludge plant effluent	8 mg/L
Tertiary filtration effluent	6 mg/L
Nitrified effluent	6 mg/L

102.3 Containers

102.31 Cylinders

150 pound (68 kg) cylinders are typically used where chlorine gas consumption is less than 150 pounds per day (68 kg/day). Cylinders must be stored in an upright position with adequate support brackets and chains at 2/3 of cylinder height for each cylinder.

102.32 Ton Containers

The use of one-ton (909 kg) containers should be considered where the average daily chlorine consumption is over 150 pounds (68 kg). Containers must be properly secured.

102.33 Liquid Hypochlorite Solutions

Storage containers for hypochlorite solutions must be of sturdy, nonmetallic lined construction and must be provided with secure tank tops and pressure relief and overflow piping. Storage tanks should be either located or vented outside. Provision must be made for adequate protection from light and extreme temperatures. Tanks must be located where leakage will not cause corrosion or damage to other equipment. A means of secondary containment must be provided to contain spills and facilitate cleanup. Due to deterioration of hypochlorite solutions over time, it is recommended that containers not be sized to hold more than one month's needs. At larger facilities and locations where delivery is not a problem, it may be desirable to limit on-site storage to one week. Refer to Section 57 (Safety).

102.34 Dry Hypochlorite Compounds

Dry hypochlorite compounds should be kept in tightly closed containers and stored in a cool, dry location. Some means of dust control should be considered, depending on the size of the facility and the quantity of compound used. Refer to Section 57 (Safety).

102.4 Equipment

102.41 Scales

Scales for weighing cylinders must be provided at all plants using chlorine gas. At large plants, scales of the indicating and recording type are recommended. At least a platform scale must be provided. Scales must be of corrosion-resistant material.

102.42 Evaporators

Where manifolding of several cylinders or ton containers will be required to evaporate sufficient chlorine, consideration should be given to the installation of evaporators to produce the quantity of gas required.

102.43 Mixing

The disinfectant must be positively mixed as rapidly as possible, with a complete mix being affected in 3 seconds. This may be accomplished by either the use of turbulent flow regime or a mechanical flash mixer.

102.44 Contact Period and Tank

For a chlorination system, a minimum contact period of 15 minutes at design peak hourly flow or maximum rate of pumpage must be provided after thorough mixing. For evaluation of existing chlorine contact tanks, field tracer studies should be done to assure adequate contact time.

The chlorine contact tank must be constructed so as to reduce short-circuiting of flow to a practical minimum. Tanks not provided with continuous mixing must be provided with "over-and-under" or "endaround" baffling to minimize short-circuiting.

The tank should be designed to facilitate maintenance and cleaning without reducing effectiveness of disinfection. Duplicate tanks, mechanical scrapers, or portable deck-level vacuum cleaning equipment must be provided. Consideration should be given to providing skimming devices on all contact tanks. Covered tanks are discouraged.

102.45 Piping and Connections

Piping systems should be as simple as possible, specifically selected and manufactured to be suitable for chlorine service, with a minimum number of joints. Piping should be well supported and protected against temperature extremes.

Due to the corrosiveness of wet chlorine, all lines designated to handle dry chlorine must be protected from the entrance of water or air containing water. Even minute traces of water added to chlorine results in a corrosive attack. Low pressure lines made of hard rubber, saran-lined, rubber-lined, polyethylene, polyvinylchloride (PVC), or other approved materials are satisfactory for wet chlorine or aqueous solutions of chlorine.

The chlorine system piping must be color coded and labeled to distinguish it from other plant piping. Refer to Section 54.6 (Painting). Where sulfur dioxide is used, the piping and fittings for chlorine and sulfur dioxide systems must be designed so that interconnection between the two systems cannot occur.

102.46 Standby Equipment and Spare Parts

Standby equipment of sufficient capacity should be available to replace the largest unit during shutdowns. Spare parts must be available for all disinfection equipment to replace parts that are subject to wear and breakage.

102.47 Chlorinator Water Supply

An ample supply of water must be available for operating the chlorinator. Where a booster pump is required, duplicate equipment should be provided, and, when necessary, standby power as well. Protection of a potable water supply must conform to the requirements of Section 56.2 (Water Supply). Adequately filtered plant effluent should be considered for use in the chlorinator.

102.48 Leak Detection and Controls

A bottle of 56 percent ammonium hydroxide solution must be available for detecting chlorine leaks. Where ton containers (909 kg) or tank cars are used, a leak repair kit approved by the Chlorine Institute must be provided. Consideration should be given to the provision of caustic soda solution reaction tanks for absorbing the contents of leaking one-ton (909 kg) containers where such containers are in use. At large chlorination installations, consideration should be given to the installation of automatic gas detection and related alarm equipment.

102.5 Housing

102.51 Feed and Storage Rooms

If gas chlorination equipment or chlorine cylinders are to be in a building used for other purposes, a gas-tight room must separate this equipment from any other portion of the building. Floor drains from the chlorine room must not be connected to floor drains from other rooms. Doors to this room may open only to the outside of the building, and must be equipped with panic hardware. Chlorine rooms must be at ground level, and should permit easy access to all equipment.

Storage areas for 1-ton (909 kg) cylinders should be separated from the feed area. In addition, the storage area must have designated areas for "full" and "empty" cylinders. Chlorination equipment should be situated as close to the application point as reasonably possible. For additional safety considerations, refer to Section 57 (Safety).

102.511 Locker-Type Chlorine Enclosure

This section applies to small systems that wish to avoid the cost of a large chlorine room by installing a small locker-type enclosure to a building. The enclosure must be sized such that it is just big enough to house the chlorination equipment. Under no circumstances can it be big enough for a person to enter. Chlorine gas feed equipment and storage must be enclosed and separated from other operating areas. Because the enclosure is sized to prevent entry, Section 102.52 (Inspection Window), and Section 102.54 (Ventilation and Accidental Release) requirements of this section are not applicable to the locker type enclosure. The enclosure must be heated. The access doors must be properly secured and labeled with an appropriate chlorine warning placard.

102.52 Inspection Window

A clear glass, gas-tight, window must be installed in an exterior door or interior wall of the chlorinator room to permit the units to be viewed without entering the room.

102.53 Heat

Rooms containing disinfection equipment must be provided with a means of heating so that a temperature of at least 60° F (16° C) can be maintained. The room should be protected from excess heat. Cylinders must be kept at essentially room temperature. If liquid hypochlorite solutions are used, the containers may be located in an unheated area.

102.54 Ventilation and Accidental Release

With chlorination systems, forced, mechanical ventilation must be installed that will provide one complete air change per minute when the room is occupied. The entrance to the air exhaust duct from the room must be near the floor and the point of discharge must be located so as not to contaminate the air inlet to any buildings or inhabited areas. Air inlets must be located so as to provide cross ventilation with air and at such temperature that will not adversely affect the chlorination equipment. The outside air inlet must be at least three feet above grade. The vent hose from the chlorinator must discharge to the outside atmosphere above grade. Where public exposure may be extensive, scrubbers may be required on ventilation discharge.

See the Uniform Fire Code requirements for treatment of gases as:

Treatment systems may be necessary to handle the accidental release of gas.

Treatment systems may be necessary to process all exhaust ventilation to be discharged from gas cabinets, exhausted enclosures or separate gas storage rooms.

102.55 Electrical Controls

Switches for fans and lights must be outside of the room at the entrance. A labeled signal light indicating fan operation must be provided at each entrance, if the fan can be controlled from more than one point.

102.56 Protective and Respiratory Gear

Respiratory air-pac protection equipment, meeting the requirements of the National Institute for Occupational Safety and Health (NIOSH), must be available where chlorine gas is handled, and must be stored at a convenient location, but not inside any room where chlorine is used or stored. Instructions for using the equipment must be posted. The units must use compressed air, have at least 30 minute capacity, and be compatible with the units used by the fire department responsible for the plant.

102.6 Sampling and Control

102.61 Sampling

Facilities must be included for sampling disinfected effluent after the contact chamber as monitoring requirements warrant. In large installations, or where permit conditions warrant, provisions should be made for continuous monitoring of effluent chlorine residual.

102.62 Testing and Control

Equipment must be provided for measuring chlorine residual using accepted test procedures. The installation of demonstrated effective facilities for automatic chlorine residual analysis, recording, and proportioning systems should be considered at all large installations.

Equipment must also be provided for measuring fecal coliform (e.g., *E. coli*) organisms, using accepted test procedures as required by the Department.

103. DECHLORINATION

103.1 Types

Dechlorination of wastewater effluent may be necessary to reduce the toxicity due to chlorine residuals. The most common dechlorination chemicals are sulfur compounds, particularly sulfur dioxide gas or aqueous solutions of sulfite or bisulfite. Pellet dechlorination systems are also available for small facilities.

The type of dechlorination system should be carefully selected considering criteria including the following: type of chemical storage required, amount of chemical needed, ease of operation, compatibility with existing equipment, and safety.

103.2 Dosage

The dosage of dechlorination chemical should depend on the residual chlorine in the effluent, the final residual chlorine limit, and the particular form of the dechlorinating chemical used. The most common dechlorinating agent is sulfite. The following forms of the compound are commonly used and yield sulfite (SO_2) when dissolved in water.

Dechlorination Chemical	Theoretical mg/L Required to Neutralize 1 mg/L Cl_2
Sulfur dioxide (gas)	0.9
Sodium meta bisulfite (solution)	1.34
Sodium bisulfite (solution)	1.46
Sodium thiosulfate (solution)	0.56
Sodium sulfite (tablet)	1.78

Theoretical values may be used for initial approximations, to size feed equipment with the consideration that under good mixing conditions 10 percent excess dechlorinating chemical is required above theoretical values. Excess sulfur dioxide may consume oxygen at a maximum of 1.0 mg dissolved oxygen for every 4 mg SO_2.

The liquid solutions come in various strengths. These solutions may need to be further diluted to provide the proper dose of sulfite.

103.3 Containers

Depending on the chemical selected for dechlorination, the storage containers will vary from gas cylinders, liquid in 50 gallon (190 L) drums, or dry compounds. Dilution tanks and mixing tanks will be necessary when using dry compounds and may be necessary when using liquid compounds to deliver the proper dosage. Solution containers should be covered to prevent evaporation and spills.

103.4 Feed Equipment, Mixing, and Contact Requirements

103.41 Equipment

In general, the same type of feeding equipment used for chlorine gas may be used with minor modifications for sulfur dioxide gas. However, the manufacturer should be contacted for specific equipment recommendations.

No equipment should be used alternately for the two gases. The common type of dechlorination feed equipment utilizing sulfur compounds include vacuum solution feed of sulfur dioxide gas and a positive displacement pump for aqueous solutions of sulfite or bisulfite.

The selection of the type of feed equipment utilizing sulfur compounds must include consideration of the operator safety and overall public safety relative to the wastewater treatment plant's proximity to populated areas and the security of gas cylinder storage. The selection and design of sulfur dioxide feeding equipment must take into account that the gas reliquifies quite easily. Special precautions must be taken when using 1-ton (909 kg) containers to prevent reliquification.

Where necessary to meet the operating ranges, multiple units must be provided for adequate peak capacity and to provide a sufficiently low feed rate on turn down to avoid depletion of the dissolved oxygen concentrations in the receiving waters.

103.42 Mixing Requirements

The dechlorination reaction with free or combined chlorine will generally occur within 15 to 20 seconds. The dechlorination chemical should be introduced at a point in the process where the hydraulic turbulence is adequate to assure thorough and complete mixing. If no such point exists, mechanical mixing must be provided. The high solubility of SO_2 prevents it from escaping during turbulence.

103.43 Contact Time

A minimum of 30 seconds for mixing and contact time must be provided at the design peak hourly flow or maximum rate of pumpage. A suitable sampling point must be provided downstream of the contact zone. Consideration must be given to a means of reaeration to assure maintenance of an acceptable dissolved oxygen concentration in the stream following sulfonation.

103.44 Standby Equipment and Spare Parts

The same requirements apply as for chlorination systems. See Section 102.46 (Standby Equipment and Spare Parts).

103.45 Sulfonator Water Supply

The same requirements apply as for chlorination systems. See Section 102.47 (Chlorinator Water Supply).

103.5 Housing Requirements

103.51 Feed and Storage Rooms

The requirements for housing SO_2 gas equipment must follow the same guidelines as used for chlorine gas. Refer to Section 102.5 (Housing) for specific details.

When using solutions of the dechlorinating compounds, the solutions may be stored in a room that meets the safety and handling requirements set forth in Section 57 (Safety). The mixing, storage, and solution delivery areas must be designed to contain or route solution spillage or leakage away from traffic areas to an appropriate containment unit.

103.52 Protective and Respiratory Gear

The respiratory air-pac protection equipment is the same as for chlorine. See Section 102.56 (Protective and Respiratory Gear). Leak repair kits of the type used for chlorine gas that are equipped with gasket material suitable for service with sulfur dioxide gas may be used. (Refer to The Compressed Gas Association Publication CGA G-3-1995, "Sulfur Dioxide.") For additional safety considerations, see Section 57 (Safety).

103.6 Sampling and Control

103.61 Sampling

Facilities must be included for sampling the dechlorinated effluent for residual chlorine. Provisions must be made to monitor for dissolved oxygen concentration after sulfonation when required by the regulatory agency.

103.62 Testing and Control

Provision must be made for manual or automatic control of sulfonator feed rates based on chlorine residual measurement or flow.

104. ULTRAVIOLET RADIATION DISINFECTION

104.1 General

The effectiveness of an ultraviolet (UV) disinfection system depends on characteristics of the wastewater (i.e., clarity), the intensity of UV radiation, the amount of time the microorganisms are exposed to the radiation, and the reactor configuration. The requirements of this section apply to both open channel and closed vessel UV systems.

104.2 Design Considerations Wastewater

104.21 Characteristics

Whenever possible, a representative wastewater sample must be collected and sent to the UV manufacturer for chemical analysis and design considerations.

For all UV systems, the wastewater should contain low levels of total suspended solids, preferably 30 milligrams per liter or below and the effluent should have at least 65 percent ultraviolet radiation transmittance at 254 nanometers. In addition, iron, calcium, aluminum, manganese and magnesium should be evaluated due to their tendency for fouling quartz sleeves.

104.22 Hydraulics

The UV system must be designed to effectively treat the expected minimum, average, and maximum effluent flows. The Department may require a hydraulic analysis to justify maximum effluent flows.

Inlet and outlet structures for the UV system must be designed to achieve relatively uniform flow velocities for all flows. A minimum of 5 feet (1.5 m) should be provided between inlet/outlet structures and the closest lamp array in open channel systems to help achieve uniform flow.

Optimum plug flow characteristics in open channels will be considered to be a depth:width ratio of 1:1. A positive means of water level control in each channel must be provided to achieve the necessary exposure time.

“Flow-pacing” and/or “dose-pacing” including the ability to turn lamps on or off in relation to flow and/or light dimming capabilities to respond to changes in flow or UV transmittance should be considered.

104.23 Installation and Maintenance

Adequate space must be provided around the UV units to accommodate maintenance activities. Building layout must provide adequate floor space for separate components of the UV system including requirements for power supply cabinets and cleaning equipment.

Multiple units must be provided to allow uninterrupted service due to equipment failure or maintenance activities. Wastewater systems that can store and not discharge for a reasonable period of time (e.g., one week) will not be required to have multiple units, but must be equipped with a means to stop the discharge upon unit failure.

Accessory cleaning equipment, generally in the form of chemical cleaning, mechanical wipers or ultrasonics must be provided. The system must be able to continue providing adequate disinfection during replacement of UV lamps, quartz sleeves, ballasts and cleaning of the UV lamp sleeves. Closed vessel and open channel units must be equipped with drains for maintenance activities. A closed vessel system should be installed in a “trap” in order to make sure the UV lamps are always submerged.

104.24 System Sizing

As a general guide in system sizing for an activated sludge effluent (BOD and TSS < 30 mg/L), a UV radiation dosage not less than 30,000 $\mu Wsec/cm^2$ may be used after adjustments for maximum tube fouling, lamp output reduction after 8760 hours of operation, and other energy absorption losses.

104.25 Electrical

Electrical standards must conform to the National Electrical Code and State of Montana and all local applicable codes and standards.

For emergency power requirements see Section 56.1 (Emergency Power Facilities). An exception to this requirement would be a wastewater system that can store and not discharge during a power outage. These facilities must be equipped with a means to stop the discharge automatically upon power loss.

Systems must be equipped with safety interlocks that shut off operating modules if they are moved out of their position or the water level drops below a specified point. Ground fault interruption circuitry must be provided with each operating module. An alarm system shall be provided to separately indicate lamp failure and low UV intensity.

Adequate ventilation of the structure housing the electrical components of the system must be provided to prevent failures from overheating.

104.26 Spare Parts

Spare parts that are subject to wear and breakage (e.g., bulbs, sleeves, etc.) must be provided. A complete standby UV unit must be provided when redundant units are not installed.

105. OZONE

Ozone systems for disinfection will be evaluated on a case-by-case basis. Design standards, operating data, and experience for this process are not well established. Therefore, design of these systems should be based upon experience at similar full scale installations or thoroughly documented prototype testing with the particular wastewater.

CHAPTER 110

SUPPLEMENTAL TREATMENT PROCESSES

111. CLARIFICATION PROCESSES

111.1 General

111.11 Method

Addition of lime or the salts of aluminum or iron may be used for the chemical removal of soluble phosphorus and other suspended particulate. The phosphorus and other suspended particulate react, or bind, with the calcium, aluminum, or iron ions to form insoluble compounds. Insoluble compounds may require the use of an additional coagulant aid to facilitate separation by sedimentation, or sedimentation followed by filtration.

111.12 Design Basis

111.121 Preliminary Testing

Laboratory, pilot or full scale studies of various chemical feed systems and treatment processes are recommended for existing plant facilities to determine the achievable performance level, cost-effective design criteria and ranges of required chemical dosages.

The selection of a treatment process and chemical dosage for a new facility should be based on such factors as influent wastewater characteristics, effluent requirements, and anticipated treatment efficiency.

111.122 System Flexibility

Systems must be designed with sufficient flexibility to allow for several operational adjustments in chemical feed location, chemical feed rates, and for feeding alternate chemical compounds.

111.123 Feed Water Characterization

Clarification processes must be capable of functioning efficiently and reliably at all anticipated loading rates and for all different types of solids that need to be removed.

The design engineer must define the water and solids characteristics for the entire range of possible feed water conditions. Seasonal changes in water temperature, solids loading, and water chemistry (pH, alkalinity, hardness, conductivity, etc.) can have a significant effect on clarification and filter performance. Solids characteristics such as floc size and strength may also change seasonally and should be defined during design. Water and solids characteristics (rate, concentration, composition, etc.) of the flow stream should be defined on a monthly basis (or at a minimum seasonally) and peak loading conditions must be established.

Other feed water characteristics that may be detrimental to specific clarification processes or filter media must be identified. Chemicals, inorganic precipitates, or particles (for example ozone, calcium carbonate, or clay, respectively) may damage or clog certain media and should be identified and considered in filter media selection. Industrial inputs to wastewater may have specific characteristics (such as chemical reactions with filter aids) that pose problems for filtration systems and must be considered.

111.2 Process Requirements

111.21 Dosage

The design chemical dosage must include the amount needed to react with the phosphorus, or other suspended particulate, in the wastewater, the amount required to drive the chemical reaction to the desired state of completion and the amount required due to inefficiencies in mixing or dispersion. Excessive chemical dosage should be avoided.

111.211 Coagulation design must include the following:

a. Provisions for multiple coagulants with separate injection points for each coagulant.

b. Provisions for chemical pH control.

c. Identification of the injection point for caustic soda or lime upstream of the coagulant addition.

d. Contact/mixing times and the order of introduction where multiple chemicals are proposed.

111.212 Coagulation occurs either by:

a. Charge Neutralization

Charge neutralization typically:

- Works at low chemical dosages producing small, destabilized pinpoint floc.
- Is ideal for treating low turbidity, low alkalinity effluent.
- Is followed by direct filtration or in-line filtration.

The design must disperse the chemical quickly and use rapid, high intensity mixing.

Charge neutralization depends on the water chemistry, type of coagulant, water temperature, particles size and concentration in the water. With alum, charge neutralization typically occurs in a pH range of 3 to 5 standard units and chemical dosages less than 20 mg/L.

For very low turbidity water, organic polymers are not effective as primary coagulants and must not be used. Although coagulation by organic polymers occurs by charge neutralization, chemical reactions are slower (between 2 and 10 seconds) than with inorganic salts and is dependent upon water temperature and alkalinity. Successful use of organic polymers as the primary coagulant may require conventional filtration or extended contact time for the flocculation.

b. Sweep Coagulation

For sweep coagulation, design must provide for sufficiently high coagulant concentrations to cause precipitation of a metal hydroxide. Since reactions take between 1 and 10 seconds, instantaneous chemical dispersion and high intensity mixing are not as critical for this type of coagulation.

Sweep coagulation is typically:

- Suitable for treating low or high turbidity, high alkalinity waters.
- Followed by conventional filtration process trains.

For alum, sweep coagulation occurs with chemical dosages > 20mg/L and a pH range of 6 to 9 standard units.

Table 111-1 lists the most common coagulants and representative dosing rates for sweep coagulation.

Table 111-1 Typical Coagulant Dosing Rate for Sweep Coagulation

Coagulant	Typical Dosing Rate (ppm) *
Alum	30 to 150
Poly-aluminum chloride (PaCl)	15 to 75
Ferric Chloride	15 to 75
Polymers	0.05 to 2

* Jar testing should be used and may be required to justify the coagulation/flocculation design if unique conditions or design approaches are proposed.

111.22 Chemical Selection

The choice of lime or the salts of aluminum or iron should be based on the wastewater characteristics, jar or pilot testing, chemical availability and handling, sludge processing and disposal methods and the economics of the total system. When lime is used, it may be necessary to neutralize the high pH prior to subsequent treatment in secondary biological systems or prior to discharge in those flow schemes where lime treatment is the final step in the treatment process.

111.23 Chemical Feed Points

Selection of chemical feed points must include consideration of the chemicals used in the process, necessary reaction times between chemical and polyelectrolyte additions, and the wastewater treatment processes and components utilized. Flexibility in feed locations must be provided to optimize chemical usage and treatment efficiency.

111.24 Chemical Mixing

Each chemical must be mixed rapidly and uniformly with the flow stream. Where separate mixing basins are provided, they should be equipped with mechanical mixing devices.

Proper chemical mixing (also called flash or rapid mixing) is fundamental to satisfactory coagulation. Designers should provide justification (which may include pilot test results) when recommending other types of mixing devices.

Designs must use hydraulic detention time at peak hour flow as the controlling design criteria for rapid mixing units. Hydraulic detention time is typically 1.0 second with a range of 0.5-5 seconds.

111.241 Mechanical Mixing

Mechanical rapid mixing units are effective for the addition of coagulants prior to flocculation. Design criteria include the following:

- Average rapid mix detention periods not exceeding 30 seconds.
- A spare motor when only a single mechanical mixer is used.
- Cleaning and draining of the rapid mix basin.

Applied mixing energy should generally achieve an average velocity gradient (G) value in the range of 1500/sec to 6000/sec for rapid mixing prior to flocculation. The design engineer must submit the design basis for the G selected, considering the chemicals, water temperature, color and other related parameters. The velocity gradient (G) can be determined using the following equation:

$$G = \sqrt{\frac{P}{\mu V}}$$ **(Equation 110-1)**

Where

G = velocity gradient
P = power input
μ = dynamic viscosity
V = effective volume

1. Effective volume (V) indicates the contact time provided in the process. This is not the physical dimensions of the vessel. Effective volume depends on tank inlet and outlet locations and conditions, internal baffling, and the type of mixing.
   (a) Rectangular, unbaffled contact tanks often provide effective volumes of 10 percent to 15 percent of the physical volume.
   (b) The effective volume, often identified as a baffling factor, is expressed as a proportion [i.e., 0.1 to 1.0] or hydraulic efficiency of the tank expressed as a percentage of the physical volume [i.e., 10 percent to 100 percent (for plug flow conditions)].
2. The dynamic viscosity (μ) varies with temperature and calculations must address the expected range.

111.242 In-line Static Mixers
Static in-line mixers use a circuitous path through fixed blades or chambers to achieve rapid mixing. Dynamic in-line mixers use powered impellers. Mixing generally occurs within 1 second. Use manufacturer's recommendations and/or studies for static mixer design. Provide for servicing or removing in-line mixer components without excavation.

111.25 Flocculation

The particle size of the precipitate formed by chemical treatment may be very small. Consideration should be given in the process design to the addition of polymeric flocculant aid to improve settling. The flocculation equipment should be adjustable in order to obtain optimum floc growth, control deposition of solids, and prevent floc destruction.

Polymeric flocculant aids may improve floc size, density and settling rates. Floc particles can remain fragile and mixing shear force can break them easily. For this reason, flocculation requires adequate detention time (t) at low velocity gradients (G), making Gt the basic design parameter.

Flocculation basin design must include baffling to minimize short-circuiting. Design values for flocculation basins should include:

- Hydraulic detention time (t) of 20 minutes with a range from 10-30 minutes.
- Velocity gradient (G) of 40/sec with a range from 20/sec to 100/sec.

- Typical mixing energy-detention time (Gt) of 50,000 with a range of 20,000 to 150,000.

111.26 Liquid - Solids Separation

The velocity through pipes or conduits from flocculation basins to settling basins should not exceed 1.5 feet per second (0.46 m/s) in order to minimize floc destruction. Entrance works to settling basins should also be designed to minimize floc shear.

When clarifier type settling basins are used, they must be designed in accordance with Chapter 70 (Settling). For design of the sludge handling system, special consideration should be given to the type and volume of sludge generated in the solids removal process.

For additional clarification processes see Circular DEQ 1 Section 4.1.4 (Sedimentation), Section 4.1.5 (Solids Contact Units), Section 4.1.6 (Tube or Plate Settlers), or Section 4.1.7 (High Rate Clarification Processes) for applicable design requirements. The Department will review and approve other clarification approaches on a case-by-case basis and may require on-site pilot studies and/or full-scale demonstrations. For full-scale demonstrations, a minimum of 3 years of performance data must be submitted from facilities with similar wastewater characteristics and operating conditions.

111.27 Filtration

Filtration may be required to achieve phosphorus concentrations of less than 1 mg/L, or to reach low concentrations of some minerals and metals in the final effluent. See Section 112 (High Rate Effluent Filtration), or Section 97 (Membrane Bioreactor (MBR)) for filtration equipment to meet these objectives.

When human exposure to the effluent is a concern, such as when reclaimed wastewater reuse is proposed, the design for filtration must meet the criteria presented within Circular DEQ 1 Section 4.2 (Filtration), or DEQ 2 Section 97 (Membrane Bioreactor (MBR)).

The Department will review alternative filtration approaches on a case-by-case basis and may require on-site pilot studies prior to final approval. Successful use of alternative filtration devices in other States with equivalent filtration standards may be used by the applicant to justify alternative filtration approaches. A minimum of 3 years of performance data supporting these alternative approaches will need to be submitted for facilities with similar filter influent wastewater characteristics.

Filtered wastewater facility design must include provisions for coagulant addition after secondary clarification where high rate media filters are used. In general, coagulants are necessary after secondary clarification when the filter influent turbidity exceeds 5 NTU for more than 15 minutes.

111.3 Feed Systems

111.31 Location

All liquid chemical mixing and feed installations should be installed on corrosion resistant pedestals and elevated above the highest liquid level anticipated during emergency conditions. The chemical feed equipment must be designed to meet the maximum dosage requirements for the design conditions. Lime feed equipment should be located so as to minimize the length of slurry conduits. All slurry conduits must be accessible for cleaning.

111.32 Liquid Chemical Feed System

Liquid chemical feed pumps should be of the positive displacement type with variable feed rate. Pumps must be selected to feed the full range of chemical quantities required for the phosphorus mass loading conditions anticipated with the largest unit out of service. Consideration should be given to systems including pumps and piping that will feed either ferric or aluminum compounds to provide flexibility. Refer to Section 111.51 (Materials).

Screens and valves must be provided on the chemical feed pump suction lines.

An air break or anti-siphon device must be provided where the chemical solution stream discharges to the transport water stream to prevent an induction effect resulting in overfeed.

Consideration must be given to providing pacing equipment to optimize chemical feed rates.

111.33 Dry Chemical Feed System

Volumetric or gravimetric feeders must be used to facilitate automated dry chemical feed to the mixing tank. The equipment must be chemically compatible with the chemicals to be used. Each dry chemical feeder must be equipped with a dissolver that is capable of providing a minimum of 5 minutes retention at the maximum feed rate. Dissolved solutions must be continuously mixed to prevent settling within the mixing tank and to maintain a uniform strength of solution.

Polyelectrolyte feed installations should be equipped with two solution vessels and transfer piping for solution make-up and daily operation.

Make-up tanks must be provided with an educator funnel or other appropriate arrangement for wetting the polymer during the preparation of the stock feed solution. Adequate mixing should be provided by a large-diameter, low-speed mixer.

111.4 Storage Facilities

111.41 Size

Storage facilities must be sufficient to insure that an adequate supply of the chemical is available at all times. Exact size required will depend on size of shipment, length of delivery time, and process requirements. Storage for a minimum supply of 10 days should be provided.

111.42 Location and Containment

The liquid chemical storage tank and tank fill connections must be located within a containment structure having a capacity exceeding the total volume of all storage vessels. Valves on discharge lines must be located adjacent to the storage tank and within the containment structure. Refer to Section 57.2 (Hazardous Chemical Handling).

Auxiliary facilities, including pumps and controls, within the containment area must be located above the highest anticipated liquid level. Containment areas must be sloped to a sump area and may not contain floor drains.

Bag storage should be located near the solution make-up point to avoid unnecessary transportation and housekeeping problems.

111.43 Accessories

Platforms, stairs, and railings should be provided as necessary, to afford convenient and safe access to all filling connections, storage tank entries, and measuring devices.

Storage tanks must have reasonable access provided to facilitate cleaning.

111.5 Other Requirements

111.51 Materials

All chemical feed equipment and storage facilities must be constructed of materials resistant to chemical attack by all chemicals normally used for phosphorus removal. Refer to Section 57 (Safety).

111.52 Temperature, Humidity, and Dust Control

Precautions must be taken to prevent chemical storage tanks and feed lines from reaching temperatures likely to result in freezing or chemical crystallization at the concentration employed. A heated enclosure or insulation may be required. Consideration should be given to temperature, humidity, and dust control in all chemical feed room areas.

111.53 Cleaning

Consideration must be given to the accessibility of piping. Piping should be installed with plugged wyes, tees or crosses with removable plugs at changes in direction to facilitate cleaning.

111.54 Filling Drains and Draw-off

Above-bottom draw off from chemical storage or feed tanks must be provided to avoid withdrawal of settled solids into the feed system. A bottom drain must also be installed for periodic removal of accumulated settled solids. Provisions must be made in the fill lines to prevent back siphonage of chemical tank contents.

111.6 Safety and Hazardous Chemical Handling

The chemical handling facilities must meet the appropriate safety and hazardous handling facilities requirements of Section 57 (Safety).

111.7 Sludge Handling

Consideration must be given to the type and additional capacity of the sludge handling facilities needed when chemicals are added. Design of dewatering systems should be based, where possible, on an analysis of the characteristics of the sludge to be handled. Consideration should be given to the ease of operation, effect of recycle streams generated, production rate, moisture content, dewaterability, final disposal, and operating costs. Refer to Chapter 80 (Sludge Processing, Storage and Disposal).

112. HIGH RATE EFFLUENT FILTRATION

112.1 General

112.11 Applicability

Granular media filters may be used as an advanced treatment device for the removal of residual suspended solids from secondary effluents. Filters may be necessary where effluent concentrations of less than 20 mg/L of suspended solids and/or 1.0 mg/L of phosphorus must be achieved. A pretreatment process such as chemical coagulation and sedimentation or other acceptable process should precede the filter units where effluent suspended solids requirements are less than 10 mg/L.

112.12 Design Considerations

Care should be given in designing pipes or conduits ahead of filter units, if applicable, to minimize shearing of floc particles. Consideration should be given in the plant design to providing flow-equalization facilities to moderate filter influent quality and quantity.

112.2 Filter Types

Filters may be of the gravity type or pressure type. Pressure filters must be provided with ready and convenient access to the media for inspection or cleaning. Where abnormal quantities of greases or similar solids that result in filter plugging are expected, filters should be of the gravity type.

112.3 Filtration Rates

112.31 Allowable Rates

Filtration rates may not exceed 5 gpm/sq. ft. (3.40 L/m^2s) based on the design peak hourly flow rate applied to the filter units. The expected design maximum suspended solids loading to the filter should also be considered in determining the necessary filter area.

112.32 Number of Units

Total filter area must be provided in two or more units, and the filtration rate must be calculated based on the total available filter area with one unit out of service.

112.4 Backwash

112.41 Backwash Rate

The backwash rate must be adequate to fluidize and expand each media layer a minimum of 20 percent based on the media selected. The backwash system must be capable of providing variable backwash rates. Minimum and maximum backwash rates must be based on demonstrated satisfactory field experience under similar conditions. The design must provide for a backwash period of at least 10 minutes.

112.42 Backwash Pumps

Pumps for back-washing filter units must be sized and interconnected to provide the required backwash rate to any filter with the largest pump out of service. Filtered water from the clear well or chlorine tank must be used as the source of backwash water. Provisions must be made to adequately treat and/or dewater the waste filter backwash.

112.43 Backwash Surge Control

The rate of return of waste filter backwash water to treatment units must be controlled so that the rate does not exceed 15 percent of the design average daily flow rate to the treatment unit. The hydraulic and organic load from waste backwash water must be considered in the overall design of the treatment plant. Surge tanks must have a capacity of at least two backwash volumes, although additional capacity should be considered to allow for operational flexibility. Where waste backwash water is returned for treatment by pumping, adequate pumping capacity must be provided with the largest unit out of service.

112.44 Backwash Water Storage

Total backwash water storage capacity provided in an effluent clearwell or other unit must equal or exceed the volume required for two complete backwash cycles.

112.5 Filter Media Selection

Selection of proper media type and size will depend on required effluent quality, the type of treatment provided prior to filtration, the filtration rate selected, and filter configuration. In dual or multi-media filters, media size selection must consider compatibility among media. Media must be selected and provided to meet specific conditions and requirements relative to the project under consideration. The selection and sizing of the media must be based on demonstrated satisfactory field experience under similar conditions. All media must have a uniformity coefficient of 1.7 or less. The uniformity coefficient, effective size, depth, and type of media must be set forth in the specifications.

112.6 Filter Appurtenances

The filters must be equipped with wash-water troughs, surface wash or air scouring equipment, means of measurement and positive control of the backwash rate, equipment for measuring filter head loss, positive means of shutting off flow to a filter being backwashed, and filter influent and effluent sampling points. If automatic controls are provided, there must be a manual override for operating equipment, including each individual valve essential to the filter operation. The underdrain system must be designed for uniform distribution of backwash water (and air, if provided) without danger of clogging from solids in the backwash water.

If air is to be used for filter backwash, separate backwash blower(s) must be provided. Provision must be made to allow periodic chlorination of the filter influent or backwash water to control slime growths. When chemical disinfection is not provided at the plant, manual dosage of chlorine compounds is acceptable.

112.7 Access and Housing

Each filter unit must be designed and installed so that there is ready and convenient access to all components and the media surface for inspection and maintenance without taking other units out of service.

Housing for filter units must be provided. The housing must be constructed of suitable corrosion-resistant materials. All controls must be enclosed and the structure housing filter, controls and equipment must be provided with adequate heat and ventilation equipment to minimize problems with excess humidity.

112.8 Proprietary Equipment

Where proprietary filtration equipment not conforming to the preceding requirements is proposed, data which supports the capability of the equipment to meet effluent requirements under design conditions must be provided. Such equipment will be reviewed on a case-by-case basis at the discretion of the regulatory agency. Refer to Section 53.2 (Engineering and Performance Requirements for Innovative Wastewater Treatment Alternatives).

CHAPTER 120

IRRIGATION AND RAPID INFILTRATION SYSTEMS

121. STANDARDS FOR THE USE OF RECLAIMED WASTEWATER FOR IRRIGATION

121.1 General

Irrigation, as discussed in this chapter; involves the controlled application of treated effluent (reclaimed wastewater) from public sewage systems to harvestable crops in a beneficial manner. The use of an irrigation system for effluent disposal requires that any industrial component of the wastewater be relatively small, with the discharge of toxic substances regulated by an effective treatment program. If significant industrial users discharge to the system, additional requirements may be imposed by the Department.

The intention and purpose of the standards and methods described in this chapter are for complete crop uptake of nutrients with no impact to groundwater and to prevent impacts to surface water from runoff. A Montana Ground Water Pollution Control System (MGWPCS) discharge permit from the Department will be required when the effluent does not meet the standards for class A-1 or class B-1 reclaimed wastewater (see Appendix B) and the system is designed or operated in a manner that applies wastewater effluent at rates greater than agronomic uptake rates.

The Department may require a groundwater monitoring and testing program for compliance determinations at an approved irrigation site. The level of monitoring and testing will be determined by the Department during the plan review and approval process.

Reclaimed wastewater mains must be installed in a manner that protects potable water mains from contamination, and which protects the water quality of the reclaimed wastewater from sewer mains. See DEQ- 2, Section 38 (Protection of Water Supplies) and DEQ- 1, Section 8.8 (Separation of Water Mains, Sanitary Sewers and Storm Sewers) for separation requirements.

Prior to receiving Department approval for a reclaimed wastewater project, the applicant must provide a copy of the Department of Natural Resources and Conservation's (DNRC) approved change of appropriation or water right, or a written statement from DNRC that no authorization is needed under Title 85, Water Use. An approval from the DNRC regarding water rights must be obtained prior to approval of plans and specifications by the Department.

121.2 Definitions

a. Agronomic Rate

Controlled application of treated effluent (reclaimed wastewater) from public sewage treatment facilities to crops in a manner such that all nutrients are utilized by the crop and no impact to groundwater or surface water occurs.

b. Irrigation Site

A Department approved site with well defined boundaries, designated to receive reclaimed wastewater for an approved irrigation use, in conformance with laws and regulations of all applicable regulatory agencies.

c. Coagulated Wastewater

Coagulated wastewater is oxidized wastewater in which colloidal and finely divided suspended matter have been destabilized and agglomerated by the addition of suitable floc-forming chemicals or by an equally effective method.

d. Disinfected Wastewater

Disinfected wastewater is wastewater in which most microorganisms have been inactivated, or otherwise rendered non-virulent.

e. Filtered Wastewater

Filtered wastewater is an oxidized, clarified wastewater which has been passed through filter media, such as sand or diatomaceous earth, anthracite, approved cartridges, or membranes so that the turbidity as determined by an approved laboratory method does not exceed an average operating turbidity of 2 nephelometric turbity units (NTU) and does not exceed 5 NTU at any time.

f. Food Crops

Food crops are any crops intended for human consumption.

g. Nutrient Management Plan

Nutrient management plan (NMP) is a written plan that establishes the operation, maintenance and sampling steps necessary to prevent the over-application of nutrients (primarily nitrogen and phosphorus) at an approved irrigation site. The strategy of the NMP is to prevent inadvertent runoff of nutrients to surface water or discharge to groundwater in quantities that could lead to degradation or impairment.

h. Oxidized Wastewater

Oxidized wastewater is wastewater in which the organic matter has been stabilized, is non-putrescible, and contains dissolved oxygen. This level of treatment is comparable to that from facilities producing secondary effluent. For wastewater treatment pond systems see Section 93.36 (Pond Design Criteria) for treatment requirements.

i. Reclaimed Wastewater

Means wastewater treated by a public sewage system for reuse for private, public, or commercial purposes. Wastewater must be treated to the standards in Table 121-1 or Table B-1 and used in accordance with Table 121-2 and Table B-2.

j. Reuse

The practice of placing reclaimed wastewater into service in a manner appropriate with the level of treatment.

k. Irrigation

Irrigation means a conservative land application process using reclaimed wastewater**,** where the primary use of the reclaimed wastewater is for crop growth. This conservative process utilizes the nutrient uptake and evapotranspiration mechanisms of plants and soil surfaces to prevent or minimize discharge to groundwater.

l. Supplemental Irrigation Water

Is water used in addition to reclaimed wastewater in order to sustain a crop or optimize crop growth.

121.3 Classes and Standards for Reclaimed Wastewater

This section addresses four classes of reclaimed wastewater that are required for various irrigation uses. These four classes are differentiated by the degree of additional treatment provided following secondary treatment, which is defined in 40 CFR Part 133**.** The treatment standards defined for each class must be met prior to delivery to the reuse system. The four reclaimed wastewater classes and additional treatment requirements are defined in Table 121-1.

Table 121-1
Reclaimed Wastewater Classifications and Associated Treatment Requirements

CLASS	TREATMENT STANDARDS
A	Class A reclaimed wastewater must, at all times, be oxidized, coagulated, filtered and disinfected, as described below or defined in this chapter. Following treatment, Class A reclaimed wastewater effluent quality should have 10 mg/L or less of BOD_5 and TSS. To achieve the turbidity requirements for Class A reclaimed wastewaters, a treatment process that incorporates coagulation, flocculation, sedimentation, and filtration is typically required. See Section 111 (Clarification Processes) for the required design standards. Class A reclaimed wastewater must be disinfected such that the median number of total coliform organisms in the wastewater after disinfection, does not exceed 2.2 colony forming units (CFU) per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed and such that the number of total coliform organisms does not exceed 23CFU per 100 milliliters in any sample. The minimum monitoring level required during periods of use (including prior to seasonal startup) must include: continuous turbidity analysis with recorder, weekly total coliform analysis, and monthly total nitrogen analysis. Weekly disinfectant residual analysis if chemical disinfection is being utilized.*
B	Class B reclaimed wastewater must, at all times, be oxidized, settled and disinfected, as described below or defined in this chapter. Class B reclaimed wastewater must be disinfected such that the median number of total coliform organisms in the effluent does not exceed 2.2 colony forming units (CFU) per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform organisms does not exceed 23 CFU per 100 milliliters in any sample. The minimum monitoring level required during periods of use (including prior to seasonal startup) must include: weekly total coliform analysis and monthly total nitrogen analysis. Weekly disinfectant residual analysis if chemical disinfection is being utilized.*
C	Class C reclaimed wastewater must, at all times, be oxidized, settled and disinfected, as described below or defined in this chapter. Class C reclaimed wastewater must be disinfected such that the median number of total coliform organisms in the effluent does not exceed 23 colony forming units (CFU) per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform organisms does not exceed 240 CFU per 100 milliliters in any sample. The minimum monitoring level required during periods of use (including prior to seasonal startup) must include: monthly total coliform and monthly total nitrogen analysis. Weekly disinfectant residual analysis if chemical disinfection is being utilized.*

Table 121-1 Reclaimed Wastewater Classifications and Associated Treatment Requirements	
CLASS	**TREATMENT STANDARDS**
D	Class D reclaimed wastewater must, at all times, be oxidized and settled, as described below or defined in this chapter. Disinfection will generally not be required for Class D reclaimed wastewater; however, proximity to areas of public access or habitation may dictate that disinfection be provided in order to protect public health. The minimum monitoring level required during periods of use (including prior to seasonal startup) must include: monthly total nitrogen analysis. *

* The Department, where appropriate to protect public health and ensure water quality protection, may require additional sampling and/or annual or quarterly reporting. If industrial sources are contributors to the treated public sewage being proposed for reuse, monitoring for the various metals and contaminants described in Table 121-4 may be required annually. If the industrial source qualifies under the Federal Clean Water Act, Title 40, Chapter I, Part 401-403, a pretreatment program must be implemented before reuse of the effluent can be allowed by the Department.

121.4 Use of Reclaimed Wastewater

Reclaimed wastewater can be used for any of the allowable uses identified in Appendix B. This chapter, however, focuses on the use of reclaimed wastewater for irrigation at or below agronomic rates only. Direct contact of reclaimed wastewater on food crops that will be consumed raw is not allowed. Examples of reclaimed wastewater for various irrigation uses and associated classifications are displayed in Table 121-2.

Table 121-2 Allowable Irrigation Uses of Reclaimed Wastewater and Associated Classes				
Allowable Irrigation Uses of Reclaimed Wastewater	Class of Reclaimed Wastewater Required for Identified Irrigation Use			
	A	B	C	D
Spray Irrigation of Nonfood Crops				
Trees and Fodder, Fiber, and Seed Crops	YES	YES	YES	YES
Sod, Ornamental Plants for Commercial Use, and Pasture to Which Milking Cows or Goats Have Access	YES	YES	YES	NO
Drip or Subsurface Irrigation of Nonfood Crops				
Trees	YES	YES	YES	YES
Spray Irrigation of Food Crops				
Food Crops Which Undergo Physical or Chemical Processing Sufficient to Destroy All Pathogenic Agents	YES	YES	YES	NO
Drip or Subsurface Irrigation of Food Crops				
Food Crops Where There is No Reclaimed wastewater Contact With Edible Portion of Crop (e.g. orchards, vineyards)	YES	YES	NO	NO
Root Crops	YES	NO	NO	NO
Landscape Irrigation				
Restricted Access Areas (e.g., Cemeteries and Freeway Landscapes)	YES	YES	YES	NO
Unrestricted Access Areas (e.g., Golf Courses, Parks, Playgrounds, School Yards and Residential Landscapes	YES	NO	NO	NO

121.5 Buffer Zone

Table 121-3 indicates the buffer zone requirements for each class of reclaimed wastewater. The buffer zone must be maintained between the fencing and the irrigated land. No dwelling, residential property, or areas with public access are allowed within the buffer zone. Where the buffer zone is not owned by the party irrigating, an easement must be obtained prohibiting construction of any dwelling or access road within the buffer zone.

In all cases, the Department may require a wider buffer zone than listed in Table 121-3, if necessary to protect public health.

Cultivation of trees and shrubs to serve as a screen around the spray field is encouraged.

Table 121-3 Buffer Zone Requirements	
Class	Buffer Zone Width (ft)
A	NA
B and C[1]	50
D	200

1. Class B reclaimed wastewater utilized for subsurface or drip irrigation do not require a buffer zone.

121.6 Spray Irrigation Equipment

The use of low trajectory nozzles is required on spray irrigation equipment to reduce airborne aerosols. Effluent may not be disposed of through the use of an end gun or big gun due to the high potential for aerosol drift.

Carryover of treated wastewater effluent outside the buffer zone is not allowed. The irrigation system must contain a wind sensor that will shut down the system during periods of high winds. In general, the maximum allowable wind velocity during operation is 25 mph; however, the Department may require a lower maximum limit

For grazing operations, the irrigation equipment (e.g., sprinklers, risers, pipes, monitoring wells, etc.) must be protected from damage caused by animals.

121.7 Setback Distance from Surface Waters and Wells

In all cases, the edge of the buffer zone must be at least 50 feet (15.2 m) from any water supply well.

The required distance from surface water will be determined by the Department on a case-by-case basis based on the quality of effluent and the level of disinfection. In no case can reclaimed wastewater be applied directly onto surface water. A buffer zone must not include any surface water bodies.

121.8 Access Control and Advisory Signs

Appropriate fencing and advisory signs, if required by the Department, must be placed along the site boundaries to designate the use of reclaimed wastewater at the application area.

121.81 Fencing

When fencing is required, pasture or approved similar fencing must be placed along the outer perimeter of the entire buffer zone of the irrigation site.

Fencing is required for all irrigation sites with the following exceptions: Class A reclaimed wastewater; Class B reclaimed wastewater utilized for subsurface or drip irrigation; and Class C reclaimed wastewater utilized in restricted public access areas or where off-hour irrigation is practiced.

121.82 Signing

For irrigation sites with fencing requirements, signs must be posted along the fence line every 250 feet (76.2 m) and at each corner. Signs should read “No Trespassing – Irrigated With Reclaimed Wastewater” or an approved equivalent.

All other irrigation sites must have signs posted along the perimeter of the application area, every 250 feet (76.2 m) and at each corner. Signs must be posted at conspicuous public access points. Signs should read “Irrigated With Reclaimed Wastewater – Do Not Drink” or an approved equivalent.

121.9 Control of Irrigation Site

When the irrigation site is not owned by the treatment facility, a 20-year lease or similar assurance must be negotiated in order to ensure control of irrigated land. Longer leases or purchasing of land is encouraged. A copy of the signed lease must be submitted to the Department for review and approval. A statement detailing responsibility of operation must be included in the lease agreement as outlined in Section 121.123 (Responsibility of Operation).

121.10 Effluent Monitoring

121.101 Flow

The capability to measure the amount of water applied to the irrigation site on a daily basis must be provided. This can be accomplished with either a flow meter device or through the use of pump run time (e.g., hour meters) and pump capacity.

121.102 Quality

Provisions must be made that will enable the water to be sampled prior to application. Testing may be required for both biochemical and bacteriological constituents.

121.11 Design Report

A design report must be submitted to the Department demonstrating conformity with the standards provided within this Section. The design report must address the following:

121.111 Trace Element and Chemical Quality Testing

When required by the Department, an assessment pertaining to trace element and chemical loading must be conducted on treated effluent. The recommended limits for constituents in reclaimed wastewater used for irrigation are listed in Table 121-4.

Table 121-4
Recommended Limits for Constituents in Reclaimed Wastewater for Irrigation[c]

Element	For use up to 20 years on fine-textured soils of pH 6.0 to 8.5, mg/L	For waters used continuously on all soil, mg/L
Aluminum	20.0	5.0
Arsenic	2.0	0.10
Beryllium	0.50	0.10
Boron	2.0-10.0	0.75
Cadmium	0.050	0.010
Chromium	1.0	0.10
Cobalt	5.0	0.050
Copper	5.0	0.20
Fluoride	15.0	1.0
Free Chlorine Residual	< 1mg/L	< 1mg/L
Iron	20.0	5.0
Lead	10.0	5.0
Lithium	2.5[a]	2.5[a]
Manganese	10.0	0.20
Molybdenum	0.050[b]	0.010
Nickel	2.0	0.20
Selenium	0.020	0.020
Vanadium	1.0	0.1
Zinc	10.0	2.0

[a] Recommended maximum concentration for irrigating citrus is 0.075 mg/L.

[b] For only acid fine-textured soils or acid soils with relatively high iron oxide contents.
[c] Source: "Guidelines for Water Reuse 2004" (EPA/625/R-04/108) published by the U.S. Environmental Protection Agency.

121.112 Groundwater and Soil Information

Groundwater, soil, and agronomic information specific to the irrigation site must be provided that addresses the following:

121.112.1 Maps/Sensitive Resource Areas

A site map, including a soil map of the irrigation site must be provided. The soil map must include soil survey geographic (SSURGO) mapping units or similar means of identification. The map unit name and symbol for all soil types at the irrigation site must be provided.

The site map must identify sensitive resource areas within 500 feet (152.4 m) of the application site (wetlands, surface water, wells, roads, buildings, property lines, etc.).

121.112.2 Soil Management, Monitoring, and Testing

When required by the Department, soil sampling adequate to define existing conditions throughout the irrigation site must be collected to characterize the existing soil conditions.

At the discretion of the Department, a composite soil sample for each major soil type within the irrigation site boundaries may need to be analyzed for total nitrogen, pH, organic matter, sodium adsorption ratio (SAR), phosphorus, potassium, and chloride. The composite sample must contain a minimum of one individual soil sample for every 3 acres of the proposed irrigation site. Field permeability must be verified for design purposes. Soil descriptions should be made by a qualified soil scientist.

121.112.3 Sodium Adsorption Ratio and Salinity Considerations

a. Sodium Adsorption Ratio (SAR)

When required by the Department, an analysis of the SAR must be conducted along with soil data (e.g., clay content) to determine if soil permeability will be negatively impacted. An SAR of 10 or less should be acceptable on soils with significant clay content (15 percent clay or greater). Soils with little clay or non-swelling clays can typically tolerate an SAR up to 20.

b. Salinity

When required by the Department, an analysis of the electrical conductivity (EC_I) or total dissolved solids (TDS) must be conducted on treated effluent to determine if plant growth will be negatively impacted

Potential impacts of salinity and SAR can be determined based upon information provided in Table 121-5. Design criteria must account for any mitigation requirements.

Table 121-5
Irrigation Water Quality Guidelines[1]

Potential irrigation water quality problem	Describing parameter	----- Degree of restriction on use -----		
		None	**Slight to moderate**	**Severe**
Salinity				
(affects crop water availability)	$\mathbf{EC_I}$[2], mmho/cm, dS/m	< 0.7	0.7 – 3.0	> 3.0
	or **TDS**[3], mg/L	< 450	450 – 2,000	> 2,000
Infiltration				
(affects infiltration rate of water into the soil based on EC_I and SAR together)[4]	**SAR**	$\mathbf{EC_I}$, mmho/cm, dS/m		
	0 – 3	> 0.7	0.7 – 0.2	< 0.2
	3 – 6	> 1.2	1.2 – 0.3	< 0.3
	6 – 12	> 1.9	1.9 – 0.5	< 0.5
	12 – 20	> 2.9	2.9 – 1.3	< 1.3
	20 – 40	> 5.0	5.0 – 2.9	< 2.9

(1) Adapted from University of California Committee of Consultants (1974); and Ayers and Westcot (1985).
(2) EC_I means electrical conductivity of the irrigation water reported in mmho/cm or dS/m at 77 ^{o}F (25 ^{o}C).
(3) TDS means total dissolved solids reported in mg/L.
(4) SAR means sodium adsorption ratio. At a given SAR, infiltration rate increases as water salinity increases.

$$SAR = \frac{[Na^{+}]}{\sqrt{\left(\frac{1}{2}\right)\left([Ca^{2+}]+[Mg^{2+}]\right)}}$$

121.112.4 Ground and Surface Water

The minimal depth to groundwater at the irrigation site must be at least 4 feet (1.2 m). The irrigation site should not be located within the 100-year floodplain.

121.112.5 Soil Water Holding Capacity

The moisture retention properties of the soil must be provided. This data can typically be found in the Soil Data Mart database located on the Montana Natural Resources Conservation Service website. To avoid runoff and/or direct discharge to groundwater, the application rate must not exceed the infiltration rate of the soil and a single application must not exceed one-half of the soil water holding capacity within the root zone. Table 121-6 presents effective rooting depth for some common crops.

Table 121-6
Typical Effective Rooting Depth of Plants[1]

Plant	Effective rooting depth, m (ft)	Plant	Effective rooting depth, m (ft)
Alfalfa	1.2-2.0 (4-6)	Lettuce	0.3-0.6 (1-2)
Avocado	0.6-1.0 (2-3)	Melons	0.6-1.0 (2-3)
Barley	1.0-1.5 (3-5)	Potatoes	0.6-1.0 (2-3)
Beans	0.3-1.0 (1-3)	Safflower	1.5-2.0 (5-6)
Citrus	0.6-1.5 (2-5)	Sorghum	1.0-1.5 (3-5)
Corn	1.0-1.5 (3-5)	Strawberries	0.3-0.6 (1-2)
Deciduous Orchard	1.2-2.0 (4-6)	Sugar beet	1.0-1.5 (3-5)
Grains, small	1.0-1.2 (3-4)	Tomatoes	1.0-1.5 (3-5)
Grapes	1.0-2.0 (3-6)	Turf grass	0.2-0.5 (0.5-1.5)
Grass	1.0-1.2 (3-4)		

1 Adapted from Burt C.M. (1995) The Surface Irrigation Manual. Waterman Industries, Inc.

121.113 Irrigation Application Analysis

Justification and calculations associated with the hydraulic and nitrogen loading rates must be provided. The methods, procedures, and considerations published herein must be employed in the design process for the irrigation of wastewater.

The loading rates analysis generally follows the recommended methods and procedures outlined in the "Process Design Manual for Land Treatment of Municipal Wastewater Effluents" (EPA 625/1-81-013) published by the U.S. Environmental Protection Agency.

Where crop rotation is implemented, the hydraulic and nitrogen loading rate analysis must be done for each crop considered.

121.113.1 Annual Hydraulic Loading Rate

The design maximum irrigation application rates must be calculated for each month using hydraulic loading rates based on soil permeability (L_P) and nitrogen loading (L_N). The corresponding monthly value for L_P and L_N must be compared, with the lower of the two values used for design. The monthly hydraulic loading rates must be summed to yield the annual hydraulic loading rate (L_H).

121.113.11 Soil Permeability Calculations

The hydraulic loading rate based on soil permeability (L_P) is determined as:

$$L_P = (ETc - P + P_w)/SE \qquad (120\text{-}1)$$

where, L_P = Hydraulic loading rate, in/month (cm/month)
ETc = Crop evapotranspiration, in/month (cm/month)
P = Precipitation, in/month (cm/month)
P_w = Percolation rate, in/month (cm/month)
SE = Distribution system efficiency, fraction (0.70 to 0.85 for sprinklers)

a. Evapotranspiration (ETc)

Crop evapotranspiration, or consumptive water use, must be based on average regional values for the selected crop(s). This data is typically provided by local or regional field offices of the United States Department of Agriculture Natural Resources Conservation Service (NRCS), local field offices of the Cooperative Extension Service, or similar.

b. Precipitation (P)

Precipitation must be based on a 10-year precipitation return period as determined using the Weibull formula or other applicable probability method of analysis, with Department approval. The Weibull analysis is given as:

$$m = (n + 1) / 10 \qquad (120\text{-}2)$$

Where: m = ranking
n = the number of years of record.

Climate data for Montana communities can be found at http://www.wrcc.dri.edu

c. Percolation Rate (P_w)

The percolation rate is a function of the limiting permeability or hydraulic conductivity in the soil profile, not to exceed 4 to 10 percent of the soil permeability. Percentages on the lower end of the scale must be used for variable or poorly defined soil conditions. In determining soil permeability, actual values based on hydraulic conductivity field measurements should be used. If the soil permeability is variable over the site, an average permeability based on areas of different soil types must be determined.

The monthly percolation rate must take into account non-operational periods. At a minimum, consideration must be given to system startup and shutdown, maintenance, cropping/harvesting practices, and adverse weather (e.g. excessive wind, freezing temperatures, excessive precipitation).

The drying/wetting ratio must be no less than 3 to 1; however, the Department may require a larger ratio.

121.113.12 Nitrogen Calculations

With the exception of Class A-1 and Class B-1 waters (see Appendix B), to be exempt from a MGWPCS permit, the irrigation system must be designed for 100 percent uptake of total nitrogen with zero contribution of nitrogen to groundwater.

The hydraulic loading based on nitrogen limits (L_N) is determined as:

$$L_N = (U \times C) / [C_n(1 - f)] \qquad (120\text{-}3)$$

where, L_N = Hydraulic loading, in/month (cm/month)
U = Crop uptake as a function of yield, lb/acre•month (kg/ha•month)
C = Conversion constant, 4.41 (10)
C_n = Applied total nitrogen concentration, mg/L
f = Nitrogen loss factor

a. Crop Nutrient Uptake (U)

Guidance on crop selection for sites irrigated with reclaimed wastewater should be obtained from a qualified scientist such as a representative from NRCS, Cooperative Extension Service, or similar.

Whenever possible, the nutrient uptake rate and specific yield expected from a site must be based on information available from the local or regional NRCS field offices or from local field offices of the Cooperative Extension Service.

In the absence of site specific data, Table 121-7 must be used in determination of an expected crop nutrient uptake rate and specific yield.

Monthly crop uptake (U) values can be estimated by assuming that annual crop uptake is distributed monthly according to the same ratio of average monthly Etc to the total annual Etc.

Table 121-7
Yield Based N, P, and K Uptake of Various Crops

Crop	Dry Weight lb/bu	Typical Yield/acre-yr Plant Part	Percent of Dry Harvested Material		
			N	P	K
Grain Crops					
Barley	48	50 bu	1.82	0.34	0.43
		1 ton straw	0.75	0.11	1.25
Buckwheat	48	30 bu	1.65	0.31	0.45
		0.5 tons straw	0.78	0.05	2.26
Corn	56	120 bu	1.61	0.28	0.40
		4.5 tons straw	1.11	0.20	1.34
Oats	32	80 bu	1.95	0.34	20.49
		2 tons straw	0.63	0.16	1.66
Rice Rye	45	5,500 lbs	1.39	0.24	0.23
		2.5 tons straw	0.60	0.09	1.16
Sorghum	56	30 bu	2.08	0.26	0.49
		1.5 tons straw	0.50	0.12	0.69
Wheat	56	60 bu	1.67	0.36	0.42
		3 tons straw	1.08	0.15	1.31
	60	40 bu	2.08	0.62	0.52
		1.5 tons straw	0.67	0.07	0.97
Oil Crops					
Flax	56	15 bu	4.09	0.55	0.84
		1.75 ton straw	1.24	0.11	1.75
Oil Palm	--	2,200 lbs	1.13	0.26	0.16
		5 tons fronds & stems	1.07	0.49	1.69
Peanuts	22-30	2,800 lbs	3.60	0.17	0.50
		2.2 tons vines	2.33	0.24	1.75
Rapeseed	50	35 bu	3.60	0.79	0.76
		3 tons straw	4.48	0.43	3.37
Soybeans	60	35 bu	6.25	0.64	1.90
		2 tons stover	2.25	0.22	1.04
Sunflower	25	1,100 lbs	3.57	1.71	1.11
		4 tons stover	1.50	0.18	2.92

Table 121-7 Yield Based N, P, and K Uptake of Various Crops					
Crop	Dry Weight lb/bu	Typical Yield/acre-yr Plant Part	Percent of Dry Harvested Material		
			N	P	K
Fiber Crops					
Cotton		600 lb Lint and			
		1,000 lb seeds,	2.67	0.85	0.83
		burs & stalks	1.75	0.22	1.45
Pulpwood		98 cords	0.12	0.02	0.06
		bark, branches	0.12	0.02	0.06
Forage Crops					
Alfalfa		4 tons	2.25	0.22	1.87
Bahiagrass		3 tons	1.27	0.13	1.73
Big bluestem		3 tons	0.99	0.85	1.75
Birdsfoot trefoil		3 tons	2.49	0.22	1.82
Bluegrass-pasted		2 tons	2.91	0.43	1.95
Bromegrass		5 tons	1.87	0.21	2.55
Clover-grass		6 tons	1.52	0.27	1.69
Dallisgrass		3 tons	1.92	0.20	1.72
Guineagrass		10 tons	1.25	0.44	1.89
Bermudagrass		8 tons	1.88	0.19	1.40
Indiangrass		3 tons	1.00	0.85	1.20
Lespedeza		3 tons	2.33	0.21	1.06
Little bluestem		3 tons	1.10	0.85	1.45
Orchardgrass		6 tons	1.47	0.20	2.16
Pangolagrass		10 tons	1.30	0.47	1.87
Paragrass		10.5 tons	0.82	0.39	1.59
Red clover		2.5 tons	2.00	0.22	1.66
Reed canarygrass		6.5 tons	1.35	0.18	
Ryegrass		5 tons	1.67	0.27	1.42
Switchgrass		3 tons	1.15	0.10	1.90
Tall fescue		3.5 tons	1.97	0.20	2.00
Timothy		2.5 tons	1.20	0.22	1.58
Wheatgrass		1 ton	1.42	0.27	2.68
Fruit Crops					
Apples		12 tons	0.13	0.02	0.16
Bananas		9,900 lbs	0.19	0.02	0.54
Cantaloupe		17,500 lbs	0.22	0.09	0.46
Grapes		12 tons	0.28	0.10	0.50
Oranges		54,000 lbs	0.20	0.02	0.21
Peaches		15 tons	0.12	0.03	0.19
Pineapple		17 tons	0.43	0.35	1.68
Tomatoes		22 tons	0.30	0.04	0.33
Silage Crops					
Alfalfa haylage (50%dm)		10 wet/ 5 dry	2.79	0.33	2.32
Corn silage (35%dm)		20 wet/ 7 dry	1.10	0.25	1.09
Forage sorghum (30%dm)		20 wet/ 6 dry	1.44	0.19	1.02
Oat haylage (40%dm)		10 wet/ 4 dry	1.60	0.28	0.94
Sorghum-sudan (50%dm)		10 wet/ 5 dry	1.36	0.16	1.45
Sugar Crops					
Sugarcane		37 tons	0.16	0.04	0.37
Sugar beets		20 tons	0.20	0.03	0.14
Tops			0.43	0.04	1.03
Turf Grass					

Table 121-7 Yield Based N, P, and K Uptake of Various Crops					
Crop	Dry Weight lb/bu	Typical Yield/acre-yr Plant Part	Percent of Dry Harvested Material		
			N	P	K
Bluegrass		2 tons	2.91	0.43	1.95
Bentgrass		2.5 tons	3.10	0.41	2.21
Bermudagrass		4 tons	1.88	0.19	1.40
Vegetable Crops					
Bell peppers		9 tons	0.40	0.12	0.49
Beans, dry		0.5 tons	3.13	0.45	0.86
Cabbage		20 tons	0.33	0.04	0.27
Carrots		13 tons	0.19	0.04	0.25
Cassava		7 tons	0.40	0.13	0.63
Celery		27 tons	0.17	0.09	0.45
Cucumbers		10 tons	0.20	0.07	0.33
Lettuce (heads)		14 tons	0.23	0.08	0.46
Onions		18 tons	0.30	0.06	0.22
Peas		1.5 tons	3.68	0.40	0.90
Potatoes		14.5 tons	0.33	0.06	0.52
Snap beans		3 tons	0.88	0.26	0.96
Sweet corn		5.5 tons	0.89	0.24	0.58
Sweet potatoes		7 tons	0.30	0.04	0.42
Table beets		15 tons	0.26	0.04	0.28

(1) Forest Crops

For forest crops, biomass production and nutrient uptake are relatively slow during the initial stages of growth (1 to 2 years) as tree seedlings are establishing a root system. To prevent leaching of nitrogen to groundwater during this period, nitrogen loading must be limited, or understory vegetation must be established that will take up and store applied nitrogen that is in excess of the tree crop needs.

In the absence of site specific data, Table 121-8 must be used in determination of an expected tree nutrient uptake rate. With respect to hybrid and other unique tree farms, data may need to be obtained from similar operations in other locations with similar climatic conditions.

Table 121-8 Nitrogen Uptake for Selected Forest Ecosystems with Whole Tree Harvesting		
	Tree Age, Years	Average Annual Nitrogen Uptake lb/(acre-year)
Western forests:		
Hybrid poplar[a]	4-5	270
Douglas fir plantation	15-25	200

a Short-term rotation with harvesting at 4 to 5 years; represents first-growth cycle from planted seedlings.

*lb/acre-yr = 1.12 kg/ha-yr.

The nitrogen stored within the biomass of trees is not uniformly distributed among the tree components, therefore the amount of nitrogen that can actually be removed from a forest crop system is dependent on the components of the tree that are harvested. Only in a whole-tree harvesting operation can 100 percent of the nitrogen uptake be assumed. The distributions of biomass and nitrogen for naturally growing hardwood and conifer (pines, Douglas-fir, fir, larch, etc.) stands in temperate regions are shown in Table 121-9.

Table 121-9
Biomass and Nitrogen Distributions by Tree Component for Stands in Temperate Regions

Tree Component	Conifers		Hardwoods	
	Biomass	Nitrogen	Biomass	Nitrogen
Roots	10%	17%	12%	18%
Trunks	80%	50%	65%	32%
Branches	8%	12%	22%	42%
Leaves	2%	20%	1%	8%

(2) Grazing Operations

Where an irrigation site is used for grazing, nutrient contribution from manure must be accounted for in the overall nitrogen loading to the site. The nutrient loading from various animal wastes should be based on the values listed in Table 121-10.

Table 121-10
Animal Waste Characterization[1]
(per 1000 pounds livestock live weight)

Animal	Nitrogen (lb/day)	Phosphorous (lb/day)	Potassium (lb/day)
Dairy Cow	0.45	0.07	0.27
Beef	0.31	0.11	0.24
Goat/Sheep[2]	0.45	0.07	0.30
Horse	0.28	0.05	0.19

1. Source: USDA Agricultural Waste Management Field Handbook.
2. Source: ASAE Manure Production and Characteristics. ASAE D384.1 Feb03

Not all nitrogen in land-applied manure is available to the crop during the year of application. Organic material decomposition is required before it is made available for plants. A percentage of last year’s nitrogen and an even smaller percentage of the previous year’s nitrogen will become plant-available during the current crop season. Therefore, mineralization rates as specified in Table 121-11 should be used to determine the amount of nitrogen available from previous manure application(s).

Table 121-11
Mineralization Rates[1]

Type of Waste	1st Year after Application Fraction Available	2nd Year after Application Fraction Available	3rd Year after Application Fraction Available
Fresh Cattle Manure	0.65	0.04	0.02
Fresh Sheep and Horse	0.55	0.06	0.02

1. Source: NRCS Specification MT633-JS1, September 2004.

Cattle, sheep, etc. must not be allowed on wet fields to avoid severe soil compaction and reduced soil infiltration rates. It is recommended that 4 to 7 days of drying time be allowed following an application before livestock are returned to the pasture. Pasture rotation should be practiced so that wastewater can be applied immediately after the livestock are removed.

In general, the pasture area should not be grazed longer than 7 days. Typical regrowth periods between grazings range from 14 to 36 days.

(3) Additional Nitrogen Sources

Where supplemental nitrogen is applied to the irrigation site (i.e., fertilizer) the amount of nitrogen removed through crop uptake (U) must be reduced by the additional nitrogen load. Where turf grass is mulched (e.g., golf courses) it must be assumed that 25 percent of the nitrogen in the mulched grass is returned to the soil.

b. Total Nitrogen Concentration (C_n)

When existing effluent nitrogen data is not available, the effluent total nitrogen concentration for wastewater treatment ponds must be based on the following:

$$C_n = (N_o)e^{-0.0075(t)} \qquad (120\text{-}4)$$

where, C_n = Total nitrogen concentration, mg/L
N_o = Influent nitrogen concentration, mg/L
t = Minimum detention time in treatment/storage ponds, \ days

c. Nitrogen Loss (f)

In accounting for nitrogen losses due to denitrification, volatilization, and soil storage, the nitrogen loss factor (f) must not exceed 0.2 for secondary treatment effluent and 0.1 for effluent from facilities utilizing nutrient removal methods in their treatment process.

121.113.13 Additional Nutrient Considerations

Phosphorus and potassium are considered essential macronutrients and are required at moderately high levels to support a healthy crop. Table 121-7 shows the phosphorus and potassium needs for various crops. Crop requirements for phosphorus and potassium must be addressed in the nutrient management plan (Section 121.122).

a. Phosphorus

When required by the Department, a phosphorus breakthrough analysis must be performed to ensure breakthrough to the nearest down gradient surface water will not occur within 50 years. The results of this analysis must be submitted to the Department.

b. Potassium

Potassium is an essential nutrient required for vegetative growth. However, reclaimed wastewater does not typically contain sufficient levels in the optimum combination with nitrogen and phosphorus (see Table 121-7 for crop requirements). Therefore, it may be necessary to add supplemental potassium to maintain nitrogen removals at the optimum level.

121.114 Irrigation Area Analysis

Justification and calculations associated with irrigation land area requirements must be provided as indicated below.

121.114.1 Required Land Area

The required land area for irrigation can be determined from the design hydraulic loading rate according to the following equation:

$$A = (Q + \Delta V_s) / (C \times L_H) \qquad (120\text{-}5)$$

where, A = Field area, acre (ha)
Q = Annual average daily flow, ft^3/yr (m^3/yr)
V_s = Net loss or gain in stored wastewater volume due to precipitation and evaporation at storage pond(s), ft^3/yr (m^3/yr)
C = Conversion constant, 3,630 (100)
L_H = Annual design hydraulic loading rate as defined in Section 121.103.1(Annual Hydraulic Loading Rate), in/yr (cm/yr)

Additional land area must be accounted for as a result of buffer zone requirements described in Section 121.4 (Buffer Zone).

121.114.2 Slope

Design slopes must be less than 15 percent to promote infiltration rather than surface runoff.

121.115 Storage Analysis

Adequate storage during inoperable periods must be provided. Justification and calculations associated with storage volume requirements must be provided including a month by month water balance based on maximum design conditions.

Design precipitation must be based on a 10-year precipitation return period as described in Section 121.103.11 b (Precipitation). Storage requirements for wastewater treatment ponds are located in Section 93.36 (Pond Design Criteria, Tables 93-1 and 93-2).

Evaporation (E) rates must be based on estimated lake evaporation in the local area, if available. Where monthly evaporation data is unavailable, average annual evaporation may be distributed based on the ratio of average monthly ETc to average annual ETc.

Average annual evaporation and monthly precipitation values for Montana communities can be found at the Western Regional Climate Center website.

121.116 Crop Management

The crop must be harvested and removed from the irrigation site or used for grazing. Mulching is allowed for turf grass only.

A crop management plan must be developed and submitted to the Department for approval in accordance with Section 121.122 (Plan of Operation).

The Department may require on-going soil monitoring to be performed to substantiate agronomic use of nutrients as a condition of approval.

121.117 Supplemental Water

The crop must be effectively managed to maintain a harvestable crop as long as treated wastewater effluent is applied. In some situations, this may require use of a supplemental water source. Application of additional water must not exceed agronomic uptake or result in leaching of nutrients below the root zone. Where supplemental water will be utilized; the volume needed, nutrient make-up, and salinity impacts must be addressed in the nutrient management plan (Section 121.122).

121.12 OPERATION AND MAINTENANCE PROCEDURES

Operation and maintenance procedures for the irrigation system must be approved by the Department prior to plan and specification approval and incorporated into the treatment system's final O&M manual (see Section 25 Operation & Maintenance Manual). These procedures must contain information that addresses the following:

121.121 Startup and Shutdown Procedures of the Irrigation System

Startup and shutdown of the irrigation system, including cold weather operation, must be described.

121.122 Nutrient Management Plan

A nutrient management plan (NMP) must be developed in order to remain in compliance with the approved design. At a minimum, the NMP must include the following:

a. Requirements for training of the system operator prior to start up.

b. A site map and a soil map of the irrigation area. The site map must show the location of the irrigation site(s) and buffer zone(s) as well as identify sensitive resource areas within 500 feet (152.4 m) of the application site(s) (wetlands, surface water, wells, roads, buildings, property lines, etc.). The soil map must include soil survey geographic (SSURGO) mapping units or similar means of identification and the map unit name and symbol for all soil types at the irrigation site.

c. A crop management plan including planting techniques, schedules, anticipated crops, current and planned crop production sequence, crop rotation, harvesting plan (method, timing, etc.), expected yield, etc.

It is recommended that consultation with the United States Department of Agriculture Natural Resources Conservation Service (NRCS), local offices of the Cooperative Extension Service, or similar should be held to aid in the development of an appropriate crop management plan. A summary of this consultation must be submitted to the Department.

d. Land/soil management plan (e.g., soil testing, tilling, disking, salinity mitigation measures, etc.).

e. Quantification of all essential macronutrient (i.e., nitrogen, phosphorus, and potassium) sources available and crop requirements. Nutrient contributions from all sources (including fertilizer, manure, mulching, etc.) must be accounted for in application rate calculations.

f. Proposed application rates (including supplemental water), timing, and method of irrigation.

g. The development of an agricultural pest control program (e.g., weeds, insects, etc.), if needed. At a minimum, contact information for state and local pest control experts must be provided.

h. Best-management-practices (BMPs), if necessary, to prevent run-off to surface water.

121.123 Record Keeping Protocol

Data sheets to record the frequency, parameters and procedures for effluent (and groundwater, if required) monitoring must be provided. At a minimum, the following procedures and requirements must be incorporated into record keeping of irrigation practices:

a. Irrigation water quantity and quality must be documented.

1. The amount of water applied on a daily basis (reclaimed or supplemental) must be logged and the basis for this quantity must be documented (e.g. meter reading or pump times and pump rates).

2. Effluent must be monitored to show the biochemical and bacteriological quality of the applied wastewater. See Table 121-1 for sampling and monitoring requirements.

b. The level of the water in the storage cell must be recorded at a minimum on a monthly basis.

c. Estimated daily irrigated area must be logged.

d. When required by the Department, soil monitoring test results and mitigation activities must be documented. The Department will determine what parameters and the monitoring frequency on a case-by-case basis. See Section 121.112.2 (Soil Management, Monitoring, and Testing) and Section 121.112.3 (Sodium Adsorption Ratio and Salinity Considerations).

e. Groundwater monitoring activities and test results must be documented, if applicable.

f. Actual crop production (i.e. crop yield) must be recorded.

g. Weather events, such as rainfall or freezing temperatures must be documented during irrigation periods and that the application rates were reduced or stopped during these conditions.

h. Operation and maintenance activities must be logged.

i. Records of correspondence with local, state, and federal agencies must be maintained.

121.124 Responsibility of Operation

Irrigation is considered part of the wastewater treatment process; therefore, the wastewater system operator must make the final decision on when irrigation may proceed. Safe operating practices must be described and encouraged.

122. STANDARDS FOR RAPID INFILTRATION SYSTEMS

122.1 General

Rapid Infiltration (RI) systems are utilized for the disposal of treated effluent to groundwater. The use of an RI system requires that the industrial component of the wastewater be relatively small, with the discharge of toxic substances regulated by an effective pretreatment program. If significant industrial users discharge to the system, additional requirements may be imposed by the Department.

RI systems, as discussed in this chapter, consist of the controlled application of wastewater to either open shallow earthen basins (commonly referred to as infiltration/percolation (I/P) basins), or subsurface absorption cells. The use of subsurface absorption cells will be considered by the Department on a case-by-case basis and only when a high quality effluent is discharged.

All RI systems owners must obtain a groundwater discharge permit (MGWPCS) from the Department in advance of constructing any RI system unless the system qualifies for one or more of the exemptions defined within ARM 17.30.1022 of the Administrative Rules of Montana relative to the facility. If it is determined that the groundwater beneath the proposed RI site is hydrologically connected to surface water, then the discharge will be considered the same as a surface water discharge and a Montana Pollutant Discharge Elimination System (MPDES) permit will be required by the Department.

122.2 Pre-Application Treatment Requirements

At a minimum, treatment comparable to secondary treatment must precede all rapid infiltration applications.

122.21 Infiltration/Percolation Basins

For I/P basins following wastewater treatment pond systems, treatment must be provided in accordance with the applicable table in Section 93.36 (Pond Design Criteria).

Algae from lagoons or storage ponds can inhibit infiltration rates as well as result in the rapid fouling of the I/P basins. To minimize problems associated with algae, the withdrawal structure in the final treatment pond should be designed with multiple takeoffs.

122.22 Subsurface Absorption Cells

For subsurface absorption cells, only high quality effluent meeting the following parameters must be discharged:

BOD_5	< 10 mg/L
TSS	< 10 mg/L
Turbidity	<5 NTU
Total N	< 5 mg/L

These systems must be designed to discharge rapidly and in a manner to prevent plugging or biofouling. Cleanout ports or other access must be provided to allow for cleaning and maintenance.

122.3 Preliminary Design Report

A comprehensive design report must be submitted to the Department prior to the design phase. In addition to the requirements outlined in Chapter 10 (Engineering Reports and Facility Plans), the preliminary design report must include the following:

1. Field observations of exposed soil profiles (on and near the site) to include road cuts, borrow pits, and plowed fields.

2. Field observation of groundwater indicators: wet spots, seepage areas, vegetation changes, ponds and streams, and general drainage characteristics within 500 feet (152.4 m) of the application site.

3. Backhoe test pit results, to 10 feet (3 m), in the major soil types on the proposed site with special consideration given to soil characteristics and the elevation of the groundwater on the site.

4. Water levels in adjacent or on-site wells and nearby surface waters should be used to prepare a preliminary water table map. Include flow direction, depth, and discharge areas for groundwater and the re-charge characteristics for the site.

5. Included in the preliminary design report should be information describing the quality of the groundwater, current nitrate levels, its uses and classification.

6. Calculations supporting the proposed hydraulic loading including depth to groundwater, groundwater quality, aquifer thickness, groundwater mounding potential, nitrate loading to groundwater, percolation rates and cycle times. Groundwater mounding must not be allowed to reach the surface using historical depth to groundwater records, where the shallowest depth is used in the mounding analysis.

7. Winter time storage requirements if necessary.

8. Chemical characteristics and compatibility of the soil and wastewater.

9. A preliminary layout of the proposed RI system showing dimensions of the application area and its proximity to wells, seeps, springs, lakes and streams.

When gathering specific data for the preliminary design report, consideration should be given to final design requirements outlined in Sections 122.4 (Site Selection) and 122.5 (Site Investigation).

122.4 Site Selection

a. The site location must be selected so that the RI system is protected from flooding and must not be located in the 100-year flood plain.

b. The location of RI systems must be a minimum of 500 feet (152.4 m)from water supply wells. The Department may require an increased setback distance and a hydrological analysis when the time of travel "zone of influence" between a proposed RI system and a water supply well is less than 200 days (which may pose public health concerns).

c. The operation of an RI system on the proposed site must not affect any existing or anticipated uses of groundwater or surface water.

122.5 Site Investigation

Final field testing must be conducted on the actual site and at the actual depth in the soil profile intended for the RI system. Extrapolation of data from nearby sites is not an acceptable basis for design.

122.51 Soils Investigation

a. Sufficient information on soil gradation, plasticity, texture, moisture, and structural characteristics should be obtained to thoroughly evaluate the permeability and drainage characteristics of the site.

b. Test pits and borings are required on all sites proposed in the final design. The number of pits and borings depends on the uniformity of the soils in the area. However, enough test pits must be dug and enough borings drilled to adequately characterize the soil profile and soil characteristics of the entire site. Generally, a grid-type approach must be used to establish the test pit locations. A minimum of one test pit is required within each I/P basin or subsurface cell location.

c. Infiltration and permeability tests must be conducted *in-situ* at the proposed site. Sufficient wetting and drying cycles should be used so that conditions similar to the proposed conditions of the RI system can be evaluated.

d. A phosphorous break-through analysis must be performed for each major soil type within the site. The analysis must include a phosphorous adsorption test.

122.6 Loading Rates

a. The hydraulic loading rate must be based directly upon the field and laboratory test results for infiltration, permeability, hydraulic conductivity, and transmissivity.

b. Hydraulic conductivity must be based on the layer of soil that is most restrictive of water flow. If there is not an obvious restricting layer in the soil profile, then the effective hydraulic conductivity of the profile is the mean of the values observed in the tests. Soil permeability (or hydraulic conductivity) should be greater than 0.6 in/hr for a site to be considered for RI.

c. The design loading rate must be based on a percentage of the minimum measured hydraulic loading rate as shown in Table 122-1.

Table 122-1 Hydraulic Loading Rates	
Test Procedure [1]	**Adjustment Factor for Annual Loading Rate**
Basin Flooding Test	7 - 10% of minimum measured infiltration rate
Air entry permeameter & cylinder infiltrometers	2 - 4% of minimum measured infiltration rate

1. The methodology for these test procedures are included in the EPA Process Design Manual Land Treatment of Municipal Wastewater Effluents, (EPA/625/R-06/016) September 2006, pp 3-12 to 3-18

d. Hydraulic loading rate must be given in gal/(yr ft^2). The annual loading rate must be reduced to account for periods when I/P basins cannot be used, such as when the ground is frozen or during maintenance periods.

122.7 Maximum Groundwater Elevation

There must be, at all times, an unsaturated zone between the bottom of the RI system and the maximum groundwater surface as determined by a groundwater mound analysis. This analysis must be performed by a qualified hydrogeologist.

122.8 Underdrains

Underdrains may be required to control groundwater mounding and to prevent surfacing of infiltrated wastewater. The discharge from underdrains which collect treated effluent from RI systems will be considered the same as a surface water discharge, and surface water standards will apply.

122.9 Wet/Dry Ratios

Adequate drying time between applications must be provided to prevent soil clogging. To maximize infiltration rates, the wetting/drying periods shown in Table 122-2 should be utilized.

Table 122-2 I/P Loading Cycles[1]		
Season	**Application Period, days**	**Drying Period, days**
Summer	1-3	4-5
Winter	1-3	5-10

1. Source: Table 10-8 in the "Process Design Manual for Land Treatment of Municipal Wastewater Effluents" (EPA 625/R-06/016) published by the U.S. Environmental Protection Agency

122.10 Application Rates

Application rates must be based on the annual hydraulic loading rate, time available for application, wet/dry ratios, nondegradation and other applicable water quality regulations for groundwater and surface water. For subsurface absorption cells application rates must be designed to allow for complete drainage of the area between dosings.

122.11 Number of Basins/Cells

In determining the number of I/P basins or subsurface cells to use, consideration must be given to drying time, if applicable, and to maintenance activities without disrupting the continual operation of the treatment works. At a minimum, three I/P basins or subsurface absorption cells must be provided.

For I/P basins, Table 122-3 should be used to determine the minimum number of basins required for continuous wastewater application.

Table 122-3 Minimum Number of Basins[1]		
Loading Application Period, days	**Cycle Drying Period, days**	**Minimum Number of Infiltration Basins**
1	5-7	6-8
2	5-7	4-5
1	7-12	8-13
2	7-12	5-7
1	4-5	5-6
2	4-5	3-4
3	4-5	3
1	5-10	6-11
2	5-10	4-6
3	5-10	3-5
1	10-14	11-15
2	10-14	6-8
1	12-16	13-17
2	12-16	7-9
7	10-15	3-4
8	10-15	3
9	10-15	3
7	12-16	3-4
8	12-16	3
9	12-16	3

1. Source: Table 10-9 in the "Process Design Manual for Land Treatment of Municipal Wastewater Effluents" (EPA 625/R-06/016) published by the U.S. Environmental Protection Agency

122.12 Inlet Structures

Inlet structures must be provided for all basins and designed to prevent erosion of the basin or adjacent dike. At a minimum, concrete splash pads are required for I/P basins.

For subsurface cells, the distribution laterals must extend the entire length of the cell and be structurally sound for their intended use. Where open-bottom chambers are used they must consist of high-density polyolefin or other approved material. Products must maintain at least 90 percent of their original height (vertical deflection shall not exceed 10 percent of original product height) when installed according to manufacturer’s installation guidelines and subjected to a 4,000-pound axle load. Vertical deflection is the combined product height deflection due to installation (soil dead load) and the 4,000-pound axle load measured when the tire is directly over the product.

122.13 Flow Distribution

a. Influent wastewater should be distributed uniformly over the entire RI system area.

b. Flow control structures must be provided as necessary to adequately direct and control wastewater flow to any individual RI system discharge area.

122.14 Storage Requirements

Where I/P basins will not perform satisfactorily during the winter months, provisions for storing the wastewater during that period must be provided. Emergency/winter storage requirements for I/P basins are listed in Section 93.36 (Pond Design Criteria).

122.15 I/P Basin Embankments

a. Slopes must not be steeper than 1 vertical to 3 horizontal (1:3).

b. All embankments must be protected from erosion caused by wave action, weather, or flooding through seeding, rip-rap, or other acceptable method of erosion control.

c. An access road/ramp must be provided to each basin so that maintenance equipment for surface scarification may enter. Each access road/ramp must be a minimum of 10 feet (3.0 m) wide.

122.16 Overflow Protection

Overflow protection must be provided for all I/P basins to prevent washout of the embankments. Overflow pipes must be inter-cellular and may not discharge outside of the basin area.

122.17 Construction Practices

a. RI systems may not be constructed on backfilled materials without specific approval by the Department.

b. The final surface of the RI system must be uniformly graded to allow even distribution of the wastewater and utilization of the entire soil profile for infiltration.

c. Every effort must be made to avoid compaction of the treatment/infiltration area within the I/P basins or subsurface absorption cells. The I/P basin bottom surface must be scarified prior to facility start-up.

d. For subsurface RI systems the maximum spacing between distribution laterals, measured on center, must be 30 inches (762 mm) or 1.5 times the width of the open-bottom chamber. It is recommended that the burial depth of the distribution laterals be no greater than 3 feet (914 mm) for maintenance purposes. A minimum of two distribution laterals must be provided for each subsurface infiltration area.

122.18 Groundwater Monitoring

Groundwater monitoring wells must be installed near the RI system. The number and placement of the wells will be determined by the Department, or as required in the groundwater discharge permit.

122.19 Fencing

The I/P basin site must be enclosed with a fence and posted with signs designed to discourage the entrance of unauthorized persons and animals. Access gates must be secured with locks and be of sufficient width to accommodate mowing and scarification equipment.

122.20 Cold Weather Operation

Pumps, piping, and valves must be protected from freezing.

APPENDIX A

HANDLING AND TREATMENT OF SEPTAGE AT A WASTEWATER TREATMENT PLANT

A.1 GENERAL

One method of septage disposal is the discharge to a municipal or district wastewater treatment plant (WWTP). All plants require special design considerations prior to the acceptance of septage.

A.11 Septage Defined

Septage is a general term for the contents removed from septic tanks, portable vault toilets, privy vaults, holding tanks, grease traps, very small wastewater treatment plants, or semi-public facilities (i.e., schools, motels, mobile home parks, campgrounds, small commercial endeavors) receiving wastewater from domestic sources.

Non-domestic (industrial) wastes are not included in the definition and are not covered by this appendix.

Contents from grease traps should not be hauled to most municipal wastewater treatment plants for disposal.

A.12 Septage Characteristics

Compared to raw public sewage from a conventional municipal sewer collection system, septage usually is quite high in organic, grease, and solids concentrations. Substantial quantities of phosphorus, ammonia nitrogen, bacterial growth inhibitors, and cleaning materials may be present in septage depending on the source. Tables No. 1 and No. 2 (Table 3-4 and 3-8 from the U.S. EPA handbook entitled "Septage Treatment and Disposal" 1984, EPA-625/6-84-009 reprinted herein) give a comparison of some of the common parameters for septage and municipal wastewater.

Data for local septage to be received should be collected for design of septage receiving and treatment systems. Characteristics of septage may be expected to vary widely from load to load depending on the source (i.e., septic tank pumpage compared to grease traps or to recreational vehicles, or dump station holding tanks containing bacteria inhibitors).

A.2 TREATEMENT OF SEPTAGE AT A WWTP

Septage is normally considered treatable at a WWTP with the exception of facultative lagoons. However, unless proper engineering, planning, and design are provided, septage may represent a shock load, or have other adverse impacts on plant processes and effluent quality which will be influenced by many factors including the following:

A.21 Capacity (MGD) (m^3/d) of the WWTP relative to the amount and rate of septage feed to the plant;

A.22 Unused WWTP capacity available (above current sewer collection system loadings) to treat septage loadings;

A.23 Sensitivity of the treatment plant process to daily fluctuations in loadings brought about by the addition of septage;

A.24 Sludge septage loads of BOD, ammonia, phosphorus or other chemical agents which may pass through to the effluent, cause process upset, odor nuisance, foaming within the aeration tank/aerated digester, or other problems;

A.25 The point of introduction of the septage into the WWTP process. The point of introduction should be upstream of the headworks or into the headworks. Alternative points of introduction into the WWTP process may be allowed with adequate justification;

A.26 The ability to control feed rates of septage to the WWTP during off peak loading periods; and

A.27 The volume and concentrations of bacterial growth inhibitors in septage from some portable vault toilets and recreational dump station holding tanks.

The permitted plant effluent regulatory limits for WWTP on each of the controlled parameters must be considered when evaluating these factors.

A.3 CONSIDERATIONS FOR SEPTAGE TREATMENT AT WASTEWATER TREATMENT FACILITIES

It is essential that an adequate engineering evaluation be made of the existing WWTP and the anticipated septage loading being considered prior to receiving septage at the WWTP. The regulatory agency must be contacted to obtain the appropriate approvals prior to the acceptance of septage. For proposed WWTP expansion and upgrading, the engineering report or facility plan (refer to Chapter 10 Engineering Report and Facility Plans) must include anticipated septage loading in addressing treatment plant sizing and process selection. The following items should be included as appropriate in the engineering evaluation and facility planning:

A.31 The uninterrupted and satisfactory treatment (within the plant regulatory limits) of waste loads from the sewer system must not be adversely affected by the addition of septage to the plant;

A.32 In general, the smaller the WWTP design capacity relative to the septage loading proposed, the more subject the WWTP will be to upset and potential violation of permitted discharge effluent limits;

A.33 Allocation of organic plant capacity originally planned for future growth;

A.34 For plants to be expanded and upgraded, the engineering evaluation and facility planning should jointly consider the sensitivity of the WWTP process to receiving of septage, and the impact on the discharge parameter limits;

A.35 An evaluation should be made of available WWTP operator staff and the staffing requirements necessary when septage is to be received. Staff should be present when septage is being received and unloaded. Added laboratory work associated with the receiving of septage for treatment should be included in the staffing evaluation;

A.36 Septage receiving facilities should be off-line from the raw wastewater incoming from the sewer system and be designed to allow for the slow release of the septage into the treatment system during non-peak periods. Selection of the location of the septage receiving facility and the septage hauler unloading area should consider other plant activity, and traffic flow; and

A.37 The impact of the septage handling and treatment on the WWTP sludge handling and processing units and ultimate sludge disposal procedures.

A.4 SEPTAGE RECEIVING FACILITY DESIGN CRITERIA

The design of the septage receiving station at the WWTP should provide for the following elements:

A.41 A hard surface haul truck unloading ramp sloped to a drain to allow ready cleaning of any spillage and washing of the haul tank, connector hoses, and fittings. The ramp drainage must be tributary to treatment facilities and must exclude excessive stormwater;

A.42 A flexible hose fitted with quick connect coupling to provide for direct connection from the haul truck outlet to minimize spillage and help control odors;

A.43 Washdown water with ample pressure, hose, and spray nozzle for convenient cleaning of the septage receiving station and haul trucks. The use of disinfected WWTP effluent may be considered for this purpose. If a potable water source is used, it must be protected in accordance with Section 56.2 (Water Supply);

A.44 An adequate off-line septage receiving tank should be provided. Capability to collect a representative sample of any truck load of waste accepted for discharge to the WWTP must be provided. The receiving tank should be designed to provide complete draining and cleaning by means of a sloped bottom equipped with a drain sump. The design should give consideration to adequate mixing, for testing, uniformity of septage strength, and chemical addition, if necessary, for treatability and odor control. The WWTP must have authority to prevent and/or stop discharge that is likely to cause a WWTP discharge violation;

A.45 Screening, grit, and grease removal of the septage as appropriate to protect the WWTP treatment units;

A.46 Pumps provided for handling the septage should be of the non-clogging design and capable of passing 3 inch (76.2 mm) diameter solids;

A.47 Valving and piping for operational flexibility to allow the control of the flow rate and point of discharge of the septage to the WWTP;

A.48 Safety features to protect the operational personnel. Refer to Section 57 (Safety);

A.49 Laboratory and staffing capability to determine the septage strength and/or toxicity to the WWTP treatment processes. Provision for the WWTP operation reports to include the plant load attributed to septage; and

A.50 Septage receiving stations should be designed with a key pad, card reader or other device capable of recording the source of septage.

APPENDIX A
TABLE NO. 1*

PHYSICAL AND CHEMICAL CHARACTERISTICS OF SEPTAGE,
AS FOUND IN THE LITERATURE, WITH SUGGESTED DESIGN VALUES [a, b]

Parameter	United States				Europe/Canada				EPA Mean	Suggested Design
	Average	Minimum	Maximum	Variance	Average	Minimum	Maximum	Variance		
TS	34,106	1,132	130,475	115	33,800	200	123,860	619	38,800	40,000
TVS	23,100	353	71,402	202	31,600	160	67,570	422	25,260	25,000
TSS	12,862	310	93,370	301	45,000	5,000	70,920	14	13,000	15,000
VSS	9,027	95	51,500	542	29,900	4,000	52,370	13	8,720	10,000
BOD_5	6,480	440	78,600	179	8,343	700	25,000	36	5,000	7,000
COD	31,900	1,500	703,000	469	28,975	1,300	114,870	88	42,850	15,000
TKN	588	66	1,060	16	1,067	150	2,570	17	677	700
NH_3-N	97	3	116	39	---	---	---	---	157	150
Total P	210	20	760	38	155	20	636	32	253	250
Alkalinity	970	522	4,190	8	---	---	---	---	---	1,000
Grease	5,600	208	23,368	112	---	---	---	---	9,090	8,000
pH	---	1.5	12.6	8	---	5.2	9.0		6.9	6.0
LAS	---	110	200	2	---	---	---	---	157	150

a Values expressed as mg/L, except for pH.

b The data presented in this table were compiled from many sources. The inconsistency of individual data sets results in some skewing of the data and discrepancies when individual parameters are compared. This is taken into account in offering suggested design values.

* Table No. 1 including footnotes is taken from the US EPA Handbook entitled, "Septage Treatment and Disposal," 1984, EPA-625/6-84-009 and is designated in that document as "Table 3-4."

APPENDIX A
TABLE NO. 2*
COMPARISON OF SEPTAGE AND MUNICIPAL WASTEWATER [a]

Parameter	Septage [b]
TS	40,000
TVS	25,000
TSS	15,000
VSS	10,000
BOD_5	7,000
COD	15,000
TKN	700
NH_3-N	150
Total P	250
Alkalinity	1,000
Grease	8,000
pH	6.0
LAS	150

a. Values expressed as mg/L, except for pH.
b. Based on suggested design values in Table No. 1 (US EPA Table 3-4).
c. From Metcalf and Eddy, 2nd Edition, "medium strength sewage."
* Table No. 2 including footnotes is taken from the US EPA Handbook entitled "Septage Treatment and Disposal," 1984, EPA-625/6-84-009 and is designated in that document as "Table 3-8."

NEW APPENDIX B
WATER RECLAMATION AND REUSE

B.1 General

The required treatment and water quality requirements for the various classes of reclaimed wastewater are described in Table B-1. In addition to the irrigation standards for the use of reclaimed wastewater in Chapter 120, other allowable uses of reclaimed wastewater are listed in Table B-2. Table B-2 also specifies the class of reclaimed wastewater required for each allowable use. In addition, provisions that will ensure an adequate demonstration of public health and environmental protection are set forth throughout Appendix B and will be required of the applicant with any application requesting approval of the use of reclaimed wastewater.

Prior to receiving Department approval for a reclaimed wastewater reuse project, the applicant must provide a copy of the Department of Natural Resources and Conservation approved change of appropriation or water right, or a written statement that no authorization is needed under Title 85, Water Use. An approval from the DNRC regarding water rights must be obtained prior to approval of plans and specifications by the Department.

A public sewage system that meets the treatment standards for Class A-1 or Class B-1 standards for a reuse project that has been approved by the Department under Title 75, Chapter 6, MCA, is exempt from groundwater permit requirements pursuant to ARM 17.30.1022. In addition, a public sewage system that land applies reclaimed wastewater according to the requirements of Chapter 120 and has been approved by the Department is similarly exempt from groundwater permit requirements pursuant to ARM 17.30.1022.

In addition to the provisions of Section 11 (Engineering Report or Facility Plan), an alternatives analysis with respect to effluent reuse must consider market stability and environmental impacts associated with the reuse location. The screening of potential markets should include comparison of unit costs of potable or other water and reclaimed wastewater. Reliability of supply, value of reclaimed wastewater nutrients, and social benefits should be considered, as well as possible savings in the potable system due to the reduced demand.

B.2 Definitions

A list of terms commonly used in Appendix B to describe reclaimed wastewater, its uses, classifications, and related processes follow:

B.2.1 Approved Use Area

A Department approved site with well defined boundaries, designated to receive reclaimed wastewater for an approved use, in conformance with laws and regulations of all applicable regulatory agencies.

B.2.2 Aquifer Injection

Aquifer injection means the use of a well to inject water directly into an aquifer system without filtration through the geologic materials overlying the aquifer system for purpose of aquifer recharge or for an aquifer storage and recovery project.

B.2.3 Aquifer Recharge

Aquifer recharge means either the controlled subsurface addition of water directly to the aquifer or controlled application of water to the ground surface for the purpose of replenishing the aquifer to offset adverse effects resulting from the net depletion of surface water.

B.2.4 Aquifer Storage and Recovery Project

An aquifer storage and recovery project means a project involving the use of an aquifer to temporarily store water through various means, including but not limited to injection, surface spreading and infiltration, drain fields, or another method approved by the Department of Natural Resources and Conservation. The stored water may be either pumped from the injection well or other wells for beneficial use or allowed to naturally drain away for a beneficial use.

B.2.5 Coagulated

A treatment process in which colloidal and finely divided suspended matter have been destabilized and agglomerated by the addition of suitable floc-forming chemicals or by an equally effective method.

B.2.6 Disinfected

A treatment process in which most microorganisms have been killed, inactivated, or otherwise rendered non-virulent.

B.2.7 Filtered

A treatment process in which oxidized, coagulated wastewater passes through filter media, such as sand, anthracite, diatomaceous earth, or manmade ultra filtration products such as membranes so that the turbidity as determined by an approved laboratory method does not exceed an average operating turbidity of 2 nephelometric turbidity units (NTU) and does not exceed 5 NTU at any time.

B.2.8 Indirect Potable Reuse

The conveyance of reclaimed wastewater directly into an aquifer or reservoir used as a raw water source for a drinking water supply with the intent of supplementing the raw water supply.

B.2.9 Irrigation

Reclaimed wastewater irrigation, where the primary use of the effluent is for crop growth. Utilizes the evapotranspiration mechanism of plants and soil surfaces to prevent or minimize discharge.

B.2.10 Landscape Use

Means an approved use area, where reclaimed wastewater is used to support turf, flowers, shrubs, trees and decorative ponds of an ornamental nature. Landscape irrigation can include restricted and non-restricted application areas depending upon the class of reclaimed wastewater to be used.

B.2.11 Oxidized Wastewater

Means wastewater in which the organic matter has been stabilized, is non-putrescible, and contains dissolved oxygen. This level of treatment is comparable to that from facilities producing secondary effluent. Biological treatment to produce oxidized wastewater is discussed in Chapter 90 (Biological Treatment).

B.2.12 Reclaimed Wastewater

Means wastewater treated to the standards in Table 121-1 or Table B-1 that is reused for private, public, or commercial purposes.

B.2.13 Reuse

Means the practice of placing reclaimed wastewater into service in a manner appropriate with the level of treatment.

B.2.14 Restricted Recreational Impoundment (Landscape Ponds, Fishing Ponds)

Means a body of reclaimed wastewater where recreation is limited to fishing, boating, and other non-body-contact water recreation activities, or a body of reclaimed wastewater used for aesthetic features or otherwise serves a function not intended to include public contact.

B.2.15 Stream Flow Augmentation

Means a discharge to surface waters of the state, either directly or via groundwater transfer, for the purpose of sustaining minimum flows within the stream.

B.2.16 Unrestricted Recreational Impoundment

Means a body of reclaimed wastewater on which no limitations are imposed on body-contact water recreation activities.

B.3 Classes of Reclaimed Wastewater

There are six classes of reclaimed wastewater, differentiated by the degree of additional treatment provided following secondary treatment, as defined in 40 CFR 133, which applies to all reclaimed wastewater. The treatment standards defined for each class must be met prior to delivery to the reuse system. The six reclaimed wastewater classes and the treatment standards that apply to each of those classes are listed in Table B-1. Reclaimed wastewaters classified as A-1 and B-1 can be applied at rates that exceed the agronomic uptake rate. Even though Class A-1 and Class B-1 reclaimed wastewater may meet most drinking water standards, direct reuse for human consumption is not permitted. Bodily contact with Class A-1 reclaimed wastewater may be permitted at the discretion of the Department, when it can be shown by the applicant to be safe for the proposed use.

Table B-1 Reclaimed Wastewater Classifications and Associated Treatment Requirements

CLASS	TREATMENT STANDARDS
A-1	Class A-1 reclaimed wastewater must, at all times, be oxidized, coagulated, filtered and disinfected, as described below or defined in this Appendix B. Class A-1 reclaimed wastewater that is treated to the standards below is exempt from ground water permit requirements pursuant to ARM 17.30.1022. Following treatment, Class A-1 reclaimed wastewater effluent quality should have approximately 10 mg/L or less of BOD and TSS. To achieve the turbidity requirements for Class A-1 reclaimed wastewaters, a treatment process that incorporates coagulation, flocculation, sedimentation and filtration is typically required. See Section 111 (Clarification Processes) for the required design standards. Class A-1 reclaimed wastewater must be disinfected such that the median number of total coliform organisms, in the wastewater after disinfection, does not exceed 2.2 colony forming units (CFU) per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed and such that the number of total coliform organisms does not exceed 23 CFU per 100 milliliters in any sample. Class A-1 reclaimed wastewater has the quality of effluent such that all constituents meet Montana nondegradation requirements prior to application, allowing it to be applied to land at rates that exceed the agronomic uptake rate. Specifically, total nitrogen must not exceed 5.0 mg/L at any time. Per MCA 75-5-410, reclaimed wastewater proposed for aquifer recharge or injection purposes must meet, at a minimum, secondary treatment, as defined in 40 CFR Part 133, and Level II treatment for the removal of nitrogen. For aquifer recharge proposals, the effluent quality must meet either primary drinking water standards or non-degradation requirements at the point of discharge. For aquifer injection proposals, the effluent quality must meet the more stringent of either the primary drinking water standards or the nondegradation requirements at the point of discharge. Soil aquifer treatment (infiltration/percolation basins) may not be considered in meeting these requirements. The minimum monitoring level required during periods of use (including prior to seasonal startup, if applicable) must include: continuous turbidity analysis with recorder, weekly total coliform analysis, and bi-weekly total nitrogen analysis. Weekly disinfectant residual analysis if chemical disinfection is being utilized.*
A	Class A reclaimed wastewater must, at all times, be oxidized, coagulated, filtered and disinfected, as described below or defined in this Appendix B. Following treatment, Class A reclaimed wastewater effluent quality should have 10 mg/L or less of BOD and TSS. To achieve the turbidity requirements for Class A reclaimed wastewaters, a treatment process that incorporates coagulation, flocculation, sedimentation and filtration is typically required. See Section 111 (Clarification Processes) for the required design standards. Class A reclaimed wastewater must be disinfected such that the median number of total coliform organisms in the wastewater after disinfection does not exceed 2.2 colony forming units (CFU) per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and such that the number of total coliform organisms does not exceed 23CFU per 100 milliliters in any sample. The minimum monitoring level required during periods of use (including prior to seasonal startup, if applicable) must include: continuous turbidity analysis with recorder, weekly total coliform analysis, and monthly total nitrogen analysis. Weekly disinfectant residual analysis if chemical disinfection is being utilized.*

CLASS	TREATMENT STANDARDS
B-1	Class B-1 reclaimed wastewater must, at all times, be oxidized, settled and disinfected, as described below or defined in this Appendix B. Class B-1 reclaimed wastewater that is treated to the standards below is exempt from ground water permit requirements pursuant to ARM 17.30.1022. Class B-1 reclaimed waste water must be disinfected such that the median number of total coliform organisms in the wastewater after disinfection does not exceed 2.2 colony forming units (CFU) per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform organisms does not exceed 23 CFU per 100 milliliters in any sample. Class B-1 reclaimed wastewater has the quality of effluent such that all constituents meet Montana nondegradation requirements prior to application, allowing it to be applied to land at rates that exceed the agronomic uptake rate. Specifically, total nitrogen must not exceed 5.0 mg/L at any time. Per MCA 75-5-410, reclaimed wastewater proposed for aquifer recharge or injection purposes must meet, at a minimum, secondary treatment, as defined in 40 CFR Part 133, and Level II treatment for the removal of nitrogen. For aquifer recharge proposals, the effluent quality must meet either primary drinking water standards or nondegradation requirements at the point of discharge. For aquifer injection proposals, the effluent quality must meet the more stringent of either the primary drinking water standards or the nondegradation requirements at the point of discharge. Soil aquifer treatment (infiltration/percolation basins) may not be considered in meeting these requirements. The minimum monitoring level required during periods of use (including prior to seasonal startup, if applicable) must include: weekly total coliform analysis and bi-weekly total nitrogen analysis. Weekly disinfectant residual analysis if chemical disinfection is being utilized.*
B	Class B reclaimed wastewater must, at all times, be oxidized, settled and disinfected, as described below or defined in this Appendix B. Class B reclaimed wastewater must be disinfected such that the median number of total coliform organisms in the wastewater after disinfection does not exceed 2.2 colony forming units (CFU) per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform organisms does not exceed 23 CFU per 100 milliliters in any sample. The minimum monitoring level required during periods of use (including prior to seasonal startup, if applicable) must include: weekly total coliform analysis and monthly total nitrogen analysis. Weekly disinfectant residual analysis if chemical disinfection is being utilized.*
C	Class C reclaimed wastewater must, at all times, be oxidized, settled and disinfected, as described below or defined in this Appendix B. Class C reclaimed wastewater must be disinfected such that the median number of total coliform organisms in the wastewater after disinfection does not exceed 23 colony forming units (CFU) per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform organisms does not exceed 240 CFU per 100 milliliters in any sample. The minimum monitoring level required during periods of use (including prior to seasonal startup, if applicable) must include: monthly total coliform and monthly total nitrogen analysis. Weekly disinfectant residual analysis if chemical disinfection is being utilized.*
D	Class D reclaimed wastewater must, at all times, be oxidized and settled, as described below or defined in this Appendix B. Disinfection will typically not be required for Class D reclaimed wastewater; however, proximity to areas of public access or habitation may dictate that disinfection be provided in order to protect public health.

CLASS	TREATMENT STANDARDS
	The minimum monitoring level required during periods of use (including prior to seasonal startup, if applicable) must include: monthly total nitrogen analysis. *

***** The Department, where appropriate to protect public health and ensure water quality protection, may require additional sampling and direct annual or quarterly reporting. If industrial sources are contributors to the treated public sewage being proposed for reuse, monitoring for the various metals and contaminants described in Table 121-4 may be required annually. If the industrial source qualifies under the Federal Clean Water Act, Title 40, Chapter I, Part 401-403, a pretreatment program must be implemented before reuse of the effluent can be allowed by the Department.

B.4 Allowable Uses of Reclaimed Wastewater and Associated Classes

Reclaimed wastewater can be used for a variety of purposes. Allowable reclaimed wastewater uses and associated treatment levels are presented in Table B-2.

Table B-2 Allowable Uses of Reclaimed Wastewater and Associated Classes

Allowable Uses of Reclaimed Wastewater	Class of Reclaimed Wastewater Required for Identified Use					
	A-1	A	B-1	B	C	D
Spray Irrigation of Nonfood Crops *(greater than agronomic uptake rate)**						
Trees and Fodder, Fiber, and Seed Crops	YES	NO	YES	NO	NO	NO
Sod, Ornamental Plants for Commercial Use, and Pasture to Which Milking Cows or Goats Have Access	YES	NO	YES	NO	NO	NO
Drip or Subsurface Irrigation of Nonfood Crops *(greater than agronomic uptake rate)**						
Trees	YES	NO	YES	NO	NO	NO
Spray Irrigation of Food Crops *(greater than agronomic uptake rate)**						
Food Crops Which Undergo Physical or Chemical Processing Sufficient to Destroy All Pathogenic Agents	YES	NO	YES	NO	NO	NO
Drip or Subsurface Irrigation of Food Crops *(greater than agronomic uptake rate)**						
Food Crops Where There is No Reclaimed wastewater Contact With Edible Portion of Crop (e.g. orchards, vineyards)	YES	NO	YES	NO	NO	NO
Root Crops	YES	NO	NO	NO	NO	NO
Landscape Irrigation *(greater than agronomic uptake rate)**						
Restricted Access Areas (e.g., Cemeteries and Freeway Landscapes)	YES	NO	YES	NO	NO	NO
Unrestricted Access Areas (e.g., Golf Courses, Parks, Playgrounds, School Yards and Residential Landscapes)	YES	NO	NO	NO	NO	NO
Impoundments						
Landscape Impoundments	YES	NO	NO	NO	NO	NO
Restricted Recreational Impoundments	YES	NO	YES	NO	NO	NO
Unrestricted Recreational Impoundments	YES	NO	NO	NO	NO	NO
Animal & Fish Operations						
Fish Hatchery Basins (with discharge permit)	YES	YES	YES	NO	NO	NO
Zoo Operations and Animal Shelter Wash Down Water *(discharge to sewer)*	YES	YES	YES	YES	NO	NO

Allowable Uses of Reclaimed Wastewater	Class of Reclaimed Wastewater Required for Identified Use					
	A-1	A	B-1	B	C	D
Decorative Fountains *(discharge to sewer)*	YES	YES	NO	NO	NO	NO
(discharge to groundwater)	YES	NO	NO	NO	NO	NO
Jetting and Flushing of Sanitary Sewers	YES	YES	YES	YES	YES	NO
Street Cleaning and Washing Operations						
Street Sweeping, Brush Dampening	YES	YES	YES	YES	YES	NO
Sidewalks and Parking Lot Washing, Spray	YES	NO	YES	NO	NO	NO
Dust Control and Soil Compaction/Consolidation						
Unpaved road dust control, road construction compaction, backfill consolidation around pipelines (Not Drinking Water lines)	YES	YES	YES	YES	YES	NO
Fire Fighting and Fire Protection Systems						
Dumping from Aircraft	YES	YES	YES	YES	YES	NO
Hydrants or Sprinkler Systems in Buildings	YES	YES	NO	NO	NO	NO
Toilet and Urinal Flushing	YES	YES	NO	NO	NO	NO
Washing Aggregate and Concrete Batching Operations *(no discharge)*	YES	YES	YES	YES	YES	NO
Industrial Uses						
Aerosols not created (e.g. heat pumps, boilers) (non-discharging recirculation type)	YES	YES	YES	YES	YES	NO
Aerosols or other mist created (e.g., cooling towers, forced air evaporation, or spraying)	YES	YES	NO	NO	NO	NO
Aquifer Recharge						
Controlled Surface or Subsurface Addition to Replenish the Aquifer **	YES	NO	NO	NO	NO	NO
Aquifer Injection						
Direct Injection into Aquifer for Purpose of Enhancing a Water Right or Allocation **	YES	NO	NO	NO	NO	NO
Indirect Potable Reuse						
Intentional Return of Reclaimed Wastewater to Augment Raw Water Supplies***	YES	YES	NO	NO	NO	NO
Stream flow Augmentation						
Fisheries Support, or Recreational Enhancement with Unrestricted Access ***	YES	YES	YES	YES	NO	NO
Snow Making						
Restricted Access – designed for discharge to groundwater	YES	NO	YES	NO	NO	NO
Unrestricted Access – such as ski slopes***	YES	NO	NO	NO	NO	NO

* At the discretion of the Department, applicable portions of Section 121 (Standards for the Use of Reclaimed Wastewater for Irrigation) will be applied to the design of irrigation systems where agronomic rates are exceeded.

** Per MCA 75-5-410, reclaimed wastewater proposed for aquifer infiltration or aquifer recharge must meet at a minimum level two treatment for the removal of nitrogen and the effluent quality must meet either primary drinking water standards or nondegradation requirements prior to discharge. Soil aquifer treatment may not be considered in meeting these provisions for augmentation.

*** Any discharge to surface water must be authorized under an NPDES or MPDES permit, and the discharge will need to meet the provisions of the permit(s).

B.5 Conveyance and Distribution of Reclaimed Wastewater

The distribution network includes pipelines, pump stations, and storage facilities. Reuse water systems may present more corrosion challenges than typically experienced in potable water systems. Generally, reclaimed wastewater is more mineralized with a higher conductance and chloride content and lower pH, enhancing the potential for corrosion of metallic pipe. Where a reclaimed wastewater distribution system is created, the design must follow Circular DEQ 1, Chapters 6 (Pumping Facilities), 7 (Finished Water Storage), and 8 (Transmission Mains, Distribution Systems, Piping & Appurtenances) as described below. If the reclaimed wastewater distribution system does not provide for essential services, such as fire protection or sanitary uses, or does not result in a sanitary or environmental risk, the reliability of the reuse water system need not be as stringent with respect to sizing and redundancy. However, redundancy may be required to meet effluent disposal needs.

Note that circular DEQ 1 must be used with the interpretation that reclaimed wastewater is to be considered sewage for the purpose of complying with Section 8.8 (Separation of Water Mains, Sanitary Sewers and Storm Sewers). Likewise, in DEQ 2, Section 38.3 (Relation to Water Works) adequate separation must be maintained between pipes carrying sewage and pipes carrying reclaimed wastewater. Therefore, the required vertical and horizontal separation distances must be met.

B.5.1 Pumping facilities used to convey reclaimed wastewater, must meet the provisions of Circular DEQ 1, Chapter 6, unless the Department determines some provisions of this chapter are unnecessary based on the level of service to be provided or requirements for continuity of effluent disposal.

B.5.2 Storage facilities used to hold reclaimed wastewater must meet the provisions of Circular DEQ 1, Chapter 7, Sections 7.0.2 through 7.0.16* and 7.3. It may be necessary to supplement the disinfectant dosage in reclaimed wastewater storage tanks to ensure minimal regrowth of bacteria. In cases where UV disinfection is used at the treatment plant, it may be necessary to add oxidizing disinfectants such as chorine in low dosages, on a continual basis, to ensure control of bacteria. Provisions for total coliform and residual disinfectant sampling must be provided at the point of reclaimed wastewater delivery to document the efficacy of the residual disinfectant. Disposal of heavily chlorinated water from the tank disinfection process must be in accordance with the requirements of the Department.

* Section 7.0.7 (Overflow) applies with the exception that the overflow must discharge to a sanitary sewer main.

Storage ponds, tanks and other vessels holding reclaimed wastewater must be signed or labeled to ensure easy identification.

B.5.3 Conveyance systems for delivery of reclaimed wastewater must follow the provisions contained within Circular DEQ 1, Chapter 8, unless the Department determines some provisions of this chapter are unnecessary based on the level of service to be provided.

Conveyance systems for delivery of reclaimed wastewater must be easily identifiable. The use of purple piping or purple striped piping is encouraged. In lieu of that approach, permanent markings or labels must be installed at intervals (not to exceed 10 feet (3 m)) to ensure easy identification when pipes are buried and later excavated.

Plumbing within structures must utilize the purple pipe or other approved identification system and must be inspected to ensure they are not cross connected to any potable water supply within the structure(s). Reclaimed wastewater delivered to a commercial building must have adequate back-flow prevention on the domestic water line entering the building in accordance with Circular DEQ-1, Section 8.10 (Cross-Connections and Inter Connections). It is recommended that a cross connection management agreement be in place to protect the water supply in the building from cross connection with reclaimed wastewater.

B.6 Setbacks, Separation and Buffer Distances for Reclaimed Wastewater Use

The required distance of the approved use area from surface water and any well will be determined by the Department case-by-case based on the quality of effluent and the level of disinfection. In no case can reclaimed wastewater be discharged or applied directly to surface water unless an MPDES discharge permit is obtained from the Department.

The Department will establish buffer zones on a case by case basis as necessary to protect public health.

B.7 Access Control and Advisory Signs

Appropriate fencing and advisory signs, if required by the Department, must be utilized designating the use of reclaimed wastewater in the approved use area.

B.7.1 Fencing

When fencing is required, pasture or approved similar fencing must be placed along the outer perimeter of the approved use area.

B.7.2 Signing

For approved use areas with fencing requirements, signs must be posted along the fence line every 250 feet (76.2 m)and at each corner. Signs should read “No Trespassing – Reclaimed wastewater” or an approved equivalent.

All other approved use areas must have signs posted at conspicuous public access points and should read “Reclaimed wastewater – Do Not Drink” or an approved equivalent.

B.8 Control of Reclaimed Wastewater Use Area

When an approved use area is not owned by the party responsible for the delivery of the reclaimed wastewater, a 20-year lease or similar assurance must be negotiated. Longer leases or purchasing of land is encouraged. A copy of the signed lease or assurance must be submitted to the Department for review and approval. A statement detailing responsibility of operation must be included in the lease agreement as outlined in Section 121.123 (Responsibility of Operation) and Section B.10 (Operation and Maintenance Manual Specific to Reuse).

B.9 Effluent Monitoring

B.9.1 Flow

The capability to measure the amount of water applied to the reuse site on a daily basis must be provided. This can be accomplished with either a flow meter device or through the use of pump run time (e.g., hour meters) and pump capacity.

B.9.2 Quality

Provisions must be made that will enable the water to be sampled prior to use. Testing provisions for the various uses of reclaimed wastewater are defined in Section B.10 (Operation and Maintenance Manual Specifics for Reuse Alternatives).

B.10 Operation and Maintenance Manual Specific to Reuse

Operation and maintenance (O&M) procedures are critical to the success of a reclaimed wastewater treatment and application project. As such, an O&M manual must be prepared to help direct and establish appropriate monitoring, recordkeeping and operations during start up and after the project is constructed. A complete draft O&M manual must be submitted to the Department prior to plan and specification approval. This manual can become fairly complex depending on the nature of the project and the types of equipment involved. Emphasis must be placed on development of daily logs and balance sheets to be used by operations staff to operate the reclamation system and document compliance with approval conditions. In addition to those requirements listed under each reuse alternative, the Department may identify project-specific monitoring and operational provisions within the conditions of approval, where circumstances warrant.

a. Irrigation of Nonfood Crops, Food Crops, and Landscaping

Only reclaimed wastewater as classified in Table B-2 may be used for the irrigation of crops and landscaping at rates that exceed the agronomic uptake of nitrogen.

The O&M document prepared by the designer must develop a means to ensure the following minimum level of operation is established. Systems utilizing this reuse approach must:

1. Document that the reclaimed wastewater continuously meets the provisions of Table B-1 for the class of reclaimed wastewater utilized. Discontinue use if water quality does not meet the minimum provisions of Table B-1 for the water utilized for the proposed use.
2. At the discretion of the Department, applicable portions of Section 121.12 (Operation and Maintenance Procedures) must be addressed in the O&M manual.
3. Develop a plan for maintenance of water balance to ensure overflow or over-application will not occur.

b. Landscape and Recreational Impoundments

Only reclaimed wastewater as classified in Table B-2 may be used for the development of landscape or recreational impoundments.

The O&M document prepared by the designer must develop a means to ensure the following minimum level of operation is established. Systems utilizing this reuse approach must:

1. If discharge from impoundment is other than to a sewer collector, a groundwater or surface water discharge permit must be obtained from the Department. Class A-1 and B-1 reclaimed wastewater is exempt from permitting requirements if the discharge occurs to groundwater only.
2. A pond management plan to ensure control of algae, weeds and erosion due to wind or other impacts.
3. Document that the reclaimed wastewater continuously meets the provisions of Table B-1 for the class of reclaimed wastewater utilized. Discontinue use if

water quality does not meet the minimum provisions of Table B-1 for the water utilized for the proposed use.

4. Where the pond serves as a winter storage basin for later land application or turf watering, apply the appropriate O&M provisions to the combined system.
5. At the discretion of the Department, applicable portions of Section 121.12 (Operation and Maintenance Procedures) must be addressed in the O&M manual.
6. Develop a plan for maintenance of water balance to ensure overflow will not occur.
7. Implement all BMP's, such as signage, control structures and liners where appropriate.

c. Animal and Fish Operations

Only reclaimed wastewater as classified in Table B-2 may be used for zoos, shelter or rearing facilities. Reclaimed wastewater must be used as wash-down water only and not for consumption by the animals. Runoff from these uses must be directed to the facilities wastewater collection system.

The O&M document prepared by the designer must develop a means to ensure the following minimum level of operation is established. Systems utilizing this reuse approach must:

1. Develop a pond management plan to ensure control of algae, fungi or weeds or other impacts.
2. Document that the reclaimed wastewater continuously meets the provision of Table B-1 for the class of reclaimed wastewater utilized. Discontinue use if water quality does not meet the minimum provisions of Table B-1 for the water utilized for the proposed use.
3. Where the pond serves as a winter storage basin for later land application or turf watering, apply the appropriate O&M provisions to the combined system.
4. Develop a plan for maintenance of water balance to ensure overflow will not occur.
5. Implement all BMP's, such as signage, control structures and liners where appropriate.
6. Ensure appropriate worker training and worker safety provisions including appropriate showering or washing facilities.
7. Ensure that plumbing within structures supplying reclaimed wastewater utilize the purple pipe or other approved identification system and are inspected to ensure they are not cross connected to any potable water supply within the structure(s).

d. Decorative Fountains

Only reclaimed wastewater as classified in Table B-2 may be used for decorative fountains and other similar features. Decorative fountains and similar features must be adequately signed to ensure public notice.

The O&M document prepared by the designer must develop a means to ensure the following minimum level of operation is established. Systems utilizing this reuse approach must:

1. Secure and maintain a groundwater or surface water discharge permit unless the effluent at all times discharges to a sewer collector. Class A-1 reclaimed

wastewater is exempt from permitting requirements if the discharge occurs to groundwater only.

2. Document that the reclaimed wastewater continuously meets the provision of Table B-1 for the class of reclaimed wastewater utilized. Discontinue use if water quality does not meet the minimum provisions of Table B-1 for the water utilized for the proposed use.
3. Implement all BMP's, such as signage, control structures and liners where appropriate.
4. Ensure that plumbing within structures supplying reclaimed wastewater utilize the purple pipe or other approved identification system and are inspected to ensure they are not cross connected to any potable water supply within the structure(s).

e. Jetting and Flushing of Sanitary Sewers

Only reclaimed wastewater as classified in Table B-2 may be used for sanitary sewer flushing or jetting operations. Flushing or jetting operations are considered a periodic process where effluent reuse in lieu of fresh water or drinking water use is appropriate.

The use of reclaimed wastewater for this purpose would involve the following:

1. Notify the permit program in advance if the reclaimed wastewater is a portion of effluent normally discharged through an associated permit.
2. Document that the reclaimed wastewater continuously meets the provision of Table B-1 for the class of reclaimed wastewater utilized. Discontinue use if water quality does not meet the minimum provisions of Table B-1 for the water utilized.
3. Track the volume of effluent used for the flushing operation.
4. Implement BMP's, such as signage, control structures and worker safety as appropriate.

f. Street Cleaning and Washing Operations

Only reclaimed wastewater as classified in Table B-2 may be used by road crews or contractors for the seasonal wash down of paved surfaces, sidewalks and building structures. Water used must either evaporate from the surface or be directed to a storm water collection system with a groundwater connection. In no case shall this reclaimed wash down water be discharged to surface water.

The O&M document prepared by the designer must develop a means to ensure the following minimum level of operation is established. Systems utilizing this reuse approach must:

1. Notify the Department permit program in advance if the reclaimed wastewater is a portion of effluent normally discharged through an associated permit.
2. Document that the reclaimed wastewater continuously meets the provision of Table B-1 for the class of reclaimed wastewater utilized. Discontinue use if water quality does not meet the minimum provisions of Table B-1 for the water utilized for the proposed use.
3. Track the volume of effluent used for the washdown operation.
   Implement BMP's, such as signage, control structures and worker safety as appropriate.

g. Dust Control and Soil Compaction/Consolidation

Only reclaimed wastewater as classified in Table B-2 may be used for unpaved road dust control, unpaved road construction compaction and backfill compaction. Water used must be limited to quantities which wet the surfaces but not saturate those soils. In no case shall this reclaimed wastewater be discharged to storm drains or stormwater collection systems with a surface water connection.

The O&M document prepared by the designer must develop a means to ensure the following minimum level of operation is established. Systems utilizing this reuse approach must:

1. Notify the permit program in advance if the reclaimed wastewater is a portion of effluent normally discharged through an associated permit.
2. Document that the reclaimed wastewater continuously meets the provision of Table B-1 for the class of reclaimed wastewater utilized. Discontinue use if water quality does not meet the minimum provisions of Table B-1 for the water utilized.
3. Track the volume of effluent used for the dust control or compaction operation.
4. Implement BMP's, such as signage, control structures and worker safety as appropriate.

h. Fire Fighting and Fire Protection Systems

Only reclaimed wastewater as classified in Table B-2 may be used for forest fire fighting and fire protection within a structure. The use of reclaimed wastewater for forest fire suppression (i.e., dumping from aircraft) would normally be an incidental operation and involve access to a reclaimed wastewater filling station. This approach must ensure the following minimum level of operation:

1. Notify the permit program in advance if the reclaimed wastewater is a portion of effluent normally discharged through an associated permit.
2. Document that the reclaimed wastewater continuously meets the provision of Table B-1 for the class of reclaimed wastewater utilized. Discontinue use if water quality does not meet the minimum provisions of Table B-1 for the water utilized.
3. Track the volume of effluent used for forest fire suppression.
4. Implement BMP's, such as signage, control structures and worker safety as appropriate.

The use of reclaimed wastewater for fire protection within buildings or on structures (i.e., hydrants or sprinkler system) involves a higher degree of worker and occupant safety and may include the use of storage reservoirs, vessels and fires suppression standpipe or pressurized systems within commercial or residential structures. If this approach to reclaimed wastewater use is proposed, the O&M document prepared by the designer must develop a means to ensure the following minimum level of operation is established:

1. Notify the permit program if the reclaimed wastewater is a portion of effluent normally discharged through an associated permit.
2. Document that the reclaimed wastewater continuously meets the provision of Table B-1 for the class of reclaimed wastewater utilized. Discontinue use if water quality does not meet the minimum provisions of Table B-1 for the water utilized.

3. Where a pond or basin serves as a storage basin for fire suppression, the water must be recirculated and a residual disinfectant must be applied to control regrowth.
4. Implement BMP's, such as signage, control structures and liners where appropriate.
5. Ensure appropriate worker training and worker safety provisions.
6. Ensure that plumbing within structures supplying reclaimed wastewater utilize the purple pipe or other approved identification system and are inspected to ensure they are not cross connected to any potable water supply within the structure(s).

i. Toilet or Urinal Flushing

Only reclaimed wastewater as classified in Table B-2 may be used for commercial business toilet or urinal flushing. These uses must be adequately signed to ensure the public is aware the facilities use reclaimed wastewater for this purpose.

The O&M document prepared by the designer must develop a means to ensure the following minimum level of operation is established. Systems utilizing this reuse approach must:

1. Ensure that plumbing within structures where toilets and urinals are supported by reclaimed wastewater utilize the purple pipe or other approved identification system and are inspected to ensure they are not cross connected to any potable water supply within the structure(s).
2. Document that the reclaimed wastewater continuously meets the provision of Table B-1 for the class of reclaimed wastewater utilized. Discontinue use if water quality does not meet the minimum provisions of Table B-1 for the water utilized.
3. Implement BMP's, such as signage, control structures and user safety as appropriate.

j. Washing Aggregate and Concrete Batching Operations

Only reclaimed wastewater as classified in Table B-2 may be used for gravel washing and batching operations associated with concrete plants. Water used must be limited to quantities which achieve the desired washing and batching, but do not result in a discharge to ground or surface waters. In no case shall this reclaimed wastewater be discharged to storm drains or stormwater collection systems with a surface water connection.

Use of reclaimed wastewater in concrete batching processes where the water is mechanically dispensed into the truck mixer drum through a metal chute, or as an on-truck water supply to use for maintaining and adjusting concrete slump is appropriate.

The O&M document prepared by the designer must develop a means to ensure the following minimum level of operation is established. Systems utilizing this reuse approach must:

1. Notify the permit program in advance if the reclaimed wastewater is a portion of effluent normally discharged through an associated permit.
2. Document that the reclaimed wastewater continuously meets the provision of Table B-1 for the class of reclaimed wastewater utilized. Discontinue use if water

quality does not meet the minimum provisions of Table B-1 for the water utilized.

3. Track the volume of effluent used for the washing and or batching operation.
4. Implement BMP's, such as signage, control structures and worker safety as appropriate.

k. Industrial Uses

Only reclaimed wastewater as classified in Table B-2 may be used for industrial operations. Water used must be limited to quantities which achieve the desired industrial need, but do not result in a discharge to ground or surface waters unless the industry obtains an appropriate discharge permit for that purpose.

In areas where workers may be exposed to, or come in direct contact with, reclaimed wastewater, a specific worker safety program must address potential and actual contact with the reclaimed wastewater. Although reclaimed wastewater can be deemed safe for workers after a given treatment, there are general precautions for hygiene, emergency situations, and ingestion that must be covered in O&M manuals or user agreements with the generator. Worker safety programs are viewed as part of proper management of the reclaimed wastewater after meeting permit requirements.

Reclaimed wastewater delivered to a commercial building must have adequate back-flow prevention on the domestic water line entering the building in accordance with Circular DEQ-1, Section 8.10 (Cross-Connections and Inter Connections). It is recommended that a cross connection management agreement be in place to protect the water supply in the building from cross connection with reclaimed wastewater.

1. On-Site Applications

Because suspended matter may exist in the reclaimed wastewater, certain features must be incorporated into the design of a project for safe and adequate distribution of the water.

(a) Strainers at Meter

Depending on the quality of reclaimed wastewater and the type of storage used, strainers may be required at the meter or service to building. Strainer types that are generally satisfactory are as follows:

- Wye strainers. Not recommended for belowground installations (in vaults).
- Basket strainers. Suitable for aboveground or belowground installations (in vaults).
- Filter strainers. Normally used above ground on drip systems.

In choosing the location, consider the following:

- Installation before any meter to protect the meter as well as the on-site reclaimed wastewater system. Maintenance of the strainer should be the responsibility of the reclaimed wastewater purveyor.

Strainers can range in mesh size from 20 to 325. A mesh size of 20 to 80 is normally adequate. An analysis of the potential debris in the reclaimed wastewater will aid in prescribing the optimum strainer size.

The O&M document prepared by the designer must develop a means to ensure the following minimum level of operation is established. Systems utilizing this reuse approach must:

1. **1.** Notify the permit program in advance if the reclaimed wastewater is a portion of effluent normally discharged through an associated permit.
2. **2.** Document that the reclaimed wastewater continuously meets the provision of Table B-1 for the class of reclaimed wastewater utilized. Discontinue use if water quality does not meet the minimum provisions of Table B-1 for the water utilized for the proposed use.
3. **3.** Ensure that plumbing within structures supplying reclaimed wastewater utilize the purple pipe or other approved identification system and are inspected to ensure they are not cross connected to any potable water supply within the structure(s).
4. **4.** Track the volume of effluent used via the industrial application.
5. **5.** Implement BMP's, such as signage, control structures and worker safety as appropriate.

l. Aquifer Recharge or Aquifer Injection

Only reclaimed wastewater as classified in Table B-2 may be used for the specific intent of replenishing groundwater. Although practices such as reclaimed wastewater irrigation may contribute to groundwater augmentation, the replenishment is an incidental byproduct of the primary activity and is not further discussed. Should the reuse project be proposed as a means of providing for aquifer recharge in a "closed basin" as defined in State law (MCA 75-5-410), the application must address the following:

"75-5-410. Water quality requirements – aquifer recharge or certain mitigation plans – minimum requirements. (1) (a) Except as provided in subsection (1)(b), a person who proposes an aquifer recharge or mitigation plan pursuant to 85-2-362 shall apply for, if necessary, a current permit pursuant to this chapter."

(b) The requirements of this section do not apply to the portion of a mitigation plan that consists of a change in appropriation rights for instream flow filed pursuant to 85-2-402.

(2) The minimum treatment requirements for sewage systems subject to this section are the federal requirements provided for in 40 CFR 133, and the system must meet, at a minimum, the requirements of level two treatment for the removal of nitrogen in the effluent.

(3) In addition to the minimum treatment requirements of subsection (2), sewage systems subject to this section that are used for aquifer injection must meet the more stringent of either primary drinking water standards pursuant to Title 75, chapter 6, or the nondegradation requirements pursuant to 75-5-303 at the point of discharge.

(4) In addition to the minimum treatment requirements of subsection (2), sewage systems subject to this section that are used for aquifer recharge must meet either primary drinking water standards pursuant to 75, chapter 6, or the nondegradation requirements pursuant to 75-5-303 at the point of discharge."

1. Purposes for Groundwater Recharge

Infiltration and percolation of reclaimed wastewater takes advantage of the natural removal mechanisms within soils, including biodegradation and filtration, thus providing additional in-situ treatment of reclaimed wastewater and additional treatment reliability to the overall reclaimed wastewater management system. The treatment achieved in the subsurface environment must not be considered for groundwater augmentation projects proposed for closed basins.

2. Methods of Groundwater Recharge

Groundwater recharge can be accomplished by surface spreading, vadose zone injection wells, or direct injection. These methods of groundwater recharge use more advanced engineered systems. With the exception of direct injection, all engineered methods require the existence of an unsaturated aquifer.

(a) Surface Spreading

Surface spreading is a direct method of recharge whereby the water moves from the land surface to the aquifer by infiltration and percolation through the soil matrix. This method must be compared against the following characteristics and rejected where it cannot be relied upon to achieve the desired objective:

- Rapid infiltration rates and transmission of water. Soil permeability should exceed 0.6 inches (15.2 mm) per hour to be considered.
- No layers that restrict the movement of water to the desired unconfined aquifer.

The following geologic and hydrologic characteristics must be investigated to determine the total usable storage capacity and the rate of movement of water from the spreading grounds to the area of groundwater withdrawal:

- Physical character and permeability of subsurface deposits
- Depth to groundwater
- Specific yield, thickness of deposits, position and allowable fluctuation of the water table
- Transmissivity, hydraulic gradients and pattern of pumping
- Structural and lithologic barriers to both vertical and lateral movement of groundwater
- Oxidation state of groundwater throughout the receiving aquifer

For surface spreading of reclaimed wastewater to be effective, the wetted surfaces of the soil must remain unclogged, the surface area must maximize infiltration and the quality of the reclaimed wastewater must not inhibit infiltration. Techniques for surface spreading may include ridge and furrow systems and infiltration basins.

Section 122 (Standards for Rapid Infiltration Systems) defines design constraints and parameters for rapid infiltration basins.

(b) Vadose Zone Injection

An advantage of vadose zone injection wells is the significant cost savings as compared to direct injection wells. The infiltration rates per well are often similar to direct injection wells. A significant disadvantage is that they cannot be backwashed and a severely clogged well can be permanently destroyed.

(c) Direct Injection

In many cases, wells used for injection and recovery are classified by the EPA as Class V injection wells and must be addressed as such in the planning stages.

Direct injection involves pumping reclaimed wastewater directly into the groundwater zone, which is usually a well-confined aquifer. Direct injection is used where groundwater is deep or where hydrogeologic conditions are not conducive to surface spreading. Such conditions might include unsuitable soils of low permeability, unfavorable topography for construction of basins, the desire to recharge confined aquifers, or scarcity of land.

For direct injection, locating the extraction wells as great a distance as possible from the recharge site, enhances the ability of the underlying aquifer to further treat and dilute the reclaimed wastewater.

Remediation in a direct injection system can be costly and time consuming. The most frequent causes of clogging are accumulation of organic and inorganic solids, biological and chemical contaminants and dissolved air and gases from turbulence. Very low concentrations of suspended solids, on the order of 1 mg/l, can clog an injection well. Even low concentrations of organic contaminants can cause clogging due to bacteriological growth near the point of injection.

Many criteria specific to the quality of the reclaimed wastewater, groundwater, and aquifer material must be considered prior to construction and operation. These include possible chemical reactions between the reclaimed wastewater and groundwater, iron precipitation, ionic reactions, biochemical changes, temperature differences, and viscosity changes. Most clogging problems are avoided by proper pretreatment, well construction, and proper operation. Injection well design and operations must consider the need to occasionally reverse the flow or back flush the well much like a conventional filter or membrane.

The O&M document prepared by the designer must develop a means to ensure the following minimum level of operation is established. Systems utilizing this reuse approach must:

1. Document that the reclaimed wastewater continuously meets the provision of Table B-1 for the class of reclaimed wastewater utilized. Discontinue injection if water quality does not meet the minimum provisions of Table B-1 for the water utilized.
2. Track the volume of effluent used for groundwater recharge.
3. Implement BMP's, such as signage, control structures and worker safety as appropriate.

m. Indirect Potable Reuse

Only reclaimed wastewater as classified in Table B-2 may be used for indirect potable reuse. Indirect potable reuse is the use of highly treated reclaimed wastewater to augment raw water supplies. The Department will review proposed "Indirect Potable Reuse" projects on a case-by-case basis. Any discharge to surface water must be authorized under an NPDES or MPDES permit, and the discharge will need to meet the provisions of the permit(s).

The O&M document prepared by the designer must develop a means to ensure the following minimum level of operation is established. Systems utilizing this reuse approach must:

1. Document that the reclaimed wastewater continuously meets the provision of Table B-1 for the class of reclaimed wastewater utilized. Discontinue injection if water quality does not meet the minimum provisions of Table B-1 for the water utilized.

2. Track the volume of effluent used to augment raw water supplies.
3. Implement BMP's, such as signage, control structures and worker safety as appropriate.

n. Stream flow Augmentation

Only reclaimed wastewater as classified in Table B-2 may be used for stream flow augmentation, the need for which may be dictated by various downstream water reservations or issues. Discharge must be authorized under an NPDES or MPDES permit, and the discharge will need to meet the provisions of the permit(s).

o. Snow Making

Only reclaimed wastewater as classified in Table B-2 may be used for snow making.

Reclaimed wastewater used for snow making may be approved by the Department if the applicant can demonstrate that public health and the environment will be protected. Snow making for use in augmenting ski slopes or where public exposure will be expected must be Class A-1 water and will only be allowed if the reclaimed wastewater is applied during times when the public will not be exposed to airborne particulate such as at night or on closed slope areas. Any discharge to surface water must be authorized under an NPDES or MPDES permit, and the discharge will need to meet the provisions of the permit(s).

Snow making as a means of storage with seasonal percolation, depending upon the proposed location and potential for public exposure, may be used with best management practices as a means of groundwater discharge. This approach would typically involve development of some form of impoundment to contain runoff and a means to optimize the hydrologic transfer of snowmelt to groundwater. Proposals for snow making will be reviewed on a case specific basis and pilot studies may be required to verify performance prior to final Department approval.

The O&M document prepared by the designer must develop a means to ensure the following minimum level of operation is established. Systems utilizing this reuse approach must:

1. Document that the reclaimed wastewater continuously meets the provision of Table B-1 for the class of reclaimed wastewater utilized. Discontinue use if water quality does not meet the minimum provisions of Table B-1 for the water utilized for the proposed use.
2. Track the volume of effluent used for snow making.
3. Implement BMP's, such as signage, control structures and worker safety as appropriate.

APPENDIX C

ALTERNATIVE COLLECTION SYSTEMS

C.1 GENERAL

These standards must be used for design of alternate wastewater collection systems. Alternative wastewater collection systems, as discussed in this chapter, include gravity or pressurized sewers carrying septic tank effluent, pressurized sewers carrying raw wastewater from grinder pumps, and combinations thereof.

Alternative sewer collection systems may only be used when the engineer provides detailed justification within an engineering report or facility plan per Chapter 10 (Engineering Reports and Facility Plans). This justification must document that conventional collection systems cannot be used at the proposed site. Appendix E (Capacity Development for Wastewater Systems) of Circular DEQ-2 must be adequately addressed in developing this justification.

C.11 Small Diameter Gravity Systems

Small diameter gravity (SDG) systems utilize septic tanks and small diameter sewer mains for the conveyance of wastewater to a centralized location for treatment. The removal of solids in the septic tank at each service connection enables smaller diameter pipes to be used. Solids must be removed from the septic tanks periodically. Since the liquid conveyed in an SDG system is generally septic, odor and corrosion issues for the downstream collection system may be a concern.

C.12 Septic Tank Effluent Pump Systems

Septic tank effluent pump (STEP) systems utilize septic tanks and small diameter force mains for the conveyance of wastewater. Septic tank effluent flows to a pump vault where it is pumped to a centralized collection system. The removal of solids in the septic tank at each service connection enables smaller diameter force mains to be used. Solids must be removed from the septic tanks periodically. Since the liquid conveyed in a STEP system is generally septic, odor and corrosion issues for the downstream collection system may be a concern.

C.13 Grinder Pump Systems

Grinder pump (GP) systems use a macerating type pump to grind the waste into a slurry, which is then pumped to a centralized sewer system for treatment. The slurry enables smaller diameter force mains to be utilized for the conveyance of sewage. Grinder pumps are commonly used in conjunction with conventional gravity collection systems where a particular service is located below the invert of a gravity collection pipe or there is insufficient vertical drop between the structure and the gravity pipe.

C.14 Combined Alternative Systems

Where SDG and STEP systems comprise a single collection system, the STEP units must not create a backpressure in the SDG lines that negatively impacts flow in the gravity main under all flow conditions.

C.2 MATERIALS/DESIGN CONSIDERATIONS

C.21 All piping, valves, pumps and other alternative sewer system components must be ASTM or ANSI/AWWA rated for wastewater applications. For small diameter components (less than 4”), the specified material must have a pressure rating of 200 psi. All system components must be constructed of material that is not readily subject to corrosion by raw or septic wastewater and able to withstand the pressures created during pressure cleaning.

C.22 Detection wires for locating buried pipe are recommended.

C.23 Cleanouts, air release structures or valve access vaults located in traffic areas must be designed to withstand normal traffic loads without damage.

C.24 Service lines, mainlines, force mains, and all other system components must be designed and constructed to prevent freezing. The minimum depth of bury must not be less than 6 feet to the top of pipe for pressurized pipes. The minimum depth of bury must not be less than 4 feet to the top of SDG pipe without justification by the design engineer.

C.24 Except as revised herein, the standards of Chapter 6 (Design of Sewers), and Chapter 7 (Septic Tanks) of Circular DEQ-4 also apply.

C.3 PEAK DESIGN FLOWS/ HYDRAULIC CONSIDERATIONS

C.31 Peak design flow must be based upon water use records when available. When water use records are not available the peak flow used in the pipeline design must be based on equation B.3-1:

$$\mathbf{Q = 20 + 0.5D} \qquad \textbf{(B.3-1)}$$

Where:
Q = Peak design flow, gpm
D = Homes (or equivalent dwelling units) served at full build-out

C.32 The Department may require that a hydraulic analysis (including pump head calculations and pump curves) be submitted to verify that the system will function as proposed.

C.4 SMALL DIAMETER GRAVITY SEWER DESIGN

C.41 Small diameter gravity (SDG) sewers may be used for filtered septic tank effluent only.

C.42 Hydraulic design must be based upon 1/2 to 3/4 full pipe at peak design flow (Equation B.3-1). A minimum design velocity equal to 1 ft/sec and a Manning roughness coefficient of 0.013 must be used.

C.43 All SDG sewer piping must be 4-inch (101.6 mm) diameter pipe or larger.

C.44 To minimize potential sources of infiltration, 20 foot (6.1 m) minimum pipe lengths and in-line service fittings should be used.

C.45 The installation requirements and performance tests specified in Chapter 30 (Design of Sewers) must be included in the technical specifications.

C.5 CLEANOUTS/MANHOLES

C.51 The limited use of manholes is encouraged. Cleanouts may be used in place of manholes at changes in grade, alignment, and at the end of each line to minimize infiltration, reduce odor potential, limit introduction of extraneous materials and reduce cost. Manholes must be located at major junctions of three or more pipes and limited to strategic locations for cleaning purposes. Watertight manhole covers are required for odor control and to limit inflow.

C.52 Manholes must be waterproofed and tested for watertightness and should be of the type, which has the base riser section cast with an integral floor. Manholes must meet the requirements of Section 34.6 (Watertightness) and Section 34.7 (Inspection and Testing).

C.53 Spacing of cleanouts and manholes depends upon cleaning capabilities. A maximum of 600 feet (182.9 m) for mechanically cleaned and jet-cleaned systems and a maximum of 1000 feet (304.8 m) for systems cleaned by pigging.

C.6 PUMP STATIONS FOR ALTERNATIVE COLLECTION SYSTEMS

In addition to the requirements of Chapter 40 (Wastewater Pumping Stations), the following standards apply to pump stations that pump septic tank effluent:

C.61 Pumps must be sized to pass the expected wastewater and for the proposed force main diameter. Filters or screens must be used to protect the pump(s) and force main from clogging.

C.62 Inlet pipes must be extended below the low water elevation in the wet well in order to reduce turbulence and odors.

C.63 The lift station wet well must have watertight covers for odor control and to limit inflow.

C.64 A vent must be provided with odor control. The vent can be connected to carbon, soil filters, or other odor control devices.

C.65 The force main sizing must be based on hydraulic requirements using a minimum design velocity of 1.0 ft/sec based on a Hazen-Williams friction coefficient of 130 to 140. The minimum pipe diameter for force mains is 1.5 inches (38.1 mm).

C.66 Leakage tests must be specified including testing methods and leakage limits.

C.7 SEPTIC TANK EFFLUENT PUMP (STEP) AND GRINDER PUMP (GP) SEWER DESIGN

One STEP or GP unit must be provided per household. Where multiple family dwellings or trailer courts are served, duplex pumps, each capable of handling maximum flow must be provided.

C.71 System hydraulic requirements for STEP systems must be based on a minimum design velocity of 1.0 ft/sec, and a Hazen-Williams friction coefficient of 130 to 140. System hydraulic requirements for GP systems must be based on 2ft/sec, and a Hazen-Williams friction coefficient of 120.

C.72 Pumping Units

C.721 STEP and GP units receiving wastewater from private sewers must be provided with pumps and controls that are corrosion resistant and are listed by Underwriters Laboratories, Canadian Standards Association, or other approved testing and/or accrediting agency as meeting the requirements for National Electric Code Class I, Division 2 locations. Submersible pumps and motors must be designed specifically for totally submerged operation and meet the requirements of the National Electric Code for such units. In addition, the design must provide for the pumps and motors to be totally submerged at all times.

C.722 Pumping units must be activated by appropriate level control switches. High and low level alarms will be required with audio-visual alarms recommended. Low level pump deactivation controls must be provided. A control panel with appropriate circuit protection and electrical safety devices must be used. The alarm circuit should be separately wired from the pump circuit. All applicable electrical codes must be satisfied. The power cables to the pump must be designed for extra-hard usage. Electrical components must be designed to facilitate maintenance of the pumping unit. Wiring must be exterior to the residence for maintenance purposes.

C.723 Pipe fittings used should be commonly available. Appropriate isolation, check, and air release valves must be used with ease of maintenance in mind. STEP and GP pumping equipment must be serviceable from the surface without requiring operations personnel to enter vaults, tanks or other enclosed spaces.

C.73 For systems served by a community water system, STEP and GP tanks must have a minimum of 24 hours of storage within the tank. Storage volume is defined as the volume between the pump "off" switch and the invert of the influent line. The engineer must review historical records of the local power provider to determine if the area has a history of prolonged power outages. Where such conditions exist, additional storage requirements or a backup generator may be required by the Department.

C.74 Inlet pipes to wet wells must be extended below the low water elevation in the wet well in order to reduce turbulence and odors.

C.75 Each service line between the STEP or GP pump and the collection line must be a minimum of 1-1/4 inch (31.8 mm) in diameter and have a gate or ball valve installed at the main with a stem and riser to the surface. In addition, a minimum of two check valves must be installed on STEP and GP service lines to prevent surcharge. A check valve integral to either the STEP or GP pump may be one of the check valves.

C.76 Sufficient mainline valves must be installed at locations to isolate portions of the system and to ensure continuous operation for maintenance and repair.

Isolation valves must be placed upstream of where two mains intersect and at the terminal end of the system to facilitate the future extension of the main. Valves must also be installed at railroad crossings, bridge crossings, waterway crossings, and long force main lengths.

C.77 STEP and GP sewers must be installed with cleanouts (pig ports) at the end of each line and at all line size changes to necessitate cleaning. Cleanouts must be designed to launch a minimum 2 lb/cu-ft polyfoam pig for scouring the pipelines.

C.78 Air relief valves must be placed at high points to prevent air locking. Vacuum relief valves may be necessary to relieve negative pressures on force mains. The force main configuration and head conditions should be evaluated as to the need for and placement of vacuum relief valves.

Where air release devices are used, odor control such as activated carbon, soil filters or other odor control must be provided.

C.79 Leakage tests must be specified including testing methods and leakage limits. Pressure testing of service lines must be completed with the ball valve at the mainline in the closed position. Pressure testing of the mainline must be completed with the service line ball valves in the open position to verify the effectiveness of check valves.

C.8 DISCHARGE TO A CONVENTIONAL COLLECTION SYSTEM

Discharge to a conventional gravity system must be made by installing a wye on the gravity main or by connection at a manhole. Drop manholes must not be used. Discharge in a manhole must be accomplished by producing a laminar flow in the manhole channel.

When a STEP or GP system is connected to a conventional force main, the engineer must provide hydraulic calculations that demonstrate the system pump(s) will operate across the expected range of head conditions.

C.9 CORROSION CONTROL

If required by the receiving wastewater facility owner, the effluent must be conditioned to reduce or eliminate the effects of hydrogen sulfide release. Conditioning may include aeration or chemical addition with enough contact time to stabilize the hydrogen sulfide prior to connection to the conventional collection system. Special consideration should be taken to ensure the structural integrity of concrete structures (manholes) immediately downstream of the septic effluent connection due to hydrogen sulfide release.

C.10 OPERATION AND MAINTENANCE

A complete and comprehensive Operation and Maintenance Manual (O&M Manual) is required for alternative collection systems. Two copies of the O&M Manual are required and must be submitted to DEQ for review and approval prior to start-up of the new system. Once approved by DEQ, a copy of the O&M Manual will be marked approved and provided to the Owner.

The O&M Manual must, at a minimum, include the following information: system description (including an overall system schematic plan showing the number of connections contributing to each reach, pump stations with pump sizing information, pipe routes and sizes, valve locations, etc.), routine inspection requirements and checklists, operation and maintenance responsibilities (including septic tank maintenance, odor control devices, etc.), cleaning strategies, trouble-shooting, equipment and component contact information, monitoring and sampling plan for operational purposes and permit requirements, solids handling plan, record keeping, operator safety (including confined space entry and H_2S exposure issues), an emergency response plan, and warranty information.

The wastewater system entity must maintain spare pumps and a supply of spare parts for both individual and central pumping units.

The design engineer must be retained by the system owner to provide technical assistance during system start-up and to modify the manual as needed during the first year of operation.

The municipality or sewer utility should be responsible for O&M of all system components to ensure a high degree of system reliability. General easement agreements are needed to permit access to components such as septic tanks or STEP units on private property.

Section E.4 of Appendix E includes additional financial O&M information that may be required by DEQ prior to approval of the project. The owner or design engineer should contact DEQ during plan approval to determine if Appendix E.4 will be required prior to plan and specification approval.

NEW APPENDIX D

GUIDELINES FOR SEWER REHABILITATION

Sewer rehabilitation work as described in this guideline shall only be used when the existing infrastructure complies with the standards defined in DEQ-2, Chapter 30, unless a deviation from those standards is first sought and secured by the engineer. A rehabilitation project must be submitted to the Department by an engineer for approval unless the Department has issued written clarification that the project can be considered maintenance and not system modification. Plans and specifications or other documents, sufficient to allow for this determination, must be submitted to the Department to allow for this written determination.

D.1 SEWER SYSTEM REHABILITATION/REPLACEMENT TECHNIQUES

The objectives of sewer system rehabilitation/replacement are principally to preserve structural integrity and reduce I/I. There are a number of products available from a variety of manufacturers and contractors to help meet these objectives. Sewer system owners should take care to verify that a certain class of product is suited for its proposed application and that a specific product and its installer meet appropriate guidelines, including successful performance history. The purpose of this section is to highlight the advantages, disadvantages, and other issues for the various classes of sewer rehabilitation/replacement products.

D.11 Sewer Mains

The rehabilitation/replacement techniques for sewer mains are discussed in Table D-1.

Table D-1
Rehabilitation/Replacement Techniques for Sewer Mains

Technique	Advantages	Disadvantages	Issues
Sliplining Sliplining is the insertion of a new pipe, either continuous (typically butt-fused HDPE) or segmented (typically PVC, ductile iron, or HDPE), of smaller diameter into an existing host pipe.	• Economical. • Strong. • Bypass pumping of sewage may not be needed (for segmented slipliner pipe).	• Hydraulic capacity reduced. • Entry pits usually required. • Service lateral connections must be excavated.	• Flotation of sewer must be prevented during grouting of annular space. • Condition of existing pipe may limit length of slipliner runs between pits, diameter of slipliner pipe, and/or lengths of segmented pipe pieces.
Cured-In-Place Pipe (CIPP) The CIPP lining process consists of inverting a resin-impregnated flexible tube into an existing sewer using hydrostatic head or air pressure. The resin is cured using heat.	• No access pits. • Service laterals can be internally reopened. • Minimal annular space. • Suitable for various cross-sectional shapes. • Strength can be selected as a function of sewer thickness and resin formula. • Manholes can be rehabilitated rather than replaced.	• Bypass pumping of sewage required. • Limited local competition.	• Liner wet-out with resin must be ensured. • Resin pot life must not be exceeded. • Proper curing temperatures and times must be maintained. • I/I must be controlled during installation. • Expertise and performance of manufacturer and installer must be ensured.
Fold-and-Form Lining The fold-and-form process involves inserting a heated PVC or HDPE thermoplastic liner, folded or deformed into a U-shape, into an existing sewer and rerounding the liner using heat and pressure.	• No access pits. • Service laterals can be internally reopened. • Manholes can be rehabilitated rather than replaced.	• Annular space allows migration of I/I unless service lateral connections are sealed. • Bypass pumping of sewage required. • Limited local competition.	• Sewer contraction during cooling induces stresses; consider use of materials with lower coefficients of thermal expansion/contraction and minimize installation tension. • I/I must be controlled during installation. • Expertise and performance of manufacturer and installer must be ensured.
Pipe Bursting Pipe bursting is a trenchless replacement technology. Through pipe bursting, the existing pipeline is fragmented and forced into the surrounding soil by pulling a bursting head through the sewer. A new pipe (typically butt-fused HDPE) of equal or larger diameter is pulled behind the bursting head. New manholes are usually provided at insertion and withdrawal pits.	• Creates a new, strong pipeline, not just rehabilitation of existing pipes. • Capacity can be increased. • Preparation of existing sewer is not critical.	• Entry pits are required. • Service lateral connections must be excavated. • Bypass pumping of sewage required. • Manholes must usually be replaced.	• Condition and location of adjacent buried utilities and foundations as well as surface improvements should be considered. • Dense or rocky soil may limit suitability of this method.
Point Repairs Point repairs can structurally rehabilitate and eliminate infiltration in short sections of sewers by such methods as short CIPP liners, epoxy resins, and structural grouting sleeves. Defects such as protruding laterals can be repaired by robotic grinding. Point repairs may be needed to properly prepare the sewer for some of the manhole-to-manhole rehabilitation/replacement options described in the techniques listed above.	• Economical. • Repairs only what is needed.	• May not be appropriate for old sewers if many more repairs may be needed in near future.	• Goals of project must be considered, along with cost estimates, to ensure manhole-to-manhole rehabilitation and replacement is not warranted.

D.12 Side Sewer Repairs

Side sewers (also referred to as private service laterals) are sewers that connect building drains on private property to the public sewer main in the public right-of-way or easements.

Research studies by EPA and others indicate that a significant percentage of system-wide I/I is caused by private property sources. These include sump pumps, foundation drains, roof drains, and defects in service laterals. Service lateral defects include cracked, broken, or open-jointed laterals. In addition, infiltration frequently occurs at a leaky connection of the lateral to the sewer main.

Repair of service lateral defects can be accomplished using many of the same methods listed above for sewer mains. Currently, chemical grouting, CIPP lining, and pipe bursting, in addition to open-cut excavation and replacement, are most widely used.

Removal of other private property I/I sources requires an effective public awareness and disconnection program.

In cases where sewage backups have occurred through service laterals and into buildings, installation of backwater valves provides an immediate solution until the longer term sewer system rehabilitation/replacement program shows results. Backwater valves are typically installed beneath basement floor slabs on that portion of the building drain serving the basement only. This allows plumbing fixtures on the main floor and above to drain even during times when the sewer main is surcharged.

D.13 Manhole Rehabilitation

Manhole rehabilitation can be performed to correct structural deficiencies, address maintenance concerns, and/or eliminate I/I. Some of the manhole rehabilitation options include lining, sealing, grouting, or replacing various components or the entire manhole. The rehabilitation method selected depends on whether inflow or infiltration, or both, are to be eliminated and whether structural integrity is an issue.

Inflow typically occurs through holes in the manhole cover or around the manhole frame and cover. Manhole covers can be sealed by replacing them entirely with new watertight covers, or by sealing existing covers with rubber-covered gaskets, rubber vents, and pick-hole plugs, or by installing watertight inserts under the existing manhole covers (inflow protectors). Inflow protectors should contain vacuum and gas release valves.

Chemical grouting is commonly used to eliminate infiltration.

D.14 Trench Excavation for System Repairs and Retrofits

Pipeline separation is a necessity for protection of public health and safety, property, and the quality of the product in the pipeline. Pipeline failure or leaks result in contamination of the pipeline product that leads to a public health and safety risk. The process of excavating one pipeline to repair a leak increases the risk of complete failure of adjacent pipelines. This can also be a concern when excavating trenches for reclaimed wastewater retrofit project.

NEW APPENDIX E

CAPACITY DEVELOPMENT FOR PUBLIC SEWAGE SYSTEMS

E.1 GENERAL

In addition to the information required in the circular, information on management, operation, maintenance, and financing of the system must be submitted. The purpose of this information is to allow evaluation of a new system for proper system management, operation and maintenance (O&M), and financial planning that provides long-term stability of the new system.

Capacity terms are defined as follows:

Managerial capability (capacity) means the management structure of the system, including but not limited to ownership accountability, staffing, and organization.

Technical capability (capacity) means the operation and maintenance resources of the system, including but not limited to technical knowledge, experience and adequate staffing.

Financial capability (capacity) means the financial resources of the system, including but not limited to the revenue sufficiency, credit worthiness, and fiscal controls.

The Department is granted the authority in Title 75, Chapter 6, Part 103 (2)(f), MCA, to ensure the financial, managerial, and technical viability of proposed public sewage systems.

E.2 MANAGERIAL CAPACITY

Provide the following information:

E.21 Name, address, and telephone number of the owner(s). If ownership is to change in the near future, such as in a subdivision where the developer will eventually relinquish ownership to another responsible entity, provide a projected timeline for change of ownership.

E.22 Administrative and management organizational charts. Define the functions and responsibilities of the organization and each administrative/managerial position. For example, if the organization has a secretary, provide a brief description of the secretary's responsibilities.

E.23 Plans for staffing the system with a certified operator and back-up operator. Provide the name of the operator if an operator has been selected. An operator should be available to operate the system even if the system has not yet become public. If the system is operated under contracted services, provide a copy of the contract.

E.24 A system or plan for maintaining records, plans and specifications for construction, as-built drawings, O&M manuals, collection system histories/maps, and compliance information. Preferably, an office space should be dedicated for storing all information so that it is readily accessible by the operator, manager(s), and owner(s) of the system.

E.25 If applicable, copies of the articles of incorporation, by-laws, or similar documents that provide the following information:

- **a.** Define the purpose of the responsible entity.
- **b.** Describe the procedures for compliance with the requirements of the Secretary of State's Office for creating and maintaining a non-profit association.
- **c.** List membership and define membership rights (all lot owners should automatically become members unless they are not in good standing, which should be defined).
- **d.** Define the format and schedule for meetings and requirements for quorums.

e. Describe the powers and duties of the board of directors.

f. Describe the process for transferring control of the system from the developer to lot owners where applicable.

g. Explain the procedures for amendment of the by-laws.

h. Confer authority to assess and collect fees for O&M, monitoring, personnel, capital improvements and equipment replacement.

i. Establish the service area of the responsible entity.

j. Confer authority to require installation of backflow prevention devices and to maintain such devices where appropriate.

Also, provide policies on how delinquent accounts, system violations, fee changes, and customer complaints will be addressed. The responsible entity must file its Articles of Incorporation with the Secretary of State.

E.26 In the event a responsible entity becomes insolvent, how will perpetuation of the system be maintained? Has a second party been considered for future ownership in the event that the responsible entity becomes insolvent?

The managerial plan must provide for:

a. Efficient operation of the system.

b. Adequate control of and accountability for the system by the owner(s), manager(s), and operator(s).

c. Adequate resources and accountability for regulatory compliance by the owner(s), manager(s) and operator(s).

d. Dissemination of information to all customers and the regulatory agencies.

E.3 TECHNICAL, OPERATIONAL, AND MAINTENANCE CAPACITY

Provide the following information in the form of an O&M manual that will be available to the operator(s), owner(s), and manager(s):

E.31 An explanation of startup and normal operation procedures. Startup should address operation of the system throughout system build-out if applicable (i.e., a subdivision will experience varying demands as the subdivision develops and builds out).

E.32 Will any equipment be leased or rented? Are easements or lease agreements necessary for any portion of the system? If applicable, provide pertinent information (i.e., copy of easement or lease agreement). Are changes in local zoning necessary to protect the proposed source(s)?

E.33 Record keeping method and system for reporting to the Department.

E.34 Sampling and analyses program to demonstrate compliance with any applicable discharge permit.

E.35 Staffing and training requirements to operate the system in compliance with any applicable approval statements and discharge permit(s).

E.36 Documentation of a safety program.

E.37 Documentation of an emergency plan and operating procedures (e.g., in the case of equipment failure or loss of power).

E.38 Manufacturers' manuals for all equipment and contact names for service. A routine maintenance program and maintenance schedules must also be included. Forms for recording routine maintenance checks per manufacturers' guidelines should be provided, including recording the frequency of maintenance and anticipated replacement dates for major equipment.

E.39 If a mechanical or other advanced level treatment facility is being proposed, the applicant must submit a plan of operation which commits the owner(s) as follows:

- **a.** Staffing levels anticipated (i.e. number and qualifications of operational staff),
- **b.** Documentation that operations staff is available and is, or will be qualified to operate the facility prior to the facility being activated.
- **c.** Annual training and enhancement budget,
- **d.** Adequate operations budget to maintain qualified staff, with provisions for long-term retention based pay.

Items E.31 – E.35 must be submitted in the form of an O&M manual prior to approval of the system. Item E.39 must be submitted in the form of a Plan of Operation prior to approval of the system.

A letter from the applicant must be provided prior to the system being used indicating that the system (or portion of the system that has been completed) was constructed in conformance with the approved plans and specifications. As-built record drawings for the system (or portion of the system that has been completed) must be provided within 90 days after the system has become operational. The as-built record drawings must include an O&M manual addressing items E.31 through E.39 and containing manufacturers' manuals and other pertinent information to complete the O&M manual.

The manual must demonstrate that the system will be operated in a manner to:

- **a.** Maintain compliance with the Montana Water Quality Act and any discharge permit.
- **b.** Allow effective operation of the system in accordance with the approved plans and specifications.
- **c.** Remain consistent with operating conditions presented in the engineer's report..

E.4 FINANCIAL CAPACITY

The following financial information must be submitted prior to receiving approval of the system:

E.41 The financial information in Table E-1 must be completed for a 5 year period.

E.42 O&M rates and capital improvement/replacement rates must be developed based on information in Table E-1. A capital improvement/replacement plan must be developed for a 20-year period and the rate set accordingly. A reserve fund must be established and maintained to address future replacement of equipment based on anticipated replacement dates for equipment?

E.43 Demonstrate how monthly sewer rates are established for each connection (e.g., meter readings, water service size, etc.)

E.44 Connection/system development fee and basis for fee, if applicable.

E.45 A description of the owner(s) or responsible entity’s access to financial capital? If a large sum of money is necessary for replacement, improvement, or expansion, can the owner(s) or responsible entity obtain a loan or grant?

E.46 Budgetary controls and audit schedule.

E.47 If the system is privately owned, has the Department of Public Service Regulation been contacted?

E.48 Provide a financial plan that demonstrates that all improvements will be constructed in conformance with the proposed plans and specifications. If bonding has been provided with a regulating entity (such as the county) for improvements, provide information on the bonded improvements.

The financial plan must demonstrate:

a. Revenues exceed expenses.

b. Adequate funds will be maintained for replacement of equipment.

c. A reserve account will be maintained.

d. The budget will be controlled, preferably by audits every 3 to 5 years.

e. The 5-year cash flow presented in Table E-1 is sufficient to properly operate the system.

f. That all proposed improvements will be constructed and in accordance with the approved plan and specifications.

TABLE E-1 - SYSTEM BUDGET

Applicant: Completed by: Date:

5 Year Projections	Year 1 Projected	Year 2 Projected	Year 3 Projected	Year 4 Projected	Year 5 Projected
Enter Year:					
1. Beginning Cash on Hand					
2. Cash Receipts: a. Total Revenues					
b. Connection Fees					
c. Interest and Dividend Income					
d. Other Income					
e. Total Cash Revenues (2a thru 2d)					
f. Transfers in/Additional Rev Needed					
g. Loans, Grants or other Cash Injection					
h. other - please specify					
3. Total Cash Receipts (2e thru 2h)					
4. Total Cash Available (1 + 3)					
5. Operating Expenses a. Salaries and wages					
b. Employee Pensions and Benefits					
c. Purchased Water					
d. Purchased Power					
e. Fuel for Power Production					
f. Chemicals					
g. Materials and Supplies					
h. Contractual Services - Engineering					
i. Contractual Services - Other					
j. Rental of Equipment/Real Property					
k. Transportation Expenses					
l. Laboratory					
m. Insurance					
n. Regulatory Commission Expenses					
o. Advertising					
p. Miscellaneous					
q. Total Cash O & M Expenses (5a + 5p)					
r. Replacement Expenditures					
s. Total O M & R Expenditures (5q + 5r)					
t. Loan Principal/Capital Lease Payments					
u. Loan Interest Payments					
v. Transfers Out					
w. Capital Purchases (specify)					
x. Other					
6. Total Cash Paid out (5s thru 5x)					
7. Ending Cash Position (4 - 6)					
8. Number of Customer Accounts					
9. Average Annual User charge Account users:(2a/8)					
10. End of Year Reserves a. Debt Service Reserve					
b. Bond Retirement Reserve					
c. Capital Improvement Reserve					
d. Replacement Reserve					
e. Total Reserves (10a thru 10 d)					
11. End of Year Operating Cash (7 - 10e)					