Recommended Design Criteria Manual

Wastewater Collection and Treatment Facilities

South Dakota Department of Environment and Natural Resources

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NOTICE

Any mention of trade names or commercial products in this publication is for illustration purposes and does not constitute endorsement or recommendation for use by the South Dakota Department of Environment and Natural Resources.

This publication is intended to establish uniformity of practice and to serve as a guide in the design and preparation of plans and specifications for compliance with the minimum requirements of the reviewing authority. The design review of the reviewing authority is primarily to determine compliance with the minimum sanitary engineering requirements and does not cover items, such as, quality of material, structural soundness, electrical and mechanical design features. The Department expressly disclaims any liability in regard to the construction or operation of a planned facility. Approval of the plans and specifications does not in any way release the applicant from the responsibility that the facility will meet all applicable State and Federal Standards when the facility is operational.

FOREWORD

In recognition of the needs for continued protection of public health and the waters of the State, the South Dakota Department of Environment and Natural Resources is revising and expanding the Recommended Design Criteria for Wastewater Collection Systems and Wastewater Treatment Facilities.

These criteria are prepared and intended to assist engineers to establish uniformity of practice in preparing plans and specifications by providing technical information and suggesting limiting values for items upon which an evaluation of such plans and specifications will be made by the reviewing authority. Where the term "shall" or "must" is used, it is intended to mean a mandatory requirement insofar as any confirmatory action by the reviewing authority is concerned. Other terms such as "recommended, should, preferred," and the like indicate discretionary use on the part of the reviewing authority and deviations are reviewed on a "case-by- case" basis.

These criteria are subject to future modifications and revisions based upon operational experience and technological development. Any questions or suggestions concerning these criteria should be directed to the Division of Environmental Regulation, Department of Environment and Natural Resources, Joe Foss Building, Pierre, South Dakota 57501.

SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

DIVISION OF ENVIRONMENTAL SERVICES

Recommended Design Criteria Manual

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CHAPTER I

GENERAL CONSIDERATIONS

A. General Statement

The factors governing design of wastewater treatment facilities are complicated and extensive. Assimilative capacity of receiving streams, protection of public health, and propagation of fish and wildlife, etc., are taken into consideration when the State and Federal governments issue a wastewater discharge permit. This permit regulates the quality of the treated wastewater discharge. In addition to the need for meeting the permissible discharge conditions, the design necessitates compliance with the criteria of being practical and cost-effective. All discharging wastewater treatment facilities are to be designed and constructed to provide at least secondary treatment capable of producing effluent in compliance with Federal and State laws, regulations, and Water Quality Standards.

Wastewater collection systems, from the place where wastewater is generated to the place where wastewater is treated, shall be properly designed in accordance with the projected community growth. Capacities of the systems shall be adequate to accommodate the peak hydraulic demand and to eliminate hydraulic surge within the system or overflow of wastewater from the system.

B. Administrative

All engineer's reports, plans and specifications shall be submitted to this Office and contain the supporting information for collection systems and wastewater treatment facilities as required by Chapter 10, Recommended Standards for Wastewater Works, 1978 or the latest edition. The standard procedure for submission and processing of such plans and specifications for review and approval is as follows:

1. Two or more sets of plans and specifications, depending upon funding sources involved, shall be submitted to this Office together with such additional information as may be required for review and approval of the items of sanitary significance. One complete set of approved plans and specifications shall become the property of this Department.

2. Facility plans, design plans, and specifications submitted to the reviewing authority must bear a seal or stamp of a registered professional engineer, architect or land surveyor licensed to practice within the State of South Dakota. In addition to these professions, it will be permissible for plumbers licensed to practice within the State of South Dakota to submit plans and specifications for minor projects involving house and community development sewers.

3. Plans and specifications shall be submitted at least thirty days prior to the date from which the owner desires action by the approving authority.

4. There shall be no deviation from the approved plans and specifications without first submitting revised plans, specifications or addenda to the plans and specifications to the

reviewing authority and receiving written supplemental approval. Department approvals become void after two years if construction is not initiated prior to that time.

5. The Department is to be notified when systems or works are to be constructed and placed into service.

6. A complete copy of as-built plans, specifications, addenda and all change orders shall be furnished to the owner. One complete set shall also be furnished to this Department.

7. All plans shall include information on ownership, lease and/or easement rights, whether permanent or temporary, to the property to be used for projects involving collection systems and treatment plant facilities.

8. A complete copy of the Operation and Maintenance Manual shall be furnished to the owner and to this Department for projects involving mechanical facilities including pumping stations and treatment facilities.

C. Engineering/Planning

1. Design Period - In general, wastewater collection systems should be designed for the estimated ultimate contributory population, except in considering parts of the systems that can be readily increased in capacity. A wastewater collection system should ordinarily be designed to provide for the projected population 20 years hence with a design life of 40 years. A wastewater treatment facility shall ordinarily be designed to provide for the projected population at least 15 years hence. Whenever cost-effectiveness permits, the construction may be programmed in stages. Similarly, consideration should be given to the maximum anticipated capacity of future institutions, industrial parks, etc.

2. Design Basis - Generally in larger communities having wastewater flows of one (1) MGD or more, a person will generate 100 gallons of wastewater per day containing 0.17 pounds of BOD5. From a hydraulic loading and organic loading standpoint, this represents "One population equivalent (P.E.)." This equivalent population flow, 100 gallons per captia per day (gpcd), is generally accepted as the upper limit for domestic flow projection on a daily average basis for new wastewater systems serving large communities. Suspended solids (SS) concentrations from domestic flows can be reasonably assumed to contain 0.2 pounds of suspended solids per capita per day. If the use of garbage grinders in a system is significant, then the design basis should be increased to 0.22 pounds of BOD5 and 0.25 pounds of suspended solids per capita per day.

   If wastewater flow data are not available, the design average daily flow shall be based on 75 gpcd for communities with flows less than 1 MGD. An alternate method to determine design capacity could be justified by local water consumption records but shall not be less than 60 gpcd. These records should generally be based on the average monthly usage for the months of December, January, and February. Special consideration may be needed for communities with highly varying seasonal consumptive water use such as tourism and certain seasonal industrial uses. Projected wastewater flows for a community could be calculated by using 80 percent of the actual water consumption. Allowances shall be made for infiltration, inflow and significant commercial/ industrial waste flows which will be added to the per capita flow rate.

If no actual data on infiltration is available, an assumed infiltration design allowance for existing sewers should be added to the design flow. For existing systems, the minimum infiltration design allowance for the existing sewers and service lines shall be no less than 200 gallons per inch of pipe diameter per mile of pipe per day. The department recommends that actual flow measurements to determine infiltration rates be conducted for those communities that have collector sewers that lie below the groundwater table.

3. Design Flows

   a. Average Daily Flow: This rate is determined by totaling all of the average flows for existing contributing sources based on a 24-hour period in which these flows are all generated during dry weather conditions. This rate is generally used to determine items such as costs, solids loading and organics loading.

   b. Minimum Flow: This rate will be based on 50 percent of the average daily flow if flow measurements are not available.

   c. Design Average Flow: This rate is determined to be the total of the projected population design domestic flow, additional maximum design wastewater flow from commercial/industrial plants, existing inflow and groundwater infiltration during wet weather flows.

   d. Peak Design: This rate is generally used to determine hydraulic sizing and mass loading of treatment units by multiplying a factor of 2.0 to 2.5 times the design average flow rate.

   e. Peak Hourly Flow: This rate shall be the ratio of peak diurnal flow to daily average flow shall be multiplied times the daily average flow as determined by Figure 1. Use of other values for peak hourly flow will be considered if justified on the basis of extensive documentation.

      The design for various components of the wastewater collection system (collector sewers, interceptor sewers, pumping stations) will be based on peak hourly flow. Force mains from pumping stations will be sized to handle the pumping capacity of the station.

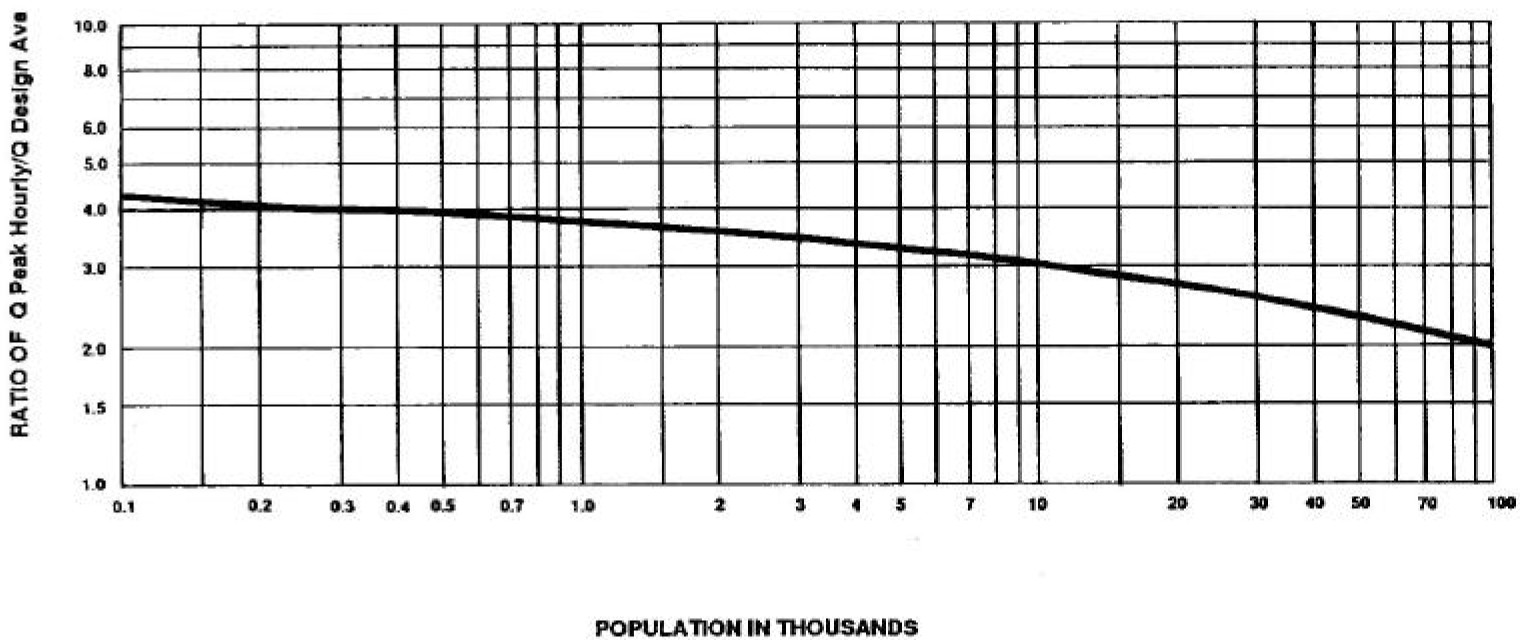
      The design for various components of the treatment plant will be based upon either peak design flow or peak hourly flow. Generally, the organic loading of a wastewater treatment unit is based on the design average flow and the hydraulic loading of a unit is based on the peak design flow. Where recirculation is provided, the recirculation rate shall be added as required.

      The design criteria for each flow rate will be designated in the Chapter pertaining to that particular unit or component.

4. New Process or Equipment - Consideration should be given whenever a new process or equipment is involved in the design, documentation of reliability and applicability in full-scale operations is recommended. Consideration should also be given to the availability of maintenance services or a convenient alternative in the event of mechanical failures. When an existing treatment works is to be upgraded or expanded, the component parts of the facility should be arranged for convenience of operation and maintenance, flexibility, economy and continuity of equipment.

5. Safety - All mechanical and treatment units should have adequate safety provisions for the personnel concerning occupational health and physical safety.

FIGURE 1.
RATIO OF PEAK HOURLY FLOW TO DESIGN AVERAGE FLOW



Q peak hourly: Maximum Rate of Wastewater Flow (Peak Hourly Flow)

Q design ave: Design Average Daily Wastewater Flow

Source: Q Peak Hourly/Q Design Ave $= \dfrac{18 + \sqrt{P}}{4 + \sqrt{P}}$ ... (P = population in thousands)

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

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CHAPTER II
RECOMMENDED DESIGN CRITERIA FOR SEWERS

A. Engineer's Report, Plans, and Specifications

Information for sewer systems must be submitted as required by Chapter 10, Recommended Standards for Wastewater Works, 1978 or the latest edition.

B. Types of Sewers

1. Community Sewers - In general, and except for special reasons, the Department will approve plans for new systems, extensions, or replacement sewers only when designed upon the separate plan, in which rain water from roofs, inflow from streets and other areas, and groundwater from foundation drains is excluded. "Combined" sewers are not permitted unless provisions have been made for directing and treating the overflows.

2. House Sewers - House sewers conveying raw wastewater to public sewers should meet all requirements of the State Plumbing Code and the plumbing code of the local authority having jurisdiction, as well as the following:

   a. They shall be of asbestos cement, plastic, cast iron, concrete, vitrified clay or other material of 1,200 pound crush strength or heavier.

   b. They shall have a nominal inside diameter of not less than four inches.

   c. House sewer joints and connections to public sewers should be watertight and root proof.

   d. House sewers should be laid on a slope of 1/4 inch per foot and in no case less than 1/8 inch per foot.

   e. House sewers shall not be directly connected to manholes.

   f. Abandoned disposal systems shall be disconnected from buildings and plugged. All receptacles or excavations in which such receptacles were contained shall be filled with earth. Prior to filling, receptacle contents shall be pumped out and disposed of in a manner to eliminate pollution.

3. Industrial Sewers - Any industrial hook-ups; such as restaurants, rendering plants and service stations should have adequate pretreatment facilities for grease and grit collection in order to prevent clogging of collection lines and wear of components in discharge lines.

C. Design Period - Refer to Chapter I.

D. Design Factors

In determining the required capacities of sanitary sewers, the following factors should be considered:

1. Peak hourly wastewater flow from residences.

2. Additional maximum wastewater flow from industrial plants and institutions.

3. Groundwater infiltration and inflow.

4. Capacity of pumps in wastewater pumping stations.

E. Design Basis

1. Per Capita Flow - New sewer systems shall be designed on the basis of an average daily per capita flow of wastewater of not less than 100 gallons per day. This figure is assumed to cover a small amount of infiltration, but an additional allowance should be made where a large amount of infiltration is present.

    a. Design capacity for laterals and sub-mains - Full running capacity of not less than 4 times the design average daily flow per capita per day.

    b. Design capacity for large sewers - Full running capacity of not less than 2.5 times the design average daily flow per capita per day or peak hourly flow, whichever is greater.

2. Alternate Method - If water consumption records are available, refer to Chapter I. When deviations from the foregoing per capita rates are demonstrated, a description of the procedure used for sewer design shall be included.

F. Gravity Sewer Design and Construction

1. *Minimum Size* - No community sewer receiving raw wastewater shall be less than six inches in diameter, however, eight inch diameter sewers are recommended. Six inch diameter pipe may be used as laterals where there are relatively low flows, a small number of people to be served, future extensions not anticipated and the sewer is capable of handling the design flows. The justification for using the six-inch pipe shall be provided by the consultant. The operating authority shall be made aware of the added possibility of cleaning problems which shall require their acceptance of any additional maintenance.

    Sewers receiving treated or partially treated wastewater and capable of handling the design flows may be four inches in diameter where adequate justification and documentation is provided. See Section N in this Chapter for EPA funded projects criteria.

2. *Depth* - Gravity sewers should be placed deep enough to serve all basements, assuming a 2 percent grade on house sewers (absolute minimum of 1 percent). They should be well below the frost line at all points and lower than any water lines placed in the same street. Where freezing conditions could occur, sewer lines should be provided with sufficient insulation or a raised berm for cover.

3. *Slope* -

a. All sewers shall be so designed and constructed to give mean velocities, when flowing full, of not less than 2.0 feet per second, based on Manning's formula using an "n" value of 0.013. Based on an "n" value of 0.013, the following are the minimum slopes which should be provided; however, slopes greater than these are desirable:

Sewer	**Minimum Slope**
	Ft/100 feet
4 inch	1.05
6 inch	0.60
8 inch	0.40
10 inch	0.28
12 inch	0.22
14 inch	0.17
15 inch	0.15
16 inch	0.14
18 inch	0.12
21 inch	0.10
24 inch	0.08
27 inch	0.067
30 inch	0.058
36 inch	0.046

b. Depending on the type of pipe, other practical "n" values may be permitted by the Department if deemed justifiable on the basis of research or field data presented. Slopes slightly less than those required for the 2.0 feet per second velocity when flowing full may be permitted. Reduced slopes will be permissible if a minimum velocity of 1.8 feet per second can be maintained and if detailed justifiable reasons are given; such as, a sewer serving a limited area or the elimination of a sewage lift station. 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. Whenever such decreased slopes are selected, the design engineer must furnish with his report his computations of the depths of flow in such pipes at minimum, average, and daily or hourly rates of flow. The operating authority shall be made aware that decreased slopes may cause additional sewer maintenance expense and septic conditions. Sewer size shall be based on design flows and not the grade that is available.

c. Sewers shall be laid with uniform slope between manholes.

d. Sewers on 20 percent slope or greater shall be anchored securely with concrete anchors or equal, spaced as follows:

1) Not over 36 feet center to center on grades 20 percent and up to 35 percent.

2) Not over 24 feet center to center on grades 35 percent and up to 50 percent.

3) Not over 16 feet center to center on grades 50 percent and over.

4. *Alignment* - Sewers 24 inches or less shall be laid with straight alignment between manholes except where street or road layouts are such that straight alignment between manholes is impractical, sewers may be curved to conform with their curvature. The radius of curvature shall not be less than 100 feet and the deflection angle shall not exceed the manufactures recommendations at any joint or point on the pipe. It is suggested that the sewer curvature be made concentric with the street curvature to simplify layout work and locating the lines at a later date. An alignment test such as "balling" must be conducted on curved sewers. The entity responsible for maintenance should be cognizant of the fact that additional maintenance may be necessary and small diameter sewers will require jet-cleaning machines.

5. *Increasing Size* - When a smaller sewer joins a larger 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 of flow point of both sewers at the same elevation. Generally, sewers should not decrease in size in the downstream direction.

6. *High Velocity Protection* - Where velocities greater than 15 feet per second are attained, sewers shall be anchored securely with concrete anchors or equal to protect against displacement by erosion and shock. The design shall be such to prevent turbulence and deterioration of the receiving manhole.

7. Materials, Trenching and Installation - 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 and similar problems.

   Installation specifications shall contain appropriate requirements based on the criteria, standards and requirements established by industry in its technical publications. Requirements shall be set forth in the specifications for the pipe and methods of bedding and backfilling thereof so as not to damage the pipe or its joints, impede cleaning operations and future tapping, nor create excessive side fill pressures or ovalation of the pipe, nor seriously impair flow capacity. The design engineer should consult the various ANSI and ASTM specifications or industry literature for information on pipe bedding classes for each pipe material used in the design. When trenching, all rock shall be removed within 6 inches of the pipe. The trench shall be dewatered for all work. Open trench time should be considered and all pipe ends plugged when installation of pipe is halted.

   In all cases, suitable backfill or other structural protection shall be provided to preclude settling and/or failure of the higher pipe.

   Backfill shall not contain debris, frozen material, large clods or stones, organic matter or other unstable material. Stones larger than 3 inches in diameter shall not be placed within 2 feet of the top of the pipe. Compaction shall be to a density at least equal to the surrounding soil or existing roadway conditions.

All sewers shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the sewer shall be made because of the width and depth of trench. When standard strength sewer pipe is not sufficient, the additional strength needed may be obtained by using extra strength pipe or by special construction. Deflection tests shall be performed on pipe after final backfill has been in place at least 30 days. No pipe shall exceed a deflection of 5%.

8. *Joints and Infiltration* - The method of making joints and materials used should be included in the specifications. Sewer joints shall be designed to minimize infiltration and to prevent the entrance of roots.

   Leakage tests shall be specified. This may include appropriate water or low pressure air testing. The leakage outward or inward (exfiltration or infiltration) shall not exceed 200 gallons per inch of pipe diameter per mile per day for any section of the system. The use of a television camera or other visual methods for inspection prior to placing the sewer in service is recommended.

9. Calculations - Computations should be presented, in a tabular form, to indicate depths and velocities at minimum, design average and peak hourly waste flow for the different sizes of sewers proposed.

G. Manholes

1. *Location* - Unless necessary, manholes should not be located in drainageways. If any flooding over manholes is anticipated; they shall be provided with watertight covers. Manholes shall be installed at the end of each line; at all changes in grade, size, or alignment; at all intersections; and at distances not greater than 400 feet for sewers 15 inches or less, and 500 feet for sewers 18 inches to 30 inches, except that distances up to 600 feet may be approved in cases where adequate cleaning equipment for such spacing is provided. Greater spacing may be permitted in larger sewers and in those carrying a settled effluent. The distance between manholes for sewers less than 15 inches in diameter may be increased to 450 feet if justification is provided by the consultant.

2. *Cleanouts* - Cleanouts may be used only for special conditions and shall not be substituted for manholes nor installed at the end of laterals greater than 150 feet in length. Cleanouts shall be provided on all service lines in accordance with State Plumbing Code. The cleanout shall be constructed using a 45 degrees bend directed downstream on vertical riser pipe to the surface. Size of the cleanout shall be the same as the pipe size.

3. *Drop Type* - A drop pipe shall be provided either inside or outside for a sewer entering a manhole at an elevation of 24 inches or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than 24 inches, the invert should be filleted to prevent solids deposition.

Inside drop connections shall be secured to the interior wall of the manhole and provide adequate access for cleaning. For exterior drop connections, the entire outside drop connection shall be encased in concrete.

4. *Diameter* - The minimum diameter of manholes shall be 48 inches. The size of the manhole access shall be 22 inches or larger in diameter.

5. *Flow Channel* - The flow channel through manholes should be made to conform in shape and slope to that of the sewers.

6. *Watertightness* - The specifications shall include a requirement for inspection of manholes for watertightness prior to placing into service and shall not exceed leakage limits for sewers. Watertight manhole covers or raised manhole frames and covers are to be used wherever the manhole tops may be flooded by street runoff or high water. Manholes of brick or segmented block should be waterproofed on the exterior with plaster coatings; supplemented by a bituminous waterproof or epoxy coating where groundwater conditions are unfavorable.

7. *Safety and Vandalism* - It is recommended that entrance into manholes contain provisions for portable ladders. Consideration should be given for providing a means of ventilation for deep manholes.

   Locked manhole covers may be desirable where vandalism or unauthorized dumping may be a problem.

H. Inverted Siphons

Inverted siphons shall require at least two barrels, with a minimum pipe size of six inches and shall be provided with necessary appurtenances for convenient flushing and maintenance; the manholes shall have adequate clearances for rodding; and in general, sufficient head shall be provided and pipe sizes selected to secure velocities of at least 3.0 feet per second for average flows. The inlet and outlet details shall be designed to permit the normal flow to be diverted to one barrel while the other barrel may be taken out of service for cleaning. The joints should not exceed 45 degrees bends to easily accommodate cleaning equipment.

I. Stream Crossings

1. *Cover Depth* - The top of sewers when entering or crossing streams shall be at a sufficient depth below the natural stream bed to protect the sewer line. The following cover requirements should be met:

   a. One foot of cover where the sewer is located in rock.

   b. Three feet of cover or more is required in other material depending on size of stream.

   c. In paved stream channels, immediately below the pavement.

d. Shallow and intermittent streams may require insulating materials.

2. *Alignment* - Sewers crossing streams should be designed to cross the stream as nearly perpendicular as possible with no change in grade.

3. *Materials* - Sewers entering or crossing streams shall be constructed of cast or ductile iron pipe with mechanical joints or other watertight materials, encasements, and anchored so no changes in alignment or grade will occur.

4. Sediment and Erosion Control

   a. Refer to Department Guide, BMP's "Best Management Practices".

   b. "404" Permit for large streams.

J. Aerial Crossings

1. Supports shall be provided to maintain the alignment and support of pipe along the aerial crossing.

2. Precautions against freezing, such as insulation and increased slope, shall be provided. Expansion jointing shall be provided for sections of pipes entering the below-ground sewers.

3. Consideration shall be given to floating debris and flood waters. The pipe should be no lower than the elevation of a hundred year (100) flood.

K. Outfalls

1. Outfall sewers and structures shall be designed and constructed to provide:

   a. Protection of the sewer against excessive receiving stream velocities, waves, floating debris, or other hazards which may damage the outfall works.

   b. Protection of the sewer from entrance of floodwater.

   c. Protection of the sewer from entrance of wildlife.

   d. Compliance with mixing zone criteria established in A.R.S.D. 74:03:02:07.

L. Sewer Extension

In general, sewer extensions shall be allowed only if the receiving wastewater treatment facility is either:

1. Capable of handling the added hydraulic load and pipe size not smaller.

2. Capable of adequately processing the added hydraulic and organic load.

3. Provision of adequate treatment facilities on a time schedule acceptable to the Department is assured.

M. Protection of Water Supplies

1. Water Supply Interconnections - There shall be no physical connection between a public or private potable water supply system and a sewer, or appurtenance thereto, which would permit the passage of any sewage or polluted water into the potable water system. Water main bleeders into sanitary sewers are prohibited. No water pipe shall pass through or come in contact with any part of a sewer manhole.

2. Relation to Water Works Structures - While no general statement can be made to cover all conditions, sewers shall be at least 75 feet from shallow water supply wells, 50 feet from underground water reservoirs and 30 feet from a well if the sewer is constructed as mentioned in section M-3-c.

3. Relation to Water Mains

   a. Horizontal Separation - Whenever possible, sewers should be laid at least 10 feet, horizontally, from any existing or proposed water main. Should local conditions prevent a lateral separation of 10 feet, a sewer may be laid closer than 10 feet to a water main if:

      1) It is laid in a separate trench; or

      2) It is laid in the same trench with the water main located at one side on a bench of undisturbed earth;

      3) In either case, the elevation of the crown of the sewer is at least 18 inches below the invert of the water main.

   b. Vertical Separation - Whenever sewers must cross under water mains, the sewer shall be laid at such an elevation that the top of the sewer is at least 18 inches below the bottom of the water main. When the elevation of the sewer cannot be buried to meet the above requirement, the water main shall be relocated to provide this separation and reconstructed with slip-on or mechanical-joint cast-iron pipe, asbestos-cement pressure pipe or prestressed concrete cylinder pipe for a distance of 10 feet on each side of the sewer. One full length of water main should be centered over the sewer so that both joints will be as far from the sewer as possible.

   c. Special Conditions - When it is impossible to obtain the proper horizontal and vertical separation as stipulated above, the water main should be constructed of slip-on or mechanical-joint cast-iron pipe, asbestos-cement pressure pipe or prestressed concrete cylinder pipe and the sewer constructed of mechanical-joint cast-iron pipe, schedule 40 ABS or PVC or equal and both services should be pressure tested to assure watertightness in accordance with AWWA standard for leakage testing. As an alternative, it is permissible to encase either the water or the sewer main with six (6) inches of concrete for a distance of 10 feet on each side of the crossing; or if PVC or cast iron is used as encasement material, the ends shall be adquately sealed with concrete as well as any joints within the 20 foot section.

d. House Sewers - The requirements in sections M-3-a, M-3-b, and M-3-c shall apply to building sewers and water service lines to buildings except that the separations mentioned in sections M-3-a and M-3-b may be reduced to state plumbing code when water lines are installed with continuous non-jointed material.

N. Small Diameter Gravity Sewers

1. General Statement - The innovative and alternative technology provisions of the Municipal Wastewater Treatment Construction Grant Amendments of 1981 (Public Law 97-117) provide for additional Federal grant funding for eligible costs associated with small diameter gravity sewers serving small communities and conveying partially or fully treated wastewater.

   Septic tank effluent is considered partially treated wastewater, and the costs for design and construction of treatment works which collect and convey it for additional centralized treatment are eligible for additional Federal grant funding, provided that all requirements in this section are met.

2. Administrative Provisions - Alternative technology grant funding for those costs associated with the transport of partially or fully treated wastewater may be provided only if the project serves a small community defined as follows:

   a. A small community is defined by 40 CFR 35.2005(40) as any municipality with a population of 3,500 or less or highly dispersed sections of larger municipalities as determined by the U.S. EPA Regional Administrator.

   b. If nonconventional systems are planned for certain sparsely developed subdivisions or parcels of a larger municipality (existing population over 3,500), then each of these subdivisions or parcels could be defined as a small community for the purpose of alternative system funding. Any such area having a density of two households per acre or less could be considered sparsely populated.

3. Small Diameter Gravity Sewer Design Criteria - The following considerations shall be used for the design of small diameter gravity sewer systems:

   a. No gravity sewer shall be less than 4 inches in diameter.

   b. Since the small diameter gravity sewers will be conveying anaerobic septic tank effluent which will be corrosive and odorous, the pipe, pumping equipment and treatment hardware shall be manufactured of suitable materials to endure these adverse conditions. Acceptable pipe materials are ABS, PVC, poly- ethylene, vitrified clay and fiberglass/ polyester composite. Concrete, asbestos cement, steel, iron and other metals are not acceptable. Bituminous-fiber pipe, commonly known as Orangeburg pipe, is not acceptable for public or community collection systems.

c. The maximum allowable infiltration-exfiltration rate shall be 200 gallons per inch of pipe diameter per mile per day.

d. Small diameter gravity sewers conveying partially or fully treated wastewater will be considered acceptable if they are designed and constructed to provide mean velocities, when flowing full, of not less than 1.5 feet per second based on Manning's formula using an "n" value of 0.013. The following slopes should be provided, however, slopes greater than specified are desirable:

	Minimum Slope
Sewer Size	**Ft/100 feet**
4 inch	**0.47**
6 inch	**0.28**
8 inch	**0.19**

While insufficient empirical data has been generated to demonstrate the absolute, unqualified acceptability of slopes less than those specified in the preceding paragraph, a system of small diameter gravity sewers conveying settled sewage may be approved if designed and constructed to provide mean velocities, when flowing full, of not less than 1.0 feet per second based on Manning's formula using an "n" value of 0.013, provided that the cost saving qualification of 40 CFR 35.2005(4) is met. The purpose of this is to ensure that the savings to be gained by installing the sewers at these flatter slopes is sufficient to justify the potential risk involved. Under these criteria, the minimum slopes which should be provided:

	Minimum Slope
Sewer Size	**Ft/100 feet**
4 inch	**0.21**
6 inch	**0.12**
8 inch	**0.08**

It is imperative that septic tanks be properly sized and septic tank maintenance procedures be established to ensure the retention of solids in the septic tanks. While important for flows at 1.5 feet per second, it is especially important below that velocity.

e. It is preferable that cleanouts and manholes be alternated at a spacing of approximately 200 to 250 feet; however, cleanouts will be allowed at deadends and intervals of 300 feet where long sections of pipe can be installed. Manholes should be provided at the junctions of two or more small diameter gravity sewer lines. Manhole and cleanout covers should be watertight and consideration given for vandalism due to grit and inflow problems experienced with conventional covers. Manholes and cleanouts should be located where they will be least susceptible to damage from street grading and snowplowing.

f. Drop type manholes should be avoided where anaerobic conditions exist. Gases generated in the septic tank under anaerobic conditions may be toxic; consequently, the creation of turbulence will enhance the release of gases from the septic tank effluent.

g. Special consideration should be given to protect the sewer against freezing due to construction at ground depths susceptible to frost penetration because the outlet piping of the septic tank is normally shallower than that of conventional gravity building sewers.

h. If severe odor problems are anticipated, peroxide feed stations may be considered for control of odors.

i. Since it is recognized that the key technology to successful operation of these systems is retention of solids in the septic tank, maintenance districts and cleaning procedures for septic tanks shall be established in conjunction with the facility planning and design phases. Sewer use ordinances and/or local health codes shall include adequate provisions to ensure proper operation, use, connection to, and construction of such small diameter sewers. Adequate cleaning equipment, such as a jet machine, shall be provided or through agreement with another entity, be readily available.

O. Storm Sewer

1. Protection of Water Supplies

Storm sewers shall be constructed to meet the requirements of section M of this chapter, with the following exception: a reinforced concrete pipe (RCP) storm sewer may cross below a water main with the separation of less than 18 inches or at any height above a water main provided the joints on the RCP that are within 10 feet of either side of the watermain are assembled with preformed butyl rubber sealant meeting federal specification #SS-S-210A and AASHTO M0198, and each of these joints are encased with a minimum 2-foot wide by 6-inch thick concrete collar centered over the joint and re-enforced with the equivalent steel area as that in the RCP; the watermain will not be required when the RCP joints are collared within the 20-foot section.

2. Pipe Sizing

To ensure any debris which enters a drain is carried through the system to the outlet, pipe sizes should not decrease in the down-stream direction even though increased slope may provide adequate capacity in the smaller pipe.

3. Inlet/Outlet Protection

Consideration should be given, especially with large diameter pipe, to providing trash guards or grid work over inlets and outlets to prevent obstructions from debris and as a safety measure to prohibit entry.

4. Erosion Protection

Erosion protection shall be required at the discharge outlet when the slope gradient and pipe discharge capacity are expected to reach erosion velocity for the existing soil conditions.

P. **Deviations from Design Criteria**

The Department may consider and allow deviations where adequate documentation is provided to prove the need for such deviation.

CHAPTER III: Recommended Design Criteria For Sewage Pumping Stations, Force Mains And Pressure Sewers

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C. Design
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E. Controls

F. Valves

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L. Submersible Pump Stations
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CHAPTER III

RECOMMENDED DESIGN CRITERIA FOR SEWAGE PUMPING STATIONS, FORCE MAINS AND PRESSURE SEWERS

A. Engineer's Report, Plans and Specifications

Information for sewage pumping stations must be submitted as required by Chapter 10, Recommended Standards for Sewage Works, 1978 or latest Edition. In addition, the following information is requested:

1. *Contributary* Area - A description of the extent of the existing and proposed contributary area with reference to a general system map as well as a description of probable future expansion of the contributary area is requested.

2. Lo*cation* - The proposed pumping station, force main and point of discharge into the existing sewer system shall be shown on a map. In addition, the report shall discuss the capacity available in the existing downstream sewer, its ability to convey the additional flow and the effect it will have on the treatment facility.

3. Design Data - The design data for the proposed project should include the following:

   a. Design Period.

   b. Population densities per acre and total population served.

   c. Area served in acres.

   d. Per capita sewage contribution expressed as an average daily and as a peak hourly value.

   e. Infiltration and inflow and method used to establish.

   f. Industrial wastes contribution.

   g. Design flow rates expressed as design average daily and peak hourly values.

B. General

1. *Flooding* - Sewage pumping stations shall not be subject to flooding. It is important that the stations be readily accessible and fully operational during a twenty-five (25) year flood. A one hundred (100) year flood recurrence interval should be considered in the design for protection of structure and electrical and mechanical equipment from physical damage. The stations shall be readily accessible; preferably located off the traffic ways of streets and alleys.

2. *Grit* - Where it may be necessary to pump sewage prior to grit removal, the design of the wet well should receive special attention and the discharge piping shall be designed to prevent grit settling in the discharge lines of pumps not operating.

3. *Security* - Pumping stations shall be designed with security and lighting to discourage vandalism.

C. Design

The following items should be given consideration in the design of sewage pumping stations:

1. *Capacity of Pumps* - The pumps shall have sufficient capacity to pump at least four times the design average flow rates for laterals and sub-main sewers; either two and one-half times the design average flow rate or peak hourly flow rate, whichever is greater, for main, trunk and interceptor sewers. Each pump shall be capable of handling peak sustained flow rates. If no peak hourly flow data is available, refer to Figure 1 in Chapter 1.

2. *Type* - Sewage pumping stations that are of the dry well type are the most desirable; however, circumstances will generally justify the use of submersible- type pumps.

3. *Structures*

    a. Wet and dry wells including their superstructures shall be completely separated.

    b. Provision shall be made to facilitate and easily remove pumps and motors.

    c. Suitable and safe means of access shall be provided to dry wells of pump stations and shall be provided to wet wells containing either bar screens or mechanical equipment requiring inspection or maintenance. Stairways should be provided for installations deeper than 15 feet and should be installed with rest landings not to exceed 10 foot vertical intervals. A manlift or elevator may be used in lieu of landings, provided emergency access is included in the design.

    d. Due consideration shall be given to the selection of materials because of the presence of hydrogen sulphide and other corrosive gases, greases, oils and other constituents frequently present in sewage. Structure materials may require cathodic and anodic protection.

    e. Where a bar rack is provided, a mechanical hoist shall also be provided. The hoist and accessories shall be rated for not less than 1.5 times the heaviest anticipated load.

    f. The pumping station compartments shall resist hydrostatic uplift pressures.

D. Pumps and Pneumatic Ejectors

1. At least two pumps or pneumatic ejectors shall be provided. Where the pumping installation will serve not more than 50 homes, a single unit will be permitted, provided that the station is designed to permit the installation of a future duplicate unit with no structural changes. A minimum of 3 pumps should be provided for stations handling flows greater than one (1) million gallons per day (mgd).

   If only two units are provided, they should have the same capacity. Each shall be capable of handling flows in excess of the expected peak hourly flow. Where three or more units are provided, they should be designed to fit actual flow conditions and must be of such capacity that with any one unit out of service the remaining units will have capacity to handle peak sewage flows. It is preferable that a standby pump or ejector be provided and available for service at all times.

2. Pumps handling raw sewage should be preceded by readily accessible bar racks with clear openings not exceeding 2 1/2 inches, unless pneumatic ejectors are used or special devices, such as, grinders, are installed to protect the pumps from clogging or damage. Where the size of installation warrants, a mechanically cleaned bar screen with grinder or comminution device is recommended. Where screens are located below ground, convenient facilities must be provided for handling screenings. For the larger or deeper stations, duplicate protection units of proper capacity are preferred.

3. Pumps or ejectors shall be capable of passing spheres of at least 3 inches in diameter. Pump suction and discharge openings shall be at least 4 inches in diameter. Turned-down bellmouth inlets are preferred. The pumps and ejectors should have non-corrosive materials for inner parts. Where turned-down bellmouth inlets are used, the bell should be not more than D/2 and not less than D/3 above the floor of the wet well. It is recommended that sump and approach channel dimensions be provided as suggested by the pump manufacturer.

4. The pump shall be so placed that under the normal operating conditions it will operate under a positive suction head, except as specified in Section K-1.

5. Electrical systems and components (e.g. motors, lights, cables, conduits, switchboxes, control circuits, etc.) in enclosed or partially enclosed spaces where flammable mixtures occasionally may be present (including raw sewage wet wells) shall comply with the National Electrical Code requirements for Class I, Division I, Groups C and D locations. When such equipment is exposed to weather it shall meet the requirements of weatherproof equipment (Nema 3R).

6. Each pump should have an individual intake. Wet well design should be such as to avoid turbulence near the intake. Intake piping should be as straight and short as possible.

7. A separate sump pump equipped with dual check valves shall be provided in the dry wells to remove leakage or drainage with the discharge above the overflow level of the wet well. A connection to the pump suction is also recommended as an auxiliary feature. 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.

8. The pumps and controls of main pumping stations, and especially pumping stations operated as part of treatment works, should be selected to operate at varying delivery rates to permit the discharge of sewage from the station to the treatment works at approximately the sewage flow rate to the pump station. Design pumping rates should be established in accordance with Chapter 1, Section C.

E. Controls

Control float tubes should be so located as not to be unduly affected by flows entering the wet well or by the suction of the pumps. Float tubes in dry wells shall extend high enough to prevent overflow. In small stations with duplicate units, provision should be made to automatically alternate the pumps in use.

F. Valves

Suitable shutoff valves shall be placed on suction and discharge lines of each pump with the exception of the suction line on submersible and vacuum-primed pumps. A check valve shall be mounted in a horizontal position on each discharge line between the shutoff valve and the pump. Valves shall not be located in the wet well. Valves shall be capable of withstanding normal pressure and water hammer.

G. Wet Wells

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

2. The wet well size and control setting shall be appropriate to avoid heat buildup in the pump motor due to frequent starting.

3. The effective capacity of the wet well, except for large capacity stations, should be such that one pump will continuously run at least five (5) minutes of every 30 minute period at the minimum flow. The volume of a wet well between start and stop elevations for pump(s) and speed(s) can be determined by using the formula:

$$V = T \times q/4$$

Where:

V= Required capacity in gallons including storage of influent line.
T= Minimum time of one pumping cycle between successive starts, or speed increases of the control range in minutes.
q= Pump capacity in gallons per minute, for one pump, or the incremental pumping capacity for an additional pump, or pump speed.

Where large pumping units (3,000 gpm) are involved, they should be operated continuously insofar as is practical, (T) should not be less than 20 minutes. For smaller pumps, (T) can be reduced to 10 minutes with 15 minutes being the more desirable.

4. The wet well floor shall have a minimum slope of one to one (1:1) to the hopper bottom. The horizontal area of the hopper bottom shall be no greater than necessary for proper installation and function of the pump inlet pipe.

H. Ventilation

Adequate ventilation shall be provided for all pump stations. Where the pump pit is below the ground surface, mechanical ventilation is required, so arranged as to independently ventilate the dry well and the wet well if screens or mechanical equipment requiring maintenance or inspection are located in the wet well. There shall be no interconnection between the wet well and dry well ventilation systems. In pits over 15 feet deep, multiple inlet and outlets are desirable. Dampers should not be used on exhaust or fresh air ducts and fine screens or other obstructions in air ducts should be avoided to prevent clogging. Switches for operation of ventilation equipment should be marked and located conveniently. All intermittently operated ventilating equipment shall be interconnected with the respective pit lighting system. Consideration should be given also to automatic controls where intermittent operation is used. The fan wheel should be fabricated from non-sparking material. In climates where excessive moisture or low temperatures are a problem, consideration should be given to installation of automatic heating and/or dehumidification equipment.

1. Wet well ventilation may be either continuous or intermittent. Ventilation, if continuous, should provide at least 12 complete air changes per hour; if intermittent, at least 30 complete air changes per hour. Such ventilation shall be accomplished by introduction of fresh air into the wet well by mechanical means.
2. Dry well ventilation may be either continuous or intermittent. Ventilation, if continuous, should provide at least six complete air changes per hour; if intermittent, at least 30 complete air changes per hour.
3. The outside vent shall terminate in an inverted "U" construction with the opening at least 24 inches above the finished ground elevation.

I. Flow Measurement

Suitable devices for measuring sewage flow should be provided at all pumping stations.

J. Water Supply

There shall be no physical connection between any potable water supply and a sewage pumping station which under any conditions might cause contamination of the potable water supply. If a potable water supply is brought to the station, it shall be provided with the proper air-gaps and backflow prevention devices. If a non-potable water supply is provided, all outlets shall be permanently posted to indicate water is not safe for drinking.

K. Suction-Lift Pump Stations

Suction-lift pump station installations shall meet the applicable requirements under Sections C through J.

1. *Priming* - Suction-lift pumps shall be of the self-priming type as demonstrated by a reliable record of satisfactory operation.

2. *Capacity* - Approval will be restricted to installations where the capacity does not exceed 200 gpm per pump and the total suction-lift does not exceed 15 feet.

L. Submersible Pump Stations

Submersible pump stations shall meet the applicable requirements under Sections C through J.

1. *Pump Removal* - Submersible pumps shall be readily removable and replaceable without dewatering the wet well and with continuity of operation of the other unit or units.

2. *Operation* - Submersible pumps shall be capable of unsubmerged operation without damage or reduction of service capability or positive provision shall be made to assure submergence, e.g., backup controls.

3. *Minimum Draw Down* - See Table 1 in this Chapter.

4. *Controls* - The control panel and alarm system shall be located outside the wet well and suitably protected from weather, humidity and vandalism.

5. *Valves* - All control valves on the discharge line for each pump shall be placed in a convenient location outside the wet well and be suitably protected from weather and vandalism.

6. *Electrical Equipment* - See Section D-5 of this Chapter.

M. Alarm Systems

Alarm systems should be provided for all pumping stations. The alarms shall be activated in cases of power failure, pump failure, or any cause of pump station malfunction. Pumping station alarms shall be telemetered to a facility or office that is manned 24 hours a day. Where no such facility exists, an audio-visual device shall be installed at the station for external observation. It is recommended that an alarm and shutoff control equipment be provided in dry well to protect motors if sump pump should fail or sudden break occurs that exceeds the capacity of the sump pump.

N. Emergency Operation

1. *Objective* - The objective of emergency operation is to prevent the discharge of raw or partially treated sewage to any waters and to protect public health by preventing back-up of sewage and subsequent discharge to basements, streets, and other public and private property. There shall be no by-passing of sewage to the groundwater, surface of the ground or any watercourse.

2. Em*ergency Power Supply* - Provision of an emergency power supply for all pumping stations should be made, and may be accomplished by connection of the station to at least two independent public utility sources, or by provision of portable or in-place internal combustion engine equipment which will generate electrical or mechanical energy, or by provision of portable pumping equipment.

3. Internal Combustion Equipment - Where in-place internal combustion equipment is utilized, the following guidelines are suggested for use:

   a. The unit shall be bolted in place. Facilities shall be provided for unit removal for purposes of major repair or routine maintenance.

   b. Provisions shall be made for automatic and manual start-up and cut-in.

   c. Unit size shall be adequate to provide power for lighting and ventilation systems and such further systems affecting capability and safety.

   d. The unit internal combustion engine shall be located above grade with suitable and adequate ventilation of exhaust gases.

4. *Portable Equipment* - Where portable equipment is utilized the following guidelines are suggested for use:

   Pumping units shall have the capability to operate between the wet well and the discharge side of the station. The station shall be provided with permanent fixtures which will facilitate rapid and easy connection of lines. Electrical energy generating units shall be protected against burn-out when normal utility services are restored, and shall have sufficient capacity to provide power for lighting and ventilation systems and such further station systems affecting capability and safety.

5. *Emergency Power Generation* - All emergency power generation equipment should be provided with instructions indicating the essentiality of regularly starting and operating such units at full load.

O. Overflows

A high-level wet well overflow to supplement alarm systems and emergency power generation may be provided. Where a high level overflow is utilized, complete retention of all overflow in storage-detention tanks or basins shall be provided. Provision shall be made to drain or pump the tanks or basins to the station wet well. The basins or tanks shall not discharge to the groundwater, surface of the ground or any watercourse.

P. Instructions and Equipment

Sewage pumping stations and their operators should be supplied with a complete set of operational instructions, including emergency procedures, maintenance schedules, tools and such spare parts as may be necessary.

Q. Force Mains

1. *Size* - Force Mains shall be no smaller than 4-inch diameter except where grinder pumps are provided.

2. *Velocity* - At design average flow, a minimum cleansing velocity of at least two feet per second shall be maintained. A velocity of eight feet per second should not be exceeded.

3. *Valves* - Automatic air release valves shall be placed at high points in the force main to prevent air locking. A blow-off shall be placed at the low points where gritty material could accumulate and restrict flow through the force main. Access to air release facilities shall not be located in traffic-ways.

4. *Termination* - Force mains should enter the gravity sewer system at a point not more than two feet above the flow line of the receiving manhole. The design shall be such as to prevent turbulence and deterioration at this point.

5. *Leakage (Ex-filtration)* - Force mains shall be tested at a minimum pressure of at least 50 percent above the design operating pressure, for at least 30 minutes. Leakage shall not exceed the amount given by the following formula:

$$L=NDP^{1/2} / 1850$$

Where:

L= The allowable leakage in gallons per hour
N= The number of pipe joints
D= The nominal pipe diameter in inches
P= The test pressure in psi

6. *Maintenance* - If the force main is taken out of service for repair or cleaning, the sewage shall be discharged to a storage-detention tank or basin and returned to the sewer system with no discharge to the groundwater, surface of the ground or any watercourse.

7. *Restraints* - Force mains shall be restrained at bends to prevent movement occurring from maximum operating pressures or surges.

R. Pressure Sewer System

1. *General*

   a. The pressure sewer system shall be considered as a supplemental tool for wastewater collection system and not as a replacement for the conventional gravity collection system. It is expected that a pressure sewer system would generally be used in small sub-divisions, sanitary districts or communities. This system may be approved for use when justified by unusual formations, low population density, difficult construction due to groundwater conditions, or other circumstances where it would offer an advantage over a gravity system.

   b. A responsible management structure (whether private company, municipal or governmental body) for inspections, repair and maintenance of septic tanks, pressure sewers and grinder pump units shall be clearly defined and established prior to the approval of any installation. The pressure sewer system including the grinder pump should be regarded as integral components of the system and not as a part of the individual home plumbing. Any industrial hook-up, such as a restaurant or service station, should have adequate pretreatment for grease and grit collection. The responsible entity must have full repair service capability available on short notice which should include a stand-by power generator, adequate spare parts, spare units and service tools.

2. *Design Criteria* - The following considerations shall be used for the design of a pressure sewer system including the grinder pump units:

   a. If a septic tank is not provided before the pump, a grinder pump shall be required. Pressure sewer collection systems shall be preceded by grinder pumps or at least 1,000 gallon capacity septic tanks. Pumping units should not be installed in the settling chamber of a septic tank if the septic tank is to be used for solids reduction.

   b. No pressure sewer less than 1 1/4 inches inside diameter shall be provided. The required size shall be determined to maintain low frictional losses in the system and a minimum scouring velocity of 2 feet per second at all points in the system.

   c. Special care shall be exercised in the hydraulic design of a pressure sewer system which is proposed to serve ultimately more houses than those expected to be served initially.

   d. The determination of flow in the pressure sewer system shall be made on the basis of the maximum probable number of grinder pump units that would be expected to run simultaneously or some other accepted method of computing the peak sewage flow rate in the system.

   e. The pressure sewer system shall be laid out in a branched or tree configuration to avoid flow-splitting at branches which cannot be accurately predicted.

f. The pressure sewer piping shall be installed in a depth sufficient to protect against freezing and damage from vehicular traffic.

g. Although any suitable pipe material can be used, plastic pipe such as PVC S.D.R.-26 or equivalent are considered suitable. A "C" factor of 130 to 150 is recommended to be used for plastic pipes in the Hazen- Williams formula. It is recommended that ball type check valves have a plastic or bronze body. Since valves are important components of the system, they should be reliable.

h. Clean-out connections shall be provided at distances not to exceed capability of available cleaning equipment (approximately 400-600 feet). Flushing clean-outs should be provided at the upstream end of every major branch.

i. Pressure and vacuum release valves shall be employed at appropriate locations. Pressure sewers should be constructed on a gradually ascending slope to minimize air binding. Valve boxes are recommended about every 1,000 feet or major change in direction.

j. The pressure sewer should have appropriate identification to distinguish between sewer and potable water lines.

k. Current criteria as outlined in Chapter II and the State Plumbing Code shall be maintained in separating pressure sewer and water systems.

l. Pressure sewer system operating pressures in general shall not exceed a range of 40 to 50 psi for any appreciable period of time.

m. Thorough pressure testing of all lines, fittings, valves, etc. shall be made prior to start-up.

n. Details of construction shall be clearly stated in the drawings and/or specifications.

o. The minimum net storage capacity of the grinder pump unit shall not be less than 50 gallons. The grinder unit tank should be able to accommodate normal peak flows and emergency storage for a period of 8 to 12 hours during short power outages or equipment malfunctions.

p. When a holding tank is provided for emergency purpose, during an extensive power outage, the tank should be sized for at least 3 days storage if continuously supplied by an outside water supply not dependent on same power source. Adequate provisions should be made to empty the holding tank when necessary.

q. The grinder pump shall have the characteristics which will continue to produce flows of at least 8 gpm even when conditions in the pressure system cause heads to rise temporarily to values as high as 50 psig. Generally 2 Hp grinder pumps are recommended for individual home applications.

r. Check and shut-off valves shall be employed to isolate the grinder pump unit from the house service line and the pressure laterals.

s. Appropriate high water and overflow detection devices such as visual and/or audio alarm shall be provided.

t. Provisions shall be made to insure that grinder pump operates even under temporary loads above normal and contains integral protection against back siphonage and over pressure.

u. The grinder pump unit shall be capable of reducing any material in the wastewater which enters the grinder unit to such size that the material will pass through the pump unit and pressure sewer without plugging or clogging. No screens or other devices requiring regular maintenance shall be used to prevent trashy material from entering the grinder pump. The pumps should be non-clog type with non-corrosive materials for inner parts.

v. Pumping units and grinder pumps used in pressure sewer systems should be reliable, easily maintained, and should have compatible characteristics. At least one stand-by grinder pump unit for each 50 units or fraction thereof shall be provided for emergency replacement. Whenever any pumping unit handles waste from two or more residential units or from a public establishment, dual grinder pump units with twice the holding capacity shall be provided to assure continued service in the event of an emergency.

w. The grinder pump unit must be capable of being removed without dewatering the pumping compartment.

x. Provisions must be made for access as well as protection from weather and vandalism.

S. Deviations from Design Criteria

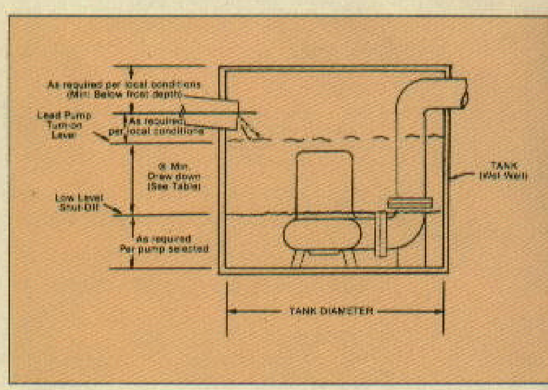
The Department may consider and allow deviations where adequate documentation is provided to prove the need for such deviation.

Minimum Wet Well Tank Draw Down Tabulation for Submersible Pump Stations

TABLE

MINIMUM DRAW DOWN (EXPRESSED IN FEET)
BASED ON WPCF MANUAL OF PRACTICE NO. FD-4 PAGE 21, ITEM 2 "SUMP-VOLUME" WHICH READS
"THE USEABLE PIT VOLUME IN GALLONS SHOULD EQUAL OR EXCEED TWO TIMES THE MAXIMUM CAPACITY IN GALLONS PER MINUTE TO BE PUMPED"

TANK DIAMETER	GALLONS PER FOOT OF DEPTH	GPM	100	200	300	400	500	600	700	800	900	1000	1500	2000	3000	4000	5000	6000
		MIN. GALLONS DRAW DOWN (2 × GPM)	200	400	600	800	1000	1200	1400	1600	1800	2000	3000	4000	6000	8000	10000	12000
4' — 0"	94.0	⊗	2.1	4.3	6.4	8.5	10.6	12.8	14.9	17.0	19.1	21.2	—	—	—	—	—	—
5' — 0"	146.9	MINIMUM	1.4	2.7	4.1	5.4	6.8	8.2	9.5	10.9	12.3	13.6	20.4	—	—	—	—	—
6' — 0"	211.5	DRAW DOWN	—	1.9	2.8	3.8	4.7	5.7	6.6	7.6	8.5	9.5	14.2	18.9	—	—	—	—
7' — 0"	287.9	(EXPRESSED IN	—	1.4	2.1	2.8	3.5	4.2	4.9	5.6	6.3	6.9	10.4	13.9	20.8	—	—	—
8' — 0"	376.0	FEET)	—	—	1.6	2.1	2.7	3.2	3.7	4.3	4.8	5.3	8.0	10.6	16.0	21.2	—	—
9' — 0"	475.9		—	—	—	1.7	2.1	2.5	2.9	3.4	3.8	4.2	6.3	8.4	12.6	16.8	21.0	—
10' — 0"	587.5		—	—	—	1.4	1.7	2.0	2.4	2.7	3.1	3.4	5.1	6.8	10.2	13.6	17.0	20.4
11' — 0"	710.9		—	—	—	—	1.4	1.7	2.0	2.3	2.5	2.8	4.2	5.6	8.4	11.3	14.1	16.9
12' — 0"	846.0		—	—	—	—	—	1.4	1.7	1.9	2.1	2.4	3.5	4.7	7.1	9.5	11.8	14.2
13' — 0"	992.9		—	—	—	—	—	—	1.4	1.6	1.8	2.0	3.0	4.0	6.0	8.1	10.1	12.1
14' — 0"	1152.9		—	—	—	—	—	—	—	1.4	1.6	1.7	2.6	3.5	5.2	6.9	8.7	10.4
15' — 0"	1321.9		—	—	—	—	—	—	—	—	1.4	1.5	2.3	3.0	4.5	6.1	7.6	9.1



1. Prior to utilizing this chart, determine the pump GPM and tank diameter via sound design criteria (e.g., number of pumps, size of piping, cycle time, Ten States Standards, etc.).

2. Once tank diameter and GPM is known, then simply find the tank diameter in left-hand column and follow horizontally to appropriate GPM column. The intersection of these two items will give you the "Minimum Draw Down" expressed in feet of liquid.

Provided by **Hydromatic Pumps**

CHAPTER IV: Recommended Design Criteria For Wastewater Stabilization And Pollution Control Ponds

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CHAPTER IV

RECOMMENDED DESIGN CRITERIA FOR WASTEWATER STABILIZATION AND POLLUTION CONTROL PONDS

A. Supplement to Engineer's Report, Plans and Specifications

The engineer's report shall contain pertinent information on the location, geology, soil conditions, area for expansion and other factors that will affect the feasibility and acceptability of the proposed treatment facilities.

The following information must be submitted in addition to that required by Chapter 10, Recommended Standards for Sewage Works, 1978 or the latest edition:

1. The location and direction of all residences, commercial or business development, and water supplies within one-half mile and information regarding location, construction features and static water levels in all wells within one-fourth mile of the proposed ponds.

2. Soil borings to determine surface and subsurface soil characteristics of the immediate area and their effect on the construction and operation of a pond located on the site. The depth of soil borings shall be at least six feet below the proposed pond bottom elevation, except one shall be a minimum of 25 feet in depth or into bedrock, whichever is shallower. A minimum of one soil boring per acre should be completed.

3. Data demonstrating anticipated percolation rates at the elevation of the proposed pond bottoms.

4. A description, including maps showing elevations and contours of the site and adjacent area suitable for expansion.

5. Sulfate content of the domestic water supply. Where lakes or streams are involved, the existing levels of phosphorus and nitrogen should be considered and the probable effect of nutrient addition to the receiving source should be considered.

6. Meteorological data on evaporation and precipitation in the area.

B. Basis of Pond Design

1. Area and Loadings

a. The maximum design loading on the primary cell(s) shall be 30 pounds of BOD5 per acre per day.

b. Multiple cells designed for series operation shall be provided in order to meet effluent standards and achieve better nutrient reduction. The design may include facilities for parallel operation for additional flexibility.

c. The area of the primary cell(s) should be approximately 50-60% of the total surface area of the entire pond system. The total surface area required shall be computed based upon both organic and hydraulic loading, and that which results in the larger surface area shall be utilized.

d. The total organic loading for the total surface area shall not exceed 20 pounds of BOD5 per acre per day.

e. The design average flow rate shall be used to determine the volume required to provide a minimum storage capacity of 180 days. The 180-day storage of the entire facility shall be provided above the two (2) foot level. The maximum normal liquid depth should not exceed five (5) feet in the primary cell or six (6) feet in the secondary cell. All subsequent cells may have an allowable liquid depth of up to eight (8) feet and shall provide at least 20 days of storage above the two (2) foot level.

f. The net water loss considered in the design resulting from evaporation and seepage shall include the average annual precipitation. Evaporation shall not be considered in the design for those systems primarily operating only during the winter months. Evaporation and precipitation and seepage should be considered when cells are designed for total containment.

g. The seepage rate for the primary cell(s) shall not exceed 1/16 inch per day. An allowable seepage rate of 1/8 inch per day for cells in series following the primary cell(s) may be considered on a case-by-case basis dependent upon underlying soil formations and proximity of water sources in the area.

h. When determining an estimate of the surface area required for non-discharge or controlled-discharge systems, the following formulas may be used:

For total retention:

$$A = I/WL$$

For summer months or year-round:

$$A = I/H+WL$$

For winter months:

$$A = I/H+S-P$$

Where:

A= Estimated surface area in acres
I= Volume of in-flow in acre-feet for the design period
WL= Net water loss (evaporation + seepage - precipitation) in feet for the design period

S= Seepage in feet for the design period
H= Operating depth in feet above the 2-foot level
P= Precipitation

i. All cells should be very nearly balanced volumetrically in order that the 2-foot minimum level and retention time may be maintained. Due to the various configurations and slopes, the average area and depth method is not accurate for water balances. Therefore, to determine the storage volumes of cells for the estimated surface areas at various operating depths the following formula is provided.

$$V = 1/6H\ (B1+4M+B2)/\ 43{,}560$$

Where:

V= Volume in acre-feet (total or operating storage)
H= Depth in feet (total or operating) from B1 to B2
B1= Bottom area in square feet of pond level selected
M= Area of mid-section in square feet between levels B1 and B2
B2= Top area in square feet of pond level selected.

From these calculations, adjustments could be made in the design for such variables as slopes, operating depths and surface areas to obtain a more accurate volume balance. Allowances for rounded corners should be included in areas of B1, M, B2.

j. Due consideration shall be given to possible future expansion on suitable land when the original land acquisition is made.

2. *Industrial Wastes*

Consideration shall be given to the type and effects of industrial wastes on the treatment process.

3. *Multiple Units*

Flexibility is desirable if one or more cells must be taken out of use for repair, enlargement or for some other reason. This flexibility allows maximum operational capability.

4. *Pre- or Post-Treatment*

When ponds are used to provide additional treatment for effluents from existing or new primary or secondary wastewater treatment works, the Department will, upon request, review and recommend BOD5 loading limits for the pond after due consideration of the efficiencies of preceding treatment units.

5. *Pond Shape*

The shape of the cells shall be such that there are no narrow, L-shaped or elongated portions. Round or square ponds are considered most desirable. Rectangular ponds shall generally have a length not exceeding three times the width. No islands, peninsulas or coves are permitted. Dikes shall be rounded at corners to minimize accumulation of floating material.

C. Pond Location

1. *Separation Distances*

A pond site should be as far as practicable from habitation or any area which may be platted and developed within a reasonable future period. A distance of at least one-half mile from the community and one-fourth mile from a farm home or residence is recommended whenever possible.

A pond shall not be located within 1,000 feet of a well used to supply potable water.

The high-water line of the pond shall be at least 50 feet from the property line of the adjacent owner. Where an existing pond facility has been established on a site with fixed boundaries, then only the additions and modifications will be subject to the 50 foot separation.

2. *Prevailing Winds*

If practicable, ponds should be located so that locally prevailing winds will be toward uninhabited areas. Preference should be given sites which will permit an unobstructed wind sweep across the ponds, especially in the direction of the locally prevailing winds. This need not apply to the third cell for ponds operated in series.

3. *Surface Runoff*

Location of ponds in watersheds receiving significant amounts of runoff water is discouraged unless adequate provisions are made to divert storm water around the ponds and otherwise protect pond embankments. Pond embankments must be above the 100-year floodplain.

4. *Groundwater Pollution*

Proximity of ponds to water supplies and other facilities subject to contamination and location in areas of porous soils and fissured rock formations should be critically evaluated to avoid creation of health hazards or other undesirable conditions. The possibility of chemical pollution may merit appropriate considerations. The pond bottom should be at least four (4) feet above the high groundwater table and ten (10) feet above rock or impervious soil strata except if synthetic liners are used. The maximum contaminant levels for groundwater affected by ponds and land application techniques shall not be exceeded. In certain areas, lysimeters or monitoring wells will be required; they shall be located and constructed in accordance with the recommendations of the Department. Refer to Chapter XIII for monitoring requirements.

D. Pond Construction Details

1. Embankments and Dikes

a. Embankments and dikes shall be constructed of relatively impervious and stable material, and compacted to at least 90 percent of Standard Proctor Density (ASTM D698 or AASHTO T99); however, 95 percent of Standard Proctor Density with a moisture content near to 3% wet of optimum is recommended. The compaction and moisture conditions shall be sufficient to limit the seepage through the dike to 1/16 inch per day for all primary cells and shall not exceed 1/8 inch per day for all other cells.

b. All vegetation, roots, and topsoil shall be removed from the area upon which the embankment is to be placed. The embankment material must not contain any organic material, debris, frozen material, large clods or stones larger than 6 inches in diameter. Topsoil shall only be used in the outer portions of the embankment and blended with the other soils. Pond bottom and embankment 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 the anticipated conditions.

c. The minimum embankment top width shall be eight (8) feet to permit access of maintenance vehicles. Lesser top widths could be considered for very small installations, one acre or less.

d. Interior embankment slopes should not be steeper than three horizontal to one vertical (3:1) and not be flatter than six horizontal to one vertical (6:1) on the inside. Flatter slopes are sometimes specified for larger installations because of wave action but have the disadvantage of added shallow areas conducive to emergent vegetation and mosquito breeding. The exterior slopes should be three or more horizontal to one vertical for prevention of erosion.

e. Minimum freeboard shall be three (3) feet except for very small installations, one acre or less, where two (2) feet will be permitted.

f. The normal minimum liquid depth in any cell shall not be less than two (2) feet.

g. The embankment exterior shall be covered with at least 4 inches of fertile topsoil.

h. Embankments shall be seeded from the outside toe to the high water line on the interior slope wherever riprap, soil sterilant, and bank stabilization is not utilized. Low growing and spreading perennial grasses that withstand erosion are most satisfactory. In general, alfalfa, clover and other long-rooted vegetation should not be used, since the roots of this type of plant are apt to impair the water holding efficiency of the dikes. For sediment and erosion control, refer to the Department Guide, BMPs "Best Management Practices". The County Agricultural Extension Agent or local Conservation District can usually advise as to hardy, locally suited permanent grasses which would be satisfactory for embankment seeding.

Prior to filling or prefilling, the newly seeded vegetation shall be well established if submergence and wave action will occur.

i. A method shall be specified which will prevent vegetation growth over the bottom of the ponds and up to the high water line on the interior embankment slopes. If prefilling is specified before weed growth is established, then soil sterilants may not be necessary up to the prefilled water level.

j. Provisions shall be made for riprapping or bank stabilization of the interior slopes of any cell of five acres or more. Protection for outer embankments (riprap) may be necessary where the dikes are subject to erosion due to severe flooding of an adjacent watercourse. Riprapping or bank stabilization is highly recommended for all cells.

k. Riprap and bank stabilization requirements

   1) The riprap or bank stabilization shall be provided on the interior slopes from the toe to the top of the freeboard. It shall be hard and durable and be stable after placement.

   2) The riprap should be approximately 6 to 18 inches in diameter.

   3) The riprap shall be placed in depths of 8-18 inches depending upon size, location and configuration of cells.

   4) Since riprap is usually placed against fine material, a filter of sand with gravel or spalls shall be placed on the embankment slopes prior to riprapping. The depth of the filter material should be at least four (4) inches. Another alternative available is synthetic filter blankets which shall be securely anchored and shall have been satisfactorily demonstrated by prior use to be suitable and durable for such purposes.

l. Adequate justification is required for not following the foregoing criteria.

E. Pond Bottom

1. The pond bottom should be as level as possible at all points. Finished elevations should not vary more than three inches from the average elevation of the bottom.

2. Prior to scarifying, all topsoil shall be removed. In cut areas, the bottom shall then be scarified to a depth of 12 inches and cleared of vegetation and debris. Organic material thus removed shall not be used in the dike core construction. However, suitable topsoil relatively free of debris may be used as cover material on the outer slopes of the embankment. If preliminary tests have determined that the soils exposed on the pond bottom are capable of meeting the allowable seepage limits, a minimum of six (6) inches of the scarified soil shall be removed, the remaining scarified soil shall be brought to the proper moisture content and compacted to the specified density, and then the removed soil shall be uniformly spread and compacted, at the proper moisture content, as specified.

3. Soil boring information and results of percolation, porosity or permeability tests to determine the characteristics of surface soil and subsoil shall be made a part of preliminary surveys to select pond sites and design preparation of plans. Gravel, gypsum and limestone areas must be avoided.

4. The ability to maintain a satisfactory water level in the ponds is one of the most important aspects of design. Removal of porous topsoil and proper compaction of subsoil improves the waterholding characteristics of the bottom. Porous areas within 2 feet of the finished pond floor, such as gravel or sand pockets, shall be removed and replaced with well-compacted clay or other suitable material. Where excessive percolation is anticipated, sealing of the bottom with a clay blanket, bentonite, synthetic liners or other sealing material may be required to achieve a percolation rate not to exceed 1/16 inch per day for all primary cells and shall not exceed 1/8 inch per day for all other cells. The proposed seal should be substantiated by a soils engineering report.

5. Clay for liners shall be placed and compacted in at least two (2) lifts, the depth of any lift shall not exceed 8 inches.

6. The suitability of sealing the pond with bentonite will depend on the type of soil and conditions encountered in the field. Application rates for an effective seal can be determined by the use of a particle size analysis and the Atterburg limits tests. The application rate shall be specified in terms of pounds per square foot. The blanket application method is preferred to the soil-bentonite mix application because it provides a complete seal using approximately one-half of the amount for a mix application.

   a. Bentonite should be applied only on well packed and smooth surfaces.

   b. After bentonite has been applied, at least two (2) inches of soil should be placed on top of the bentonite and moderately packed to insure that bentonite material will remain in place until the pond is put into operation.

7. Prior to putting the ponds into operation, percolation tests shall be conducted and submitted to DWNR. Suggested methods for conducting percolation tests are double ring infiltrometer, laboratory permeability tests on thin wall tube samples, with the neutron method supplement weighing lysimeters or seepage tests on the entire pond in which the pond is filled and the water level and pan evaporation rate are monitored daily. If tests indicate seepage limits are exceeded, the seal shall be modified and retested until it meets those limits as required.

8. Prefilling the pond should be considered in order to protect the liner, to prevent weed growth, to reduce odor, and to maintain moisture content of the seal.

F. Influent Lines

1. Any generally accepted pipe material for underground sewer construction will be given consideration for the influent line to the pond. The pipe material selected should be adapted to local conditions. Special consideration must be given to the character of the wastes, possibility of septicity, corrosion, exceptionally heavy external loadings, abrasion, the necessity of reducing the number of joints, soft foundations and similar problems. Surcharging of gravity flow sewers upstream from the inlet manhole is not permitted.

2. A manhole shall be installed at the terminus of the gravity line or force main to the primary cell and located as close to the dike as topography permits. The invert of this manhole should be at least six (6) inches above the maximum operating level of the primary cell to provide sufficient hydraulic head without surcharging the manhole. Flow distribution structures shall be designed to effectively split hydraulic and organic loads equally to multiple primary cells.

3. Influent lines shall be located along the bottom of the primary cell and shall be securely anchored to the bottom of the pond so that the invert elevation is near the bottom of the pond. This line can be placed at zero grade. The use of an exposed dike to carry the influent line to the discharge point is prohibited, as such a structure will impede circulation and cause localized deposition of sludge. Influent lines shall not be located within or below the seal.

4. Influent piping should be located to minimize short-circuiting within the cell. Each primary cell of a multiple-celled pond operated in parallel shall have a separate inlet but this does not apply to those cells following the primary cell when series operation alone is used. Influent lines or interconnecting piping to secondary cells of multiple-celled ponds operated in series may consist of pipes through the separating dikes. Influent lines to rectangular ponds should terminate at approximately one-third of the length from the upstream end of the cell and its outlet structure, except that it shall be at approximately the mid-point for cells without an outlet.

5. The end of the influent line shall be provided with a concrete headwall and shall rest on a suitable concrete apron that is at least four (4) feet by four (4) feet. The influent line shall discharge horizontally into a shallow, saucer-shaped depression.

G. Control Structures and Interconnecting Piping

1. Interconnecting piping and overflow piping should be of cast iron, corrugated metal, or other suitable materials of at least eight (8) inches in diameter. Piping shall have capacity to permit transfer of water at a minimum rate of six (6) inches of pond water depth per day at the available head.

2. Control structures shall be provided for each cell. No discharge structure will be permitted for a single cell installation. The control structure should provide a positive visual means of directing and controlling the flow and be accessible for maintenance and adjustment of controls. The control structure should consist of a manhole or box equipped with multiple-valved pond drawoff lines or an adjustable overflow device so that the liquid level of the pond can be adjusted to permit operation between the minimum and maximum operating levels. At least one drawoff line shall be located at the two (2) foot level. The lowest of the drawoff lines to such structure should be 12 inches off the bottom to control eroding velocities and avoid pickup

of bottom deposits. Erosion protection should be provided at the inlet and discharge end of the piping. The overflow from the pond during ice-free periods should be taken near, but below, the water surface to release the best effluent and insure retention of floating solids. A locking device should be provided to prevent unauthorized access to and use of the level control facilities. The outlet structure should be located to minimize short-circuiting within the cell, if possible, on the windward side. Consideration must be given in the design of all structures to protect against freezing or ice damage under winter conditions.

3. Interconnecting piping for multiple unit installations operated in series should be valved or provided with other arrangements to regulate flow between structures and permit flexible depth control. Interconnecting piping to secondary cells should discharge horizontally near the pond bottom to minimize the need for erosion control measures and should be located as near the dividing dike as construction permits. Consideration must be given in the design of all piping to protect against freezing or ice damage under winter conditions. Interconnecting piping shall be provided with splash pads. Anti-seep collars may be necessary on pipes penetrating the dikes, to discourage seepage and scouring.

4. The outlet end of the discharge pipe should be screened to prevent the entrance of wildlife.

H. Miscellaneous

1. Access Roads

An all-weather access road to the pond site shall be provided to carry out the routine inspections and maintenance which are required year-round on even the smallest installations.

A minimum 30 foot easement is recommended and not less than 20 feet should be provided. This minimum easement will permit light shaping and gravel surfacing for a ten foot roadway. Such minimums may only be satisfactory where the drainage is good and the distance from a maintained roadway is less than one-half mile. Minimum access fulfilling these requirements should be provided in all cases.

2. Fencing

The entire pond area shall be enclosed with a suitable fence to provide for public safety, to exclude livestock, and to discourage trespassing. The pond area should be fenced with at least 4 foot woven wire and two strands of barbed wire at the top. Where ponds are located near schools, parks, trailer courts, etc., the pond area shall be entirely enclosed with 6 foot high non-climbable chain-link fence. A vehicle access gate of minimum 12 foot width to accommodate mowing equipment should be provided unless the installation is small; then 8 foot will be satisfactory. All access gates shall be provided with locks. Fences shall be located away from the outside toe of the dike to facilitate dike mowing and maintenance operations.

3. Warning Signs

Appropriate signs should be provided along the fence around the pond to inform the public of the facility and advise against trespassing. A minimum size of 20 inches by 12 inches with a minimum size letter of two inches is recommended. There shall be at least one such sign on each side of the pond and every 500 feet along the fence.

4. *Flow Measurement*

Provisions for flow measurement devices shall be provided at the inlet and outlet of controlled-discharge systems. Flow measurement devices shall be capable of measuring the maximum anticipated flows. Recording equipment shall be protected from the weather and flow conditions.

5. *Depth Measurement*

Pond depth indicators shall be provided. Due to ice conditions, a calibrated, inclined concrete section anchored into the dike slope is the most desirable. The outlet structure of each cell may also be utilized if properly and permanently calibrated. The depth indicator shall allow easy observation and shall be permanent. It is recommended that the depth indicators be permanently etched in the concrete.

6. *Synthetic Liners*

   a. The minimum lining thickness shall be 30 mils. The liner material shall be resistant to sunlight and organic materials typical of wastewater.

   b. Where the bottom of pond is below the seasonal high groundwater, the liner shall be stabilized to prevent it from rising. An air-release system may be required.

   c. Liners shall be installed and securely anchored to resist movement from wave and ice conditions.

7. *Laboratory Equipment and Service Building*

Equipment for wastewater analyses should be provided as outlined in Chapter 40, Recommended Standards for Sewage Works, 1978 or the latest edition.

A minimum amount of equipment may be provided if the owner utilizes the wastewater analyses provided by the Municipal Effluent Sampling Program (MESP) of the South Dakota Department of Water and Natural Resources or any other acceptable public or private wastewater laboratory.

Consideration in design should be given to a service building to house laboratory and maintenance equipment.

8. *Deviations from Design Criteria*

The Department may consider and allow deviations where adequate documentation is provided to prove the need for such deviation.

CHAPTER V: Recommended Design Criteria For Aerated Ponds

CHAPTER V

RECOMMENDED DESIGN CRITERIA FOR AERATED PONDS

A. Supplement to Engineer's Report, Plans and Specifications

Refer to Chapter IV, Section A for applicable requirements.

B. Basis of Pond Design

1. Detention Time

The aerated stabilization pond(s) shall be designed to meet the effluent requirements as described in the discharge permit. The minimum detention time for the pond(s) is determined by the following formula:

$$t = E/2.3\ K_{T\ (100\text{-}E)}$$

where:

t= detention time, days
E= percent of 5-day BOD to be removed in aerated pond
K_T= reaction coefficient per day (base 10) in aerated pond assuming a complete mixed system. For complete treatment of normal domestic sewage, the K_T value may be assumed to be 0.20/day at 20^{o}C or 0.08/day at 0^{o}C.

The rate of biological oxidation in an aerated pond as represented by the value of the reaction coefficient K_T is affected by temperatures other than 20^{o}C shall be according to the following formula:

$$K_T = K_{20}\ 1.047^{T-20}$$

where:

K_T= reaction coefficient at temperature t^{o}C in aerated pond
K20= reaction coefficient at temperature 20^{o}C
T= temperature in aerated pond, ^{o}C

For wastewater with a 5-day BOD to the pond of 150 to 300 mg/l, the K_{20} value will be assumed to be 0.20 per day. For wastewater with a 5-day BOD to the pond greater than 301 mg/l, the reaction rate coefficient must be determined by a pilot plant study for various conditions which might be encountered in the aerated ponds.

The detention time should be based on the rate of metabolism during the coldest period of the year, when the oxygen demand rate is at its lowest. Aeration equipment should be sized according to the oxygen and mixing requirements based on peak 24-hour summer loadings.

The configuration of the aerated ponds should be such that the detention time is maintained between approximately 5 and 10 days in warm weather and between approximately 8 and 20 days in cold weather.

Due consideration shall be given to possible future expansion and/or additional sources of wastes when the original land acquisition is made. Suitable land should be available at the site for increasing the size of the original construction.

2. *Industrial Wastes*

Consideration shall be given to the type and possible effects of industrial wastes on the treatment process.

3. *Multiple Units*

There should be a minimum of two aerated ponds for a total aerated system. It is recommended that they be designed to permit both series and parallel operation. This allows maximum operational capability to achieve the desired effluent quality.

4. *Pre or Post Treatment*

Where aerated ponds are to be used in conjunction with conventional treatment works, the Department will, upon request, review and recommend BOD loading limits for the pond after due consideration of the efficiency of other treatment units.

5. *Shape*

Refer to Chapter IV, Section B-5, for applicable requirements.

C. Pond Location

Refer to Chapter IV, Section C for applicable requirements other than:

1. *Distance from Habitation*

An aerated pond system should be at least 750 feet and if used with a conventional pond system should be at least one-quarter mile or as far as practicable from habitation or any area which is likely to be developed within a reasonable future period.

D. Pond Construction Details

1. *Embankments and Dikes*

Refer to Chapter IV, Section D for applicable requirements other than:

a. Embankment slopes shall be provided with bank stabilization and liner. Embankment slopes may be as steep as two horizontal to one vertical (2:1).

b. Embankment slopes should not be flatter than four horizontal to one vertical (4:1) on the inside.

c. The maximum liquid pond depth shall not exceed 20 feet. The minimum normal liquid depth will depend upon the aeration equipment to be used with the pond depth but generally should not be less than 10 feet. Normally, the better mixing action will occur in depths of 12-15 feet. For economical reasons, diffuser systems should be used on the bottom of ponds with 15-20 foot depths.

E. Pond Bottom

Refer to Chapter IV, Section E for applicable requirements other than:

1. Adequate concrete pads shall be provided under mechanical surface aerators to prevent bottom scour.

2. Consideration should be given to providing some additional detention time and storage capacity for sludge accumulation over a period of 10 to 20 years. The maximum sludge storage depth should not be greater than 6 feet. This sludge storage capacity could be held to a minimum if the bottom was concrete lined with a hopper type sump for cleaning purposes. It may be assumed that the sludge will compact to about 6 percent dry solids.

F. Influent Lines

Refer to Chapter IV, Section F for applicable requirements other than:

1. A comminutor or manually cleaned bar screen should be provided upstream from the influent line conveying raw sewage or waste into an aerated pond system. Screening or comminution will be required to prevent damage to mechanical surface aerators.

2. Influent lines should discharge under water and provisions provided for adequate distribution to the pond of the incoming flow. Normally, the influent should be discharged under mechanical aerators, near the aeration grid or other diffusers where air diffusion systems are used. When diffused air tubing is used in the ponds, they must be installed at 90 degrees to the direction of the plug flow of the influent.

3. Recirculation should be considered when wastewater has a high sulfate content or contains waste of high BOD.

4. The inlet pipe may go directly through the dike and end at the toe of the inner slope with concrete or riprap placed in front of and around the pipe to prevent erosion of pond bottom and dike slope.

G. Control Structures and Interconnecting Piping

Refer to Chapter IV, Section G for applicable requirements other than:

1. In a multiple cell facility with a diffused air aeration system and summerged air headers, consideration must be given to arranging the overflow structure and piping to allow for independently draining each cell down to or below the level of the air header.

2. Effluent from the first cell should be withdrawn from an underflow baffle. Effluents from interconnecting cells may be discharged at or near the surface without baffling to reduce the potential for algal growth.

H. Aeration Equipment

1. Dissolved Oxygen Requirements

Oxygen requirements generally will depend on the BOD loading, the degree of treatment and the concentration of suspended solids to be maintained. Aeration equipment shall be capable of maintaining a minimum dissolved oxygen level of 2 mg/l in the ponds at all times. Suitable protection from the weather and elements shall be provided for electrical controls.

2. Required Capacity of Aeration Equipment

In designing aeration equipment, the a' factor in the following equation should be at least 1.5 and possibly 2, to provide sufficient aeration capacity during critical periods of the year:

$$R = a'L$$

Where:

R= pounds of oxygen required per day
L= pounds of 5-day BOD removed per day
a'= ratio between oxygen utilized and BOD removed

3. Emergency Operation

Spare aeration units shall be provided to allow the system to be fully operational in event a unit is out of service. Aeration units should be provided with an emergency power supply.

4. Mixing

A bottom velocity of at least 0.3 ft/sec. should be created by the aeration equipment throughout the pond.

5. Diffused Aeration

a. If fine bubble diffusers (flexible tubing diffused aeration equipment) are used, allow a transfer rate of 0.75 pounds of oxygen per horsepower-hour.

b. If a large bubble diffusers (horizontal type) are used, allow a transfer rate of 1.2 pounds of oxygen per horsepower-hour.

If large bubble diffusers (vertical tubular- type) are used, allow a transfer rate of 0.7 pounds of oxygen per horsepower-hour.

c. The specified capacity of blowers or air compressors, particularly centrifugal blowers, should take into account the possibility that the air intake temperature may reach 104 degrees F (40 degrees C) or higher and also that the pressure may be less than normal.

d. The specified capacity of the motor drive should take into account that the intake air temperature may be as low as -22 degrees F (-30 degrees C) or lower, which may require over-sizing of the motor or a means of reducing the rate of air delivery so as to prevent overheating and damage to the motor.

e. The blowers shall be provided in multiple units, so arranged and in such capacities as to meet the maximum air demand with the single largest unit out of service. The design should also provide for varying the volume of air delivered in proportion to the demand resulting from the variable loadings in the ponds.

f. Air intakes and blowers shall be designed to minimize noise.

g. The piping and air diffuser system shall be capable of delivering 200 percent of the design average oxygen demand. The spacing of the diffusers should be in accordance with oxygenation requirements throughout the length of each pond.

h. Individual assemblies or units of diffusers shall be equipped with control valves, preferably with indicator markings for throttling, or for complete shut off. The air diffusion piping and diffuser system shall be designed to deliver normal air requirements with minimal uniform pressure losses. The air diffusion system should be of non-corrosive material.

i. Air piping systems should be designed such that the total head loss from blower or silencer outlet to the diffuser inlet does not exceed 0.5 psi at average operating conditions.

j. Air filters shall be provided in numbers, arrangements, and capacities to furnish at all times an air supply sufficiently free from dust to prevent clogging of the diffuser system.

   In diffused air systems, the greatest percentage of air should be provided in the first pond.

   Connections for gassing facilities to control sealing should be provided at frequent intervals along the air header pipes.

6. *Mechanical Aeration*

   a. If surface aerators are used, allow a transfer rate of 1.5 pounds of oxygen per horsepower-hour.

   b. The mechanism and drive unit shall be designed for the expected conditions in the aeration ponds in terms of the proven performance of the equipment.

   c. The raw sewage should be discharged immediately below the aerators in the first cell so as to minimize freezing during winter.

   d. Consideration shall be given to protecting the mechanisms from freezing. Floating surface aerators are not acceptable except for installations in operation from April to November.

   e. Installations of multiple individual aerators shall be so designed as to meet the maximum oxygen demand with the largest unit in each pond out of service.

   f. The design should also provide for varying the amount of oxygen transferred in proportion to the demand represented by the load on the pond.

   g. Fix-mounted aerator units should have adjustable baseplates or other methods for varying the submergence of the rotor. Where practical, bridge-mounted platforms with handrails should be provided for maintenance.

I. Settling Pond

A 5 to 7 day detention time settling pond shall be constructed following the second or last aerated pond. Other methods of treatment may be considered by the Department where adequate documentation is provided.

The settling pond must meet the requirements for slope, bank erosion protection and water tightness for the aerated pond.

The outlet structure should be baffled with an overflow rate not to exceed 800 gpd/sq.ft.

J. Disinfection

Equipment for disinfection of the effluent when required shall be provided as outlined in Chapter 90 of the Recommended Standards for Sewage Works, 1978 or the latest edition.

K. Miscellaneous

Refer to Chapter IV, Section H for applicable requirements other than:

1. *Flow Measurement*

A flow recorder and totalizer shall be provided on the influent line at the pond. A weir should be provided at the out-fall of the pond system to allow periodic measurement of the flow of effluent. Flow measurement equipment shall be protected from the weather and flow conditions.

2. Housing

The design should provide a service building to house laboratory, mechanical, control, and maintenance equipment with chemical storage facilities.

CHAPTER VI: Recommended Design Criteria For Preliminary Treatment Processes

A. Screening Devices (Bar Racks and Screens)
1. *Purpose*
2. *Location*
3. *Design and Installation*
4. *Channels*
5. *Control Systems*
6. *Safety and Servicing*
7. *Handling and Disposal*

B. Comminuting Devices
1. *General*
2. *Design Considerations*

C. Grit Removal Devices
1. *General*
2. *Location*
3. *Design Considerations*
4. *Safety and Servicing*
5. *Grit Washing, Handling, and Disposal*

D. Pre-Aeration and Flocculation
1. *General*

E. Deviations from Design Criteria

CHAPTER VI

RECOMMENDED DESIGN CRITERIA FOR PRELIMINARY TREATMENT PROCESSES

A. Screening Devices (Bar Racks and Screens)

1. *Purpose*

   Coarse bar racks and screens shall be provided to remove coarse materials that would damage pumps and other equipment or interfere with plant operability.

2. Location

   a. Coarse bar racks or bar screens shall precede communitors and mechanically cleaned grit chambers.

   b. Fine screens, if used, should follow grit removal and have additional provisions for the removal of floatable greases and oils. Comminuting devices shall not be used ahead of fine screens.

   c. Screening devices shall be installed in a building that has adequate heat, ventilation and moisture control. Screening devices shall be separated from other equipment or offices and be provided with separate outside entrances.

3. *Design and Installation*

   a. Manually Cleaned Screens

   Manually cleaned screens shall be provided for bypass of a mechanically cleaned screen, comminutor, or for mechanical treatment plants having an average design capacity of 0.1 MGD or less. The screen shall consist of vertical or inclined bars with clear openings spaced at equal intervals of 1 to 1 3/4 inches across a channel.

   Manually cleaned screens, except those for emergency use, should be placed on a slope of 30 to 45 degrees from the vertical.

   Approach velocities, at minimum flow, shall not be less than 1.0 foot per second and not more than 2.0 feet per second at peak hourly flow. Velocities for bar screens shall be calculated from a vertical projection of the screen openings on the cross-sectional area between the invert of the channel and the flow line.

   b. Mechanically Cleaned Screens

The mechanically cleaned screen shall consist of vertical or inclined bars with clear openings spaced at equal intervals of 5/8 to 1 3/4 inches across a channel.

Mechanically cleaned bar screens should be placed on a slope of 0 to 45 degrees from the vertical.

Approach velocities, at minimum flow, shall not be less than 1.25 feet per second and not more than 3.0 feet per second at peak hourly flow. When grit chambers follow bar screens, the minimum velocity should be greater than 1.3 feet per second. Velocities shall be calculated as mentioned above for manual screens.

4. *Channels*

   a. Entrance channels shall be designed to allow equal flows and uniform distribution to the screens.

   b. The invert of the screen channel should be from 3.0 to 6.0 inches below the invert of the incoming sewer.

   c. The channel preceding and immediately following the screen shall be shaped and sloped to eliminate the deposition of solids and permit draining of the channel.

   d. Multiple parallel channels shall be provided and equipped with the necessary gates to isolate or divert the flows from sections of the channels containing screens or comminuting units.

   e. Capacity shall be provided to treat peak hourly flow with one unit out of service.

5. *Control Systems*

   a. Mechanically cleaned bar screens shall be properly controlled by differential water level and timing devices or continuous operation. Mechanical units which are operated by timing devices shall be provided with auxiliary controls which will start the cleaning operation at a preset, high water elevation and a device to stop the cleaning operation after a predetermined length of time.

   b. Flow measurement devices should be located and selected for reliability and accuracy.

   c. Automatic controls shall have manual override capability.

   d. The maximum allowable head loss through clogged racks and bar screens is generally limited to 2.5 feet. Generally, the absolute minimum head loss allowance through a manually cleaned bar screen is 6 inches, assuming frequent attention by operating personnel. Assurance should be provided that the head loss through the screening unit at peak hourly flows will not surcharge the incoming sewer.

6. *Safety and Servicing*

   a. The drive mechanism of a mechanically cleaned screen shall be enclosed.

   b. A positive power lockout device for each mechanical device shall be provided.

   c. Screen channels shall be provided with guard railings and/or deck gratings where necessary. Temporary access should be considered to facilitate maintenance and repair or removal.

   d. Manually cleaned screening facilities shall include an accessible platform from which the operator may rake screenings easily and safely. Suitable drainage facilities back to the raw wastewater wet well shall be provided for both the platform and the storage area.

   e. Screening areas shall be provided with adequate stairway access, lighting, ventilation, and a convenient means for removing the screenings.

   f. Electrical fixtures and controls in screen areas shall comply with the National Electrical Code, Class 1, Groups C and D, Division 1 locations.

   g. Treatment plant operators should be supplied with a complete set of operational instructions, including maintenance schedules, tools and spare parts as may be necessary.

   h. Due consideration shall be given to the selection of materials because of corrosive conditions present.

7. *Handling and Disposal*

   a. Screening receptacles shall be designed to contain a minimum of one day's screenings.

   b. No screenings shall be returned to the wastewater flow.

   c. Facilities shall provide for removal, handling, storage, and disposal of screenings in a sanitary manner.

   d. Screenings shall be disposed of in an approved sanitary landfill or by incineration.

   e. Pressurized wash water facilities shall be provided to facilitate cleaning. Potable water lines may be used but shall be protected with backflow prevention devices or vacuum breakers. If wash water is non-potable, all outlets shall be permanently posted to indicate water is not safe.

B. Comminuting Devices

1. *General*

   a. Provisions for location shall be in accordance with those for screening devices.

b. Comminutors shall be provided in plants that do not have primary clarifiers, fine screens, or mechanically cleaned bar screens.

c. Provisions for safety and servicing shall be in accordance with those for screening devices.

2. Design Considerations

a. Comminutors should be located downstream of grit removal equipment. If no grit removal equipment is provided; then the comminutor should be protected with at least a 6.0-inch deep gravel trap.

b. If a comminutor is to be used, the manufacturers should be consulted to select the unit size on the basis of the largest particle that may be allowed to pass. Generally, comminuting devices are installed in the wastewater flow to shred the material retained in the flow to a size of 1/4 inch to 3/4 inch.

c. Comminution or screening capacity shall be adequate to handle peak hourly flows with the largest comminutor out of service.

d. Channels in which comminutors are installed shall be provided with an emergency bypass to a bar screen. Flow exceeding the operating capacity of the comminutor(s) shall be automatically diverted to the emergency bypass. The channels shall be parallel with provision for slide gates or similar devices to permit isolating and draining of the channels.

e. The comminutor shall run continuously and provision for another comminutor to be ready for service is desirable.

C. Grit Removal Devices

1. General

a. Grit chambers should be provided for all mechanical wastewater treatment plants and some oxidation ditches. Mechanical plants receiving wastewater from combined sewers or from collection systems receiving substantial amounts of wastes from garbage disposals and/or grit shall be provided with grit removal devices. Oxidation ditches receiving wastewater from combined sewers or from collection systems receiving substantial amounts of grit shall be provided with grid removal devices.

b. Mechanical grit removal devices will be required where substantial amounts of grit to plant processes or equipment will interfere with the operation and maintenance; cause deterioration and subsequent replacement of equipment; or will substantially increase the need for additional storage capacity in other treatment units where grit is likely to accumulate.

c. If a treatment facility, is designed without grit removal devices; the design shall include provision for future installation. This condition may be required on a case-by-case basis for oxidation ditches.

d. A minimum of one mechanically cleaned unit and a bypass pipe or channel shall be provided for plants serving separate sewers and receiving flows between 0.5 and 1.0 MGD. Plants smaller than 0.5 MGD may have a manually cleaned unit with a bypass. Plants larger than 1.0 MGD or serving combined sewers, shall have two mechanically cleaned grit removal units designed for peak hourly flow with the capability to isolate each one.

e. Grit removal facilities other than channel- type are acceptable if provided with adequate and flexible controls for agitation and/or air supply devices and with grit removal equipment.

2. *Location*

a. Grit chambers may be located outdoors with proper protection from freezing, but all grit conveying, washing and handling facilities shall be installed in a building that has adequate heat, ventilation and moisture control. Ventilation, if continuous, should provide at least 12 complete air changes per hour; if intermittent, at least 30 complete air changes per hour.

b. Grit removal devices should be located after coarse bar racks or coarse bar screens, but ahead of comminutors, pumps and other treatment units. Where grit chambers are mechanized, it may be desirable to locate the bar screens and/or comminuting devices ahead of grit chambers to reduce the effect of rags and other gross particles. However, whether the screening and/or comminuting devices are located ahead of or after the grit chamber, it shall be readily accessible for inspection, maintenance and handling of materials.

3. *Design Considerations*

a. Inlet and Outlet

Turbulence should be minimized by design considerations for transition sections, such as approach channels, and inlet and outlet devices. The inlet and outlet shall be designed to avoid short circuiting. In some cases, the installation of longitudinal and traverse baffles improve grit removal.

b. Velocity and Detention

1) Channel-type grit chambers shall be designed to provide controlled velocities within the range of 0.75 and 1.25 feet per second. The velocity should be maintained as close as possible to 1.0 feet per second for all anticipated volumes of flow.

2) Detention time of a channel-type grit chamber shall be based on the size and specific weight of the particle to be removed. The chamber must be designed with a sufficient detention period to allow a particle of 0.21 mm in size to settle from the wastewater surface to the bottom before the flow leaves the chamber. A particle of this size having

a specific gravity of 2.65 will settle at a rate of about 4.0 feet per minute in wastewater at a temperature of 15.5 degrees C. In terms of overflow rates, this is slightly less than 43,000 gpd per square foot. Overflow rates may govern the basis of design whether the chamber is round or rectangular.

3) For aerated or vortex type grit chambers, the minimum detention time shall be between 1 and 3 minutes at peak hourly flow. Generally, a detention time of 3 minutes is necessary for good removal.

4) All grit removal facilities should be provided with adequate automatic control devices to regulate detention time, agitation, and air supply. The units shall have manual override capability.

c. Drains

Provisions shall be made for isolating and dewatering each unit.

d. Capacity

Since grit storage capacity is essential but cannot be easily determined due to the extreme variations in grit quantities of different collection systems, the following typical design values are suggested:

combined systems - 10 to 30 cu.ft./mil gal.

separate systems - 2 to 10 cu.ft./mil gal.

In general, 1.0 to 4.0 cubic feet of grit per million gallons of domestic wastewater flow from well constructed sewers can be expected. A generous safety factor is recommended in calculations involving the actual storage, handling, or disposal of grit.

e. Aerated Type Grit Chamber

1) The air supply must be controllable and capable of varying from 10 to 40 cfm/1,000 cubic feet. The minimum air requirement is three cubic feet per minute per foot of chamber length when the total depth of the basin is approximately 10 to 12 feet. Higher air rates are required for wider and deeper installations.

2) Chambers should have a depth to width ratio of 2 to 1 or larger but not less than 1.5 to 1. Length to width ratios of 3:1 to 5:1 are desirable.

3) Grit shall be directed to a grit hopper with steep sloped sides for removal in manually or mechanically cleaned grit basins.

4) The location of the air diffusion tubes should be approximately 1.5 to 2.0 feet from the bottom of the chamber and along its side, parallel to the wastewater flow, provided that the depth of basin is approximately 10 to 12 feet.

5) Air diffusers shall be removable without taking the basin out of service. Swing type diffusers are most desirable.

4. *Safety and Servicing*

a. Safe access shall be provided to the grit chambers and, where mechanical equipment is involved, all moving parts shall be enclosed.

b. Adequate stairway access with handrails and landings or approved type elevator or manlift to above-or- below-grade facilities shall be provided. Due consideration shall be given to the selection of materials because of corrosive conditions present.

c. Consideration should be given to locating drain valves, weir plates and stop gates for ease of operation and safety.

d. Treatment plant operators should be supplied with a complete set of operational instructions, including maintenance schedules, tools and spare parts as may be necessary.

e. Electrical equipment and controls in enclosed grit removal areas where hazardous gases may accumulate shall meet the requirements of the National Electrical Code for Class 1, Groups C and D, Division 1 locations.

5. *Grit Washing, Handling, and Disposal*

a. The need for grit washing to separate organic and inorganic materials should be determined by the method of final grit disposal.

b. Grit removal facilities located in pits 6 feet or deeper and plants larger than 0.5 MGD shall be provided with mechanical or air lift systems to hoist or transport grit to ground level. Impervious, non-slip, working surfaces with drains shall be provided for grit handling areas.

c. Grit conveying and transporting equipment shall be provided with protection against freezing and loss of material. Consideration should be given in large plants for loading facilities to discharge grit directly by mechanical means to a transport vehicle.

d. An adequate supply of water under pressure shall be provided for cleanup. If the source is a potable water line, it shall be protected with backflow prevention devices or vacuum breakers. Suitable drainage facilities back to the raw wastewater wet well shall be provided for cleanup.

e. Grit shall be disposed of in an approved sanitary landfill or a satisfactory method approved by this Department.

D. Pre-Aeration and Flocculation

1. General

a. Pre-aeration and flocculation of wastewater to reduce septicity, high organic strength or suspended solids may be required in special cases.

b. Generally, it is recommended that pre- aeration be combined with aerated grit chambers.

c. The units should be designed so that removal from service will not interfere with normal operation of the remainder of the plant.

E. Deviations from Design Criteria

The Department may consider and allow deviations where adequate documentation is provided to prove the need for such deviation.

CHAPTER VII: Recommended Design Criteria For Flow Equalization

CHAPTER VII

RECOMMENDED DESIGN CRITERIA FOR FLOW EQUALIZATION

A. INTRODUCTION

1. *Objectives*

a. The primary objective of flow equalization basins is to dampen the diurnal flow variation, as well as variations caused by inflow/infiltration, and thus achieve a nearly constant flow rate through the downstream treatment processes.

b. The secondary objective is to dampen the strength of wastewater constituents by blending the wastewater in the equalization basin to maintain a degree of reliability and operational control.

2. *General*

Flow equalization should be provided in mechanical plants where large diurnal variations are expected to cause mechanical, hydraulic, or biological process upsets. For treatment plants with capacities of less than 0.5 mgd, employment of this process is recommended.

3. *Location*

Equalization basins should be located downstream of pretreatment facilities such as bar screens, comminutors, grit chambers, and where possible, primary clarifiers.

4. *Type*

Equalization basins may be designed as either in- line or side-line units. Separate basins or unused on-line treatment units, such as primary clarifiers or aeration tanks, may be utilized for flow equalization during the early period of the plants design life. If no other unit is available and it is a single basin, then a by-pass pipe shall be provided around the basin to the downstream portion of the treatment facility. The by-pass pipe shall be valved.

5. *Size of Basins*

With a diurnal flow pattern, the volume required to achieve the desired degree of equalization can be determined from a cumulative flow volume hydrograph over a representative 24-hour period. The volume required for equalization of flows will generally vary from approximately 20 to 40 percent of the 24-hour flow for smaller plants and from approximately 10 to 20 percent of the average daily dry weather flow for larger plants. It is recommended that the equalization basin be divided into two or more separate cells.

6. *Basin Construction*

Equalization basins may be constructed of earth, concrete, or steel. Earthen basins should be constructed according to aerated pond criteria. At least 1 foot of freeboard shall be provided above the highest possible water level in the basin.

Corner fillets and hopper bottoms with draw-offs shall be provided to prevent accumulation of sludge and grit. The basins shall be capable of being isolated and drained.

Basins shall have provisions for cleaning of basin walls and for scum control with suitable access provided to facilitate the cleaning and the maintenance of equipment.

7. *Air and Mixing Requirements*

Mixing requirements for normal domestic wastewater shall range from 0.02 to 0.04 hp/1,000 gallons of storage. Multiple aeration and/or mixing units shall be provided to maintain adequate mixing and for continuous operation. The air should be supplied at a rate of 1.25 to 2.0 cfm/1,000 gallons of storage. Aeration shall be sufficient to maintain a minimum of 1.0 mg/l of dissolved oxygen in the basin at all times.

8. *Controls*

All inlets and outlets of each basin compartment shall be provided with accessible flow control devices. Flow-measuring devices or facilities shall be provided downstream of the basins to monitor liquid levels and equalized flow rates. Suitable protection from the weather and elements shall be provided for all electrical works.

B. DEVIATIONS FROM DESIGN CRITERIA

The Department may consider and allow deviations where adequate documentation is provided to prove the need for such deviation.

CHAPTER VIII: Recommended Design Criteria For Sedimentation

CHAPTER VIII

RECOMMENDED DESIGN CRITERIA FOR SEDIMENTATION

A. GENERAL CONSIDERATIONS

Sedimentation is a process used for various stages within a wastewater treatment plant to reduce the concentration of settleable and suspended matter. Sedimentation tanks, commonly referred to as clarifiers, are described as primary, intermediate and final clarifiers dependent upon the process stage. Primary clarifiers are installed to reduce organic loadings and floatables to the downstream treatment processes. Intermediate and/or final clarifiers are utilized after biological treatment processes to separate chemical and/or biological floc from the treatment process.

1. Multiple units capable of independent operation shall be provided for plants having an average design capacity greater than 0.1 MGD unless temporary removal of a single unit from service for repairs will not result in an adverse effect to the quality of the receiving stream.

2. Clarifiers shall be arranged to facilitate operating flexibility and maintenance, assure continuity of treatment, and ease of installation of future units.

3. Provision shall be made for dewatering and bypassing each unit independently. The bypass should provide for redistribution of the wastewater to an appropriate point in the remaining process units. Due consideration shall be given to the possible need for hydrostatic pressure relief devices to prevent structure flotation.

4. Effective flow measurement devices and controls shall be provided to permit proper flow distribution to each unit.

5. The anticipated flow pattern should be considered in the selection of clarifier configurations and location and type of inlets and outlets. Consideration should be given to flow equalization.

6. Primary clarifiers are required prior to trickling filters and rotating biological contactors (RBC). Bar screening and comminution are not suitable as the sole means of primary treatment.

B. DESIGN CONSIDERATIONS

1. Performance

Unless laboratory and/or pilot plant data are available, primary settling shall be assumed to remove one- third of the influent BOD and 55 percent of the influent suspended solids. It is not recommended to return waste activated sludge to the primary clarifier. This sludge should be returned to the aeration basin or a separate thickener unit.

2. Inlets

Inlets should be designed to dissipate the inlet velocity, to distribute the flow uniformly and to prevent short-circuiting. Provisions shall be made for removal of floating materials in inlet structures having submerged ports. Orifices placed in walls at the inlets should be sized to produced velocities from 0.5 to 1.0 fps. Orifices passing wastewater containing floc should not be smaller than 0.3 to 0.5 inches, to minimize floc breakup.

3. *Dimensions*

   a. The minimum distance from the influent inlet to effluent weirs shall be at least 10 feet for all clarifier configurations unless special provisions are made to prevent short-circuiting. The sidewater depth (SWD) of mechanically cleaned clarifiers shall not be less than 7 feet for primary clarifiers and those following fixed film reactors. Final clarifiers shall have sidewater depths of at least 10 feet and those following an activated sludge process shall have sidewater depths of at least 12 feet. If depth limitations due to ground conditions are less than the minimum recommended, the overflow rate should be reduced by 100 gpd/sq.ft. for each foot of sidewater depth under the recommended for clarifiers. It is preferable that the sludge collector scraping mechanism be at least 6 feet below the water level. Clarifiers having depths less than recommended will be considered on a case-by-case basis.

   b. The length-to-width ratio for rectangular clarifiers should be equal to or greater than 4 to 1.

   c. The maximum horizontal velocity in a rectangular clarifier shall not exceed 5 feet per minute near the sludge layer in a primary clarifier and 2 feet per minute in a final clarifier.

4. *Channels*

   a. Inlet channels should be designed to maintain a velocity of at least one foot per second at one-half design flow. Where minimum velocities are less, provisions shall be made for the resuspending of the solids. Corner fillets or channeling shall be provided to eliminate corner pockets and dead ends.

   b. Width of effluent channels should be at least 1.0 foot. Bottom of the channels at the outlet structures shall be at least equal to or above the water levels of the downstream treatment units. The effluent channel shall be sized to prevent weir submergence at the peak hourly flow. The bottom of effluent channels should be at least one foot below water levels maintained in the clarifiers, except for small package plants.

5. *Freeboard*

The outer walls of clarifiers shall extend at least 6 inches above the surrounding terrain or 100-year flood plain and shall provide at least 12 inches of freeboard to the water surface. Where clarifier walls do not extend 4 feet above the surrounding terrain, a cover, fence, wind screen or suitable barrier shall be provided to prevent high wind currents and debris from entering the clarifier and ice buildup which inhibits scum removal and settling.

6. *Baffling and Scum Removal*

   a. Scum baffles shall be provided around and prior to all effluent weirs. The baffles shall be located at the water surface to intercept all floating materials and scum. Baffles shall extend at least 3 inches above the weir plate elevation and 12 inches below the water surface.

   b. Circular clarifiers shall be provided with symmetrical baffling, a minimum of 6 inches inside the weir plate, to distribute the flow uniformly in all radial directions. In a circular center-feed clarifier, the inlet baffle should have a diameter of 15 to 20 percent of the clarifier diameter and should not extend more than 3 feet below the water surface. With 100 percent recirculation, circular center-feed clarifier inlet baffles should not be less than 20 percent of the clarifier diameter and have a depth of 55 to 65 percent of the SWD. The maximum inlet velocity to a center inlet well should not exceed 3 feet per second. The outflow velocity should not exceed 15 feet per minute. In a circular peripheral-feed clarifier, the inlet baffles shall extend at least 12 inches below the flowline of the inlet and shall be located above the sludge blanket zone at a distance where the critical horizontal velocity will just begin to produce scour.

   c. Rectangular clarifiers shall be provided with inlet ports or pipes and baffles for uniform distribution of flow across the clarifier and effluent weirs. The baffles shall extend across the width of the clarifier and upstream to the effluent weirs.

   d. Effective scum collection and removal facilities, including baffling, shall be provided ahead of the effluent weirs on all clarifiers. Provisions should be made for disposal of scum with the sludge; however, other special provisions for disposal of scum and floating materials may be necessary.

   e. A scum pit shall be located outside of the clarifier but adjacent to the scum collection point and located on the side of the clarifier opposite the prevailing wind direction. Provisions should be made for mixing the contents of the scum pit with such equipment as a mechanical mixer or air diffusion.

7. *Submerged Surfaces*

   The topside of beams, troughs or similar construction components shall have a minimum slope of 1.4 vertical to 1 horizontal; the underside of such components shall have a slope of 1 to 1 to prevent the accumulation of scum and solids.

8. *Weirs*

   a. Weir plates shall be adjustable for leveling and sealed against the effluent channel. Weirs shall be located to optimize actual hydraulic detention time and minimize short circuiting.

   b. Circular clarifiers, with peripheral-feed or center-feed inlets, shall be provided with a full weir. Effluent launders may be placed at points other than at the periphery. The minimum water depth below effluent weirs located near the center should be 10 feet and 12 feet if weirs are located at the periphery. These minimum water depths need not be provided for small clarifiers having low weir and surface-loading rates.

c. Double weirs to increase the length are permissible if installed sufficiently in-board for good separation of flow to minimize velocity problems at the periphery. Experimently, circular weir troughs placed at 2/3 to 3/4 of the radial distance from the center is the optimum position to intercept well-clarified effluent. The weir length of double weirs shall be computed as double the length of the centerline of the launder.

d. Weirs should be of the saw-tooth or serpentine type to allow for better weir overflow and flow distribution.

e. To determine the spacing of multiple weirs in rectangular clarifiers, the upflow velocity near the weir should be limited to approximately 12 to 24 feet per hour. If weirs are located at end walls in rectangular clarifiers, the minimum water depth below the effluent weir should be 12 feet.

f. Weir Loadings

   1) Weir loadings should not exceed 10,000 gallons per day per lineal foot for primary, intermediate or final clarifiers at peak hourly flows unless select design parameters are considered; (such as, depth, surface area, detention time, horizontal and/or vertical velocities, solids density) then the higher weir loadings may be considered. Hydraulic loading criteria in clarifier design should be based on the sum of plant inflow and recycle rates.

   2) Weir loadings at peak hourly flows should not exceed 15,000 gallons per day per lineal foot for primary or intermediate clarifiers; and should not exceed 10,000 gallons per day per lineal foot for final clarifiers in plants with average design flows of 1.0 MGD or less.

   3) Weir loadings at peak hourly flows in plants with average design flows larger than 1.0 MGD should not exceed 20,000 gallons per day per lineal foot for primary and intermediate clarifiers; and should not exceed 15,000 gallons per day per lineal foot for final clarifiers.

   4) Rectangular primary clarifiers with end weirs shall not exceed a weir loading of 80,000 gallons per day per lineal foot at peak hourly flow. Intermediate and final rectangular clarifiers with launder and weir at the outer wall shall not exceed a weir loading of 20,000 gallons per day per lineal foot at peak hourly flow.

   5) If pumping is required, weir loadings should correspond to the pumping rates to prevent short circuiting.

9. *Detention Time*

Nominal detention periods should be in the 2 to 3 hour range at the average design flow rate including consideration for recirculation. Detention periods in clarifiers vary with surface-loading rates and sidewater depths. Detention periods for various surface-loading rates and depths varies as follows:

Surface-Loading Rate Depths (ft)				
(gdp/sq.ft.)	7	8	10	12
	Detention Time (hours)			
400	3.2	3.6	4.5	5.4
600	2.1	2.4	3.0	3.6
800	1.6	1.8	2.25	2.7
1000	1.25	1.4	1.8	2.2
1500	0.85	0.95	1.2	1.55

The detention periods for final clarifiers following various activated sludge processes shall be adjusted between 2 and 4 hours dependent upon the type of process, design flow, recirculation rate, and surface- loading rate.

10. Surface-Loading Rates

a. Primary Clarifiers

Surface-loading rates for primary clarifiers should not exceed 1,000 gallons per day per square foot at average design flow and shall not exceed 1,500 gallons per day per square foot at peak hourly flow. Primary clarifiers not followed by secondary treatment should not exceed 600 gallons per day per square foot for plants with average design flows of 1.0 MGD or less.

b. Intermediate Clarifiers

Surface-loading rates for intermediate clarifiers should not exceed 1,000 gallons per day per square foot at average design flow. Clarifiers following fixed film reactor processes shall not exceed 1,500 gallons per day per square foot at peak hourly flow.

c. Final Clarifiers

1) Surface-loading rates for final clarifiers following fixed film reactors should not exceed 800 gallons per day per square foot at average design flow and shall not exceed 1,200 gallons per day per square foot at peak hourly flow.

2) Surface-loading rates for final clarifiers following activated sludge processes, such as: conventional, step aeration, contact stabilization or the carbonaceous stage of separate-stage nitrification, shall not exceed 1,200 gallons per day per square foot at peak hourly flow.

3) Surface-loading rates for final clarifiers following an extended aeration process shall not exceed 1,000 gallons per day per square foot at peak hourly flow.

4) Surface-loading rates for final clarifiers following separate-stage nitrification shall not exceed 800 gallons per day per square foot at peak hourly flow.

5) Surface-loading rates recommended for various floc suspensions at peak hourly flow are as follows:

Alum floc - 600 gpd/sq.ft.
Iron floc - 800 gpd/sq.ft.
Lime floc - 1,200 gpd/sq.ft.

6) Tests should be conducted whenever a pilot plant study is warranted because of unusual waste characteristics, treatment requirements or where design loadings exceed those limits set forth in this section.

11. Solids Loading Rate

a. The solids loading rate, excluding chemical additives applied to final clarifiers, shall not exceed 25 pounds per square foot per day at peak flow rate with 100 percent recirculation. Clarifiers following an extended aeration process or an oxidation ditch should not exceed this loading rate.

b. The solids loading rate for final clarifiers following most activated sludge processes shall not exceed 50 pounds per square foot per day at peak hourly flow. The designer should assure that the clarifier area is equal to or greater than that required by surface-loading or solids loading rates based on the maximum sludge volume index (SVI) anticipated or mixed-liquor suspended solids (MLSS). The solids-loading rate for an activated-sludge clarifier may be computed by dividing the total solids applied by the surface area of the tank as follows:

lb/sq.ft./hr = MLSS X surface loading rate/ 120,000 X 24

The solids-loading rate is expressed in pounds per square foot per hour in order that the factor is evaluated for both peak hourly and design average flow conditions to determine which values may govern in a 24-hour period. Due consideration must be given to the duration of peak hourly flows.

12. Sludge Storage

a. The floors of circular clarifiers shall be sloped at one-inch per foot (1:12) to form an inverted cone to a central sludge hopper. Floors of sludge thickners should be sloped 2:12 or greater. Simple mechanical collectors are recommended over the suction or siphon type since rapid recirculation of solids is not required.

b. The floor of a rectangular clarifier should be sloped at approximately 1 percent (1:100) toward the cross collectors or sludge hopper(s) located at the influent end. If a header type suction sludge removal mechanism is used, then the slope should be sufficient only to provide for drainage.

c. The sludge or settled solids in clarifiers shall be scraped or drawn to a hopper or sump appropriately located for removal. Where cross-collectors or screw conveyors are not provided, multiple hoppers shall be installed for rectangular clarifiers or multiple clarifiers.

d. The minimum slope of the side walls of sludge hoppers shall be 1.7 vertical to 1.0 horizontal. Hopper bottoms shall have a maximum dimension of 2 feet. Hopper walls shall be smooth with rounded corners. Extra depth sludge hoppers for sludge thickening are not permissible.

e. Vertical sludge draw-off systems shall be considered on a case-by-case basis.

f. Sludge draw-off pipes located on the side or bottom, shall be flush with the hopper bottom. Each sludge hopper shall have an individually valved sludge draw-off line that is at least 6 inches in diameter, if gravity flow, and, if pumped, 4 inches in diameter. The static head available for withdrawal of sludge shall be at least 30 inches to maintain a three foot per second (3 fps) velocity when removal is dependent upon gravity flow.

C. SLUDGE HANDLING AND WITHDRAWAL

1. Mechanical sludge collection and withdrawal equipment is required and shall provide complete and continuous removal of settled sludge for intermediate and final clarifiers. The sludge collection equipment and the drive assembly shall be designed to withstand the maximum anticipated loads of transporting sludge to a hopper. The peripheral speed for circular flight mechanisms should be in the range of 0.02 to 0.05 revolutions per minute but shall not exceed 8 feet per minute in final clarifiers. The straight line flight speed should be in the range of 2 to 4 feet per minute but shall not exceed 1 foot per minute in final clarifiers.

2. Positive displacement pumps shall be provided for pumping primary sludge intermittently and continuously. A positive head should be provided on pump suctions. If motor driven return sludge pumps are used, the maximum return sludge capacity shall be obtained with the largest pump out of service. Pumps shall have at least 3 inch suction and discharge openings. Automatic controls shall be provided to separately activate sludge pumps and sludge collection mechanisms. Sludge pumping in large plants should be controlled by timers and valve activators to provide continuous "on-off" operation. A means of measuring the sludge withdrawal rate shall be provided for each unit. It is recommended that sludge-pumping stations have a standby pump and serve two or more units. Air lift systems for sludge removal shall not be used for removal of primary sludges. Air lift pumps should be at least 3 inches in diameter and be designed with a minimum of 80 percent static submergence.

3. Rapid sludge withdrawal pipes shall return sludge to a sludge well at the water surface that enables visual observation of the flow. The return sludge withdrawal pipes shall be at least 4

inches in diameter with a hydraulic differential between the clarifier water level and the return sludge well level sufficient to maintain a velocity of 3 feet per second. The discharge piping should be designed to maintain a velocity of at least 2 feet per second when return sludge facilities are operating at normal return sludge rates. Each sludge withdrawal pipe shall be accessible for rodding or backflushing when the clarifier is in operation. Cleanouts and couplings shall be provided in sludge piping to facilitate pipe cleaning and removal of pumping equipment. High points in piping shall be provided with air releases. All sludge piping shall be metallic material.

4. Sludge recirculation from the secondary clarifier to the aeration basin shall be variable within 25 to 100 percent of the average design flow. Sludge wasting from the activated sludge process may be from the mixed liquor or the return sludge. Sludge wasting shall be variable to enable zero wasting to 50 percent of the total system solids daily.

5. The minimum permissible return sludge rate of withdrawal from the final clarifier is a function of the concentration of suspended solids in the mixed liquor (MLSS) entering it, the sludge volume index (SVI) of these solids, and the detention time that these solids are retained in the clarifier. The rate of sludge return for activated sludge processes expressed as a percentage of the average design flow of wastewater should generally be variable between the limits set forth as follows:

	Minimum	Maximum
Standard Rate, Step Aeration and Carbonaceous Stage of Separate Stage Nitrification	15	75
Contact Stabilization and Extended Aeration	50	150
Nitrification Stage of Separate Stage Nitrification	50	200

The rate of sludge return shall be varied by means of variable speed motors, drives, or timers to pump sludge as set forth in this section.

6. Waste sludge control facilities should have a maximum capacity of not less than 25 percent of the average rate of wastewater flow and function satisfactorily at rates of 0.5 percent of average wastewater flow or a minimum of 10 gallons per minute, whichever is larger.

7. Sludge wells/scum pits shall be provided adjacent to the basin and equipped with suitable devices for viewing, sampling and controlling the rate of sludge withdrawn. Metering devices shall be installed and located to indicate flow rates of all influent and effluent points, return sludge and waste sludge lines. Meters shall be accurate to within + 5 percent of the actual flow rates.

D. SAFETY AND SERVICING

1. All clarifiers shall be equipped with appropriate safety features for the protection of operators. Such features shall include drive mechanism enclosures, life lines, lighting, stairways, walkways, handrails, deck gratings and slip-resistent surfaces. Effluent pipes larger than 12

inches in diameter shall be provided with bars to prevent entry of an operator if a fall should occur.

2. If side walls are extended some distance above the water level to provide flood protection or for other purposes, convenient and safe walkways must be provided to facilitate housekeeping and maintenance. For plants having an average design capacity greater than 0.1 MGD, meters shall totalize and record.

3. Clarifier facilities shall include a convenient and safe means of access to routine maintenance items such as baffles, weirs, channels, scum equipment, gear boxes and pumping facilities. Hoisting or other means of equipment removal shall be provided. As a safety precaution, it is recommended that telescoping valves with tees and blow-off valves at the base be provided in sludge wells to unplug draw off lines.

4. Pressurized wash water facilities shall be provided for washing scum boxes, tanks and other equipment. Potable wash water facilities may be used but shall have backflow preventors. If wash water is non-potable, all outlets shall be permanently posted to indicate water is not safe.

5. Electrical equipment and controls shall comply with the National Electrical Code for Class I, Groups C and D, Division l locations. The equipment, fixtures, lighting, and controls shall be located to provide convenient and safe access for operation and maintenance. A positive means of locking out each mechanical device shall be provided.

6. Treatment plant operators should be supplied with a complete set of operation procedures, including maintenance schedules, tools, sampling equipment and spare parts as may be necessary.

7. Due consideration shall be given to the selection of materials because of corrosive conditions present.

E. DEVIATIONS FROM DESIGN CRITERIA

The Department may consider and allow deviations where adequate documentation is provided to prove the need for such deviation.

CHAPTER IX: Recommended Design Criteria For Trickling Filters

CHAPTER IX

RECOMMENDED DESIGN CRITERIA FOR TRICKLING FILTERS

A. General Considerations

Trickling filters may be used where the treatment of wastewater is amenable to aerobic biological treatment processes. Trickling filters shall be preceded by primary clarifiers equipped with scum and grease collecting devices, or other suitable pretreatment facilities. If fine screening is provided the screen size shall have from 0.03 to 0.06 inch openings. Bar screens and/or communitors are not suitable as the sole means of primary treatment.

Filters shall be designed to provide for reduction in carbonaceous and/or nitrogenous oxygen demand in accordance with the Federal Secondary Treatment requirements and/or the South Dakota Water Quality Standards, or to effectively reduce organic loading on the downstream treatment processes.

Information as well as all functional design calculations used in sizing trickling filter facilities shall be included in an engineer's report with the facilities plan, plans and specifications and/or be submitted separately for review and approval. This report shall include the following:

1. Influent wastewater characteristics;
2. Temperature range of applied wastewater;
3. Pretreatment processes;
4. Type of filter, i.e., single stage or multi- stage;
5. Hydraulic and organic loadings applied to the filter;
6. Hydraulic factors involving proper distribution computations;
7. Recirculation rate and piping system;
8. Filter beds-volume, area and depth;
9. Media-type, specific weight, void space;
10. Underdrainage and ventilation systems;
11. Equations utilized for treatment efficiency computations; and
12. Degree of treatment anticipated.

Trickling filters are affected by diurnal load conditions. The volume of media shall be determined from either pilot plant studies or use of acceptable design equations and shall be based upon the design peak hourly organic loading rate rather than the design average rate. An alternative would be to provide flow equalization.

B. Design Basis

1. Trickling filters shall be designed as standard-rate, high-rate, or super-rate based on hydraulic and biological loadings.

    a. The hydraulic loading on standard-rate trickling filters shall be between 1 and 4 million gallons per acre per day with an organic loading between 5 and 20 pounds BOD5 per 1,000 cubic feet of media per day.

    b. The hydraulic loading, including recirculation, on high-rate or super-rate filters shall be between 10 and 40 million gallons per acre per day with an organic loading between 30 and 100 pounds BOD5 per 1,000 cubic feet of media per day.

2. High-rate trickling filters may be used as roughing filters prior to further biological treatment. High-rate filters can accommodate highly variable hydraulic overloading conditions without significant deterioration of the biological growth.

3. A minimum of two trickling filters shall be provided and designed, so that with one unit out of operation, the design average flow can be handled by the remaining unit.

C. Hydraulic Considerations

3. *Distribution*

    a. Rotary distributors or fixed-nozzle systems shall be designed to provide uniform flow distribution over the surface of the entire filter media. Flow distribution devices shall be designed not to deviate by more than 10 percent from the normal rate of liquid application at any point on the media surface at design average flow conditions. Flow distribution between multiple units of stationary media systems shall be by weirs, valves, meters and other positive flow splitting devices.

    b. For rotary/reaction type distributors, a minimum head of 24 inches between the low water level in the siphon chamber and center of the arms shall be required. Similar allowance in design shall be provided for added pumping head requirements where pumping to the reaction type distributor is used. Surge relief, to prevent damage to distributor parts, shall be provided where wastewater is pumped directly to the distributors. The revolving speed varies with the flow rate for the reaction-driven unit, but it should be in the range of one revolution every 10 minutes or less for a two-arm distributor. At peak hourly flow, the peripheral speed of the arm should not exceed 4 feet per second.

    c. A minimum clearance of 12 inches shall be provided between the filter's surface and any moving parts of the distributor arms. A minimum of 18 inches clearance should be provided when severe icing problems are anticipated.

d. Design features that should be considered in selecting a distributor are the durability of construction, corrosion resistance, ease of cleaning and its ability to handle large flow variations while maintaining adequate rotational speed. The distributor arms may be designed with a constant or tapered cross section to provide minimum transport velocities at low flows. The distributor arms should be designed with adequate adjustments to maintain proper alignment and balance. End caps or gates that are quick-opening shall be provided on the arms for cleaning and draining. Orifice nozzles shall be adjustable for regulating the flow rate and spray dispersion. Mercury seals are not permitted. Distributor units should allow removal of the bearings without complete disassembly. The rotary distributor should be designed to prevent icing of the center column and filter walls.

4. *Dosing and Controls*

a. When suitable flow characteristics have been developed, wastewater may be applied to the filters by dosing siphons, pumps or by gravity flow from preceding treatment units. Where recirculation is not provided to standard-rate filters, dosing intervals should not be more than 5 minutes. Application of wastewater to high-rate filters should be practically continuous. Provisions for continuous application of wastewater to the filter media by the use of recirculation is strongly recommended.

b. The piping system, including dosing equipment and distributor, shall be designed to provide capacity for the peak hourly flow rate and recirculation to achieve the design efficiency. The recirculation rate shall be variable and subject to plant operator control.

c. Devices shall be provided to permit measurement of the recirculation rate. Time lapse meters and pump head recording devices are acceptable for facilities treating less than 1 MGD. Automatic pump controls shall have manual override capability.

D. Media

1. The media may be crushed rock, slag, redwood, or specially manufactured artificial material. The media should be durable, resistant to spalling or flaking and be insoluble in the wastewater being treated. The material should be free of fine particles, grease and oil and also should be properly screened and/or washed to remove dust and dirt before placement. Slag media shall be free from iron.

2. If rock media is used, the top 18 inches shall have a loss by the 20-cycle, sodium sulfate soundness test of not more than 10 percent. The balance of the media shall pass a 10-cycle test using the same criteria. All tests shall be conducted as prescribed by ASCE Manual of Engineering Practice, No. 13. Manufactured media shall be resistant to ultraviolet degradation, disintegration, erosion, aging, all common acids and alkalies, organic compounds, and fungus and biological attack. Such media shall be capable of supporting a person's weight or a suitable access walkway shall be provided to allow for distributor maintenance.

3. Rock and/or slag filter media for standard- rate filters shall be at least 5 feet but not more than 10 feet in depth above the underdrains. The filter media for high-rate filters shall be at least 3 feet but not more than 7 feet in depth above the underdrains. Manufactured filter media should be at least 10 feet deep to provide adequate contact time with the wastewater. Manufactured filter media depths shall not exceed 30 feet except where special construction is justified by extensive pilot studies or additional proven engineering data. The suitability of the manufactured media may be evaluated on the basis of full scale experience with other plants treating similar wastes and loadings or through actual use of a pilot plant on site. Super-rate trickling filters must have manufactured media.

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

   Passing 4-1/2 inch screen - 100% by weight

   Retained on 3 inch screen - 95-100% by weight

   Passing 2 inch screen - 0-2% by weight

   Passing 1 inch screen - 0-1% by weight

   If hand picked field stone are used, the dimensions shall be from 2 1/2 to 5 inches in diameter.

5. Material delivered to the filter site shall be stored on wood-planked or other approved clean, hard- surfaced areas. All material shall be rehandled at the filter site and no material shall be dumped directly into the filter. Crushed rock, slag and similar media shall be washed and rescreened or forked at the filter site to remove all fines. Such material shall be placed by hand to a depth of 12 inches 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 shall be carefully placed so as not to damage the underdrains. Manufactured media shall be handled and placed as approved by the engineer. Trucks, tractors, and other heavy equipment shall not be driven over the filter during or after construction.

6. The required volumes of rock or slag media filters shall 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.

E. Underdrainage System

1. Subfloor

The floor of the filter shall be able to support the underdrainage system, the filter media, and the water load. A minimum gradient of 1 percent shall be provided for the subfloor which slopes to a collection channel.

2. *Filter Block*

Precast filter blocks, made of vitrified clay or concrete should be used. The underdrainage system shall cover the entire floor of the filter. Inlet openings of the filter blocks into the underdrains shall have an unsubmerged gross combined area equal to at least 20 percent of the surface area of the filter. Underdrains shall have a minimum slope of 1 percent to a collection channel. Redwood timbers resting on concrete sleepers may be used in the place of filter blocks, when stacked redwood media is used.

3. *Collection Channel*

The collection channels (central or peripheral) shall provide capacity to carry the flow from the underdrains and permit free passage of air to the underdrains for ventilation. Channels should be sloped to provide a minimum flow velocity of 2 feet per second. The water level in the collection channel should be below the bottom of the filter blocks during peak flow conditions. Drains, channels and pipe shall be designed to have 50 percent of their cross-sectional area unsubmerged at peak hourly flows.

4. *Ventilation*

All trickling filters shall be provided with ventilation openings to the underdrains. Ventilation openings will be provided with dampers or other adjustable devices to permit adjustment of the ventilation rates. Natural draft ventilation openings shall have a minimum gross area of 4 square feet per 1,000 square feet of filter area.

Forced ventilation providing a mimimum air flow of 1 cubic foot per minute per square foot (1 cfm/ft2) shall be provided for covered filters and deep manufactured media filters.

5. *Flushing*

Provision shall be made for flushing the underdrains such as, adjustable ventilation ports. In small filters, use of a peripheral head channel with vertical vents is acceptable for flushing purposes. Inspection facilities shall be provided.

F. Special Design Considerations

1. *Flooding*

Appropriate valves, sluice gates, walls and other structures shall be provided to permit flooding of filters comprised of rock or slag media.

2. *Climatic Protection*

a. The surrounding wall shall extend at least 4 feet above the media of all uncovered filters to maximize the containment of windblown spray and reduce heat losses.

b. Other protection such as covers, wind screens or windbreaks shall be provided to maintain operation and treatment efficiencies when climatic conditions are expected to result in icing problems.

3. *Maintenance*

a. All distribution devices, underdrains, channels and pipes shall be installed so that they may be properly maintained, flushed or drained. Access shall be provided around the periphery of the underdrain system to allow flushing of the underdrains.

b. Suitable and safe access shall be provided to the top of the structure for inspection and maintenance.

c. Treatment operators should be supplied with a complete set of operational instructions, including maintenance schedules, tools and spare parts as may be necessary.

4. *Structure*

a. The walls, floor and underdrain system should be constructed of concrete, concrete blocks, vitrified clay or other approved material for containment of wastewater.

b. The wall structure shall be designed such that a cover, dome or other means may be easily installed over the trickling filter at a later date.

c. Enclosed structures shall be well lighted and ventilated.

d. Electrical equipment and controls shall meet the requirements of the National Electrical Code.

G. Deviations from Design Criteria

The Department may consider and allow deviations where adequate documentation is provided to prove the need for such deviation.

CHAPTER X: Recommended Design Criteria For Rotating Biological Contactors

CHAPTER X

RECOMMENDED DESIGN CRITERIA FOR ROTATING BIOLOGICAL CONTACTORS

A. General Considerations

1. *Applicability*

The Rotating Biological Contactor (RBC) process may be used where the wastewater is amenable to biological treatment. The RBC process can be used in many modes to accomplish varied degrees of carbonaceous and/or nitrogenous oxygen demand reductions. The process is simpler to operate than activated sludge since recycling of effluent or sludge is not required. Special consideration must be given to returning supernatant from the sludge digestion process to the RBC's.

The advantages of RBC technology include a longer contact time (8 to 10 times longer than trickling filters), a higher level of treatment than conventional high-rate trickling filters, and less susceptibility to upset from changes in hydraulic or organic loading than the conventional activated sludge process.

Whether used in small or large facilities, the RBC process should be designed to remove at least 85% of the biochemical oxygen demand (BOD) from domestic sewage. The process can also be designed to remove ammonia nitrogen (NH_3-N). In addition, effluents and process wastewater from dairies, bakeries, food processors, pulp and paper mills, and other biodegradable industrial discharges can be treated by the RBC process.

2. *Process Selection*

Choice of the process mode most applicable will be influenced by the degree and consistency of treatment required, type of waste to be treated, site constraints, and capital and operating costs. The process design of a RBC facility involves an accurate determination of influent, septage dumps, and sidestream loadings, proper media sizing, staging and equipment selection to meet effluent requirements, air requirements, and selection of an overall plant layout that shall provide for flexibility in operation and maintenance.

A comprehensive on-site pilot plant evaluation is recommended to incorporate the factors affecting RBC performance as an accurate source of information for a RBC design. Other approaches to determine the expected performance of RBC's may be based upon results of similar full scale installations and/or through documented pilot testing with the particular wastewater. Small-diameter RBC pilot units are suitable for determining the treatability of a wastewater. If small-diameter units are operated to obtain design data, each stage must be loaded below the oxygen transfer capability of a full-scale unit to minimize scale-up problems. Direct scale-up from small-diameter units to full-scale units is not possible because of the effects of temperature, peripheral speed of media, and other process and equipment factors.

In all RBC systems, the major factors controlling treatment performance are:

a. Organic and hydraulic loading rates;

b. Influent wastewater characteristics;

c. Wastewater temperature;

d. Biofilm control;

e. Dissolved oxygen levels; and

f. Flexibility in operation.

B. Pretreatment

Raw municipal wastewater shall not be applied to an RBC system. Primary settling tanks are required for effective removal of grit, debris, and excessive oil or grease prior to the RBC process. In some cases, fine screens (0.03-0.06 inches) may be considered. Screening and comminution are not suitable as the sole means of preliminary treatment ahead of RBC units.

Sulfide production must be considered in the system design. Separate facilities to accept and control feeding of septage waste or in-plant side streams should be considered where the potential for sulfide production or increased organic and ammonia nitrogen loadings will have a significant impact on the RBC system.

C. Basis of RBC Design

1. Unit Sizing

a. Organic loading is the primary design parameter for the RBC process. This is generally expressed as the organic loading per unit of media surface area per unit of time, or in units of pounds BOD5 per thousand square feet per day.

Wastewater temperatures above 55 degrees F have minimal affect on organic removal and nitrification rates; however, below 55 degrees F, manufacturers shall be contacted by the designer to obtain the various correction factors that must be utilized to determine the needed additional media surface area.

In determining design loading rates on RBC's, the following parameters should be utilized:

(1) Design flow rates and primary wastewater constituents;

(2) Total influent BOD5 concentration;

(3) Soluble influent BOD5 concentration;

(4) Percentage of total and soluble BOD5 to be removed;

(5) Wastewater temperature;

(6) Primary effluent dissolved oxygen;

(7) Media arrangement, number of stages and surface area of media in each stage;

(8) Rotational velocity of the media;

(9) Retention time within the RBC tank(s);

(10) Influent soluble BOD5 to the RBC system including SBOD from in-plant sidestreams, septage dumps, etc;

(11) Influent hydrogen sulfide concentrations; and

(12) Peak loading, BOD5 max/BOD5 avg.; TKN max/TKN avg.

In addition to the above parameters, loading rates for nitrification will depend upon influent DO concentration, influent ammonia nitrogen concentration and total Kjeldahl nitrogen (TKN), diurnal load variations, pH and alkalinity, and the allowable effluent ammonia nitrogen concentration.

Since soluble BOD5 loading is a critical parameter in the design of RBC units, it should be verified by influent sampling whenever possible.

2. *Loading Rates*

a. When peak to average flow ratio is 2.5 to 1.0 or less, average conditions can be considered for design purposes. For higher flow ratios, flow equalization should be considered.

b. The organic loading to the first stage standard density media should be in the range of 3.5 to 6.0 pounds total BOD5 per thousand square feet per day or 1.5 to 2.5 pounds soluble BOD5 per thousand square feet per day. First stage organic loadings above 6 pounds total BOD5 or 2.5 pounds soluble BOD5 per thousand square feet per day will increase the probability of developing problems such as excessive biofilm thickness, depletion of dissolved oxygen, nuisance organisms and deterioration of process performance. The most critical problem in most instances is the structural overloading of the RBC shaft(s).

c. For average conditions, the design loading should not exceed 2.5 pounds of soluble BOD5/1,000 square feet of standard media surface per day on the first stage shaft(s) of any treatment train. Periodic high organic loadings may require supplemental aeration in the first stage shafts. High density media should not be used for the first stage RBC's.

d. For peak conditions, the design loading shall not exceed 2.0 pounds of soluble BOD5/1,000 square feet for the first high density media shaft(s) encountered after the first two shafts or rows of shafts in a treatment train.

e. For average conditions, the overall system loading shall not exceed 0.6 pounds of soluble BOD5/1,000 square feet of media. This soluble BOD5 loading to all shafts should be used to determined the total number of shafts required. The equation under section C.3.c could be used as an option to determine the number of stages required.

3. *Staging Units*

a. Staging of RBC media is recommended to maximize removal of BOD and ammonia nitrogen (NH_3-N). In secondary treatment applications, rotating biological contactors shall be designed with a minimum of three stages per flow path. For combined BOD5 and NH_3-N removal, a minimum of four stages is recommended per flow path. For small installations, multiple stages are acceptable on a single shaft if interstage baffles are installed within the tank and introducing the flow parallel to the shaft. Whenever multiple process trains are employed with three or more shafts in a row; the flow path should be introduced perpendicular to the shafts, and the wastewater should be distributed evenly across the face of the RBC's.

b. The organic loading must be accurately defined by influent sampling whenever possible. For existing facilities that are to be expanded and/or rehabilitated it is unacceptable to only calculate the expected load to the shafts. Flow and load sampling must be done to demonstrate the load which is generally accomplished by composite sampling after primary clarification. To predict effluent quality for a range of loadings, the influent and effluent soluble-to-total BOD5 ratio can be assumed to be 0.5.

c. An alternative method of estimating soluble organic removal in the interstages, devised by E.J. Opatken, utilizes a second order reaction equation. The equation may be used for RBC design during the summer months; however, a temperature correction factor should be used used for the cold winter months. Wastewater temperatures below 15oC decrease shaft rotational speeds and increase loping problems resulting with insufficient biomass sloughing. This equation is as follows:

Cn = -1 + [square root (1 + 4kt (Cn -1)]/ 2kt

where:

Cn =	is the concentration of soluble organics in the nth stage (mg/l);
k =	is the second-order reaction constant of 0.083 (l/mg/hr);
t =	is the average hydraulic residence time in the nth stage (hour); and
Cn-1 =	is the concentration of soluble organics entering the ninth stage (mg/l).

The design engineer shall be aware that this equation shall be used only where appropriate, and that in the available RBC literature there may be a number of applicable equations.

4. *Design Safety Factor*

Effluent concentrations of ammonia nitrogen from the RBC process designed for nitrification are affected by diurnal load variations. An evaluation of equalization vs. additional RBC media surface area is required when consistently low ammonia nitrogen levels are necessary to meet effluent limitations. If flow equalization is not provided then it may be necessary to increase the design surface area proportional to the ammonia nitrogen diurnal peaking rates.

5. Secondary Clarification

The concentration of suspended solids leaving the last stage of an RBC system treating municipal wastewater is generally less than 200 mg/l when preceeded with primary clarification. To attain secondary effluent quality standards, secondary clarifiers must be used in conjunction with RBCs. The surface overflow rate, generally, should not exceed 800 gallons per day per square foot for secondary clarifiers. Consideration may be given to covering the clarifiers to improve efficiency.

D. Plant Design Considerations

1. *Enclosures*

   a. Wastewater temperature affects rotating contactor performance. Year-round operation in cold climates requires that rotating contactors be covered to protect the biological growth from freezing temperatues and avoid excessive loss of heat from the wastewater. In order to prevent excessive heat gain during the summer, proper ventilation of the insulated covers should be assured.

   b. The enclosures should be individual removable covers or huts rather than a building to house the RBC units. All enclosures shall be constructed of durable and corrosion-resistant materials. Snow loads should be considered in the design of individual covers.

   c. In all RBC designs, convenient access to individual bearings, shafts, media, or mechanical equipment shall be provided for inspection, maintenance, and possible removal, repair or replacement. The RBC design layout should consider the size, reach and accessibility of cranes for shaft removal.

   d. If RBC's are installed in buildings; windows, louvered mechanisms and/or doors shall be installed to provide adequate ventilation. To minimize condensation on the walls and ceilings, the building shall be humidity controlled, heated and/or adequately insulated. The structure shall be designed such that it can be readily dismantled for removal of shafts and media at minimal cost and inconvenience of continued plant operation under expected environmental conditions.

e. Electrical equipment and controls shall comply with the National Electrical Code for Class I, Groups C and D, Division 1 locations. The equipment, fixtures, lighting, and controls shall be located to provide convenient and safe access for operation and maintenance. A positive means of locking out each mechanical device shall be provided.

f. Pressurized water facilities shall be provided for spraying the media, washing tanks and other equipment. Potable water may be used but shall have backflow preventors. Non-potable wash water outlets shall be permanently posted indicating the water is not safe.

2. *Flexibility and Flow Control*

a. Multiple treatment trains should be considered in the design for adequate flexibility in operation of the facility. For maximum flexibility, each train could have a separate basin for maintenance.

b. Positive and measurable flow control equipment must be provided for each unit or flow train for proper distribution of the influent and effluent. Splitter boxes and/or weirs are preferred to long channels with slide gate controls.

c. Removable baffles shall be provided between all stages.

d. The capability to step feed stage(s) should be provided to reduce overloading.

e. Mechanical drive systems shall have provisions for variable speed rotation and supplemental air capability in first and second stages of the RBC train. A rotational speed control of 1.6 rpm shall be provided with appropriate equipment supplied to reduce or increase speed as necessary to improve treatment efficiency and reduce energy costs. The mechanical drive systems should have provisions for reversing the direction of RBC rotation and supplemental air to promote biofilm stripping.

f. A means of adding chemicals, such as hydrogen peroxide or chlorine, should be considered for the media and/or wastewater to promote biofilm stripping and enhance oxygen transfer.

g. Air drive systems shall be provided with extra air capabilities. A rotational speed capability of 1.2 rpms must be provided. Air shall be supplied at a rate to produce a range of shaft speeds throughout the year with one blower out of service plus additional air for scouring the media. Generally, air flow requirements to provide the required seasonal shaft rotational speeds and extra air for scouring, is approximately 400-600 cfm per shaft.

h. Air drive units or supplemental aeration units shall be provided with positive air flow control and metering to each shaft.

i. The capabilities of bypassing or recycling wastewater should be considered for adverse conditions.

j. Facilities for chemical addition following the biodiscs, prior to the clarifiers, may be considered to allow polymer addition.

3. Monitoring

Dissolved oxygen (DO) monitoring shall be provided for in the first stage. DO monitoring for the other stages should be considered. The RBC system design shall provide for a positive DO level in all the stages. It is recommended that the first two stages maintain at least 2 mg/l of dissolved oxygen.

4. Contactor Basins and Channels

a. Drains shall be provided for each contactor basin. A sight tube may be included to montior sludge build-up.

b. The clearance between the basin floor and the bottom of the rotating media shall be from 4 to 9 inches.

c. The basins shall have a depth for submergence of at least 40% of the total media surface area at any one time.

d. The basin volume-to-media surface area should be at 0.12 gallons per square foot.

e. Where deep channels are used to and from RBC basins, channel aeration or channel configurations shall be provided for scouring velocity.

f. Side wall slope of the biodisc basin is important to prevent sludge/solids accumulation.

E. Equipment Considerations

1. Shafts

a. RBC shafts are presently limited to approximately 27 feet in length.

b. Shafts shall be fabricated from steel and be covered with a protective coating suitable for the humid and corrosive conditions. All fabrication during construction shall conform to American Welding Society (AWS) welding and quality control standards. Media shafts shall be designed for unbalanced loads and cycle fatigue.

c. The design engineer should require the manufacturer to provide adequate assurance that the shaft(s), bearings, and media support structures are protected from structural failure for the design life of the facility. The manufacturer of the RBC units shall guarantee the shaft(s) for 5 years.

d. Structural designs shall be based on appropriate AWS stress category curves modified as necessary to account for the anticipated corrosive conditions.

e. The design engineer shall specify a load bearing capacity for each shaft considering the maximum anticipated biofilm growth and to include an adequate margin of safety.

2. *Media*

a. Media materials shall be special manufactured material suitable and durable for the rotating biological contractor process. Media shall be resistant to disintegration, ultraviolet degradation, erosion, aging, all common acids, alkalies, organic compounds, fungus, and biological attack.

b. High density media shall not be used on the first two stages or rows of shafts of a treatment train for the purpose of BOD removal.

c. Media shall be fabricated with corrugations for stiffness and spacing. The media should not exceed 12 feet in diameter. Standard density media are considered as media with a surface area of 100,000 to 120,000 square feet and high density media are considered 150,000 square feet or more.

d. The manufacturer of the RBC media shall guarantee the media for 5 years.

e. All plastic media shall be adequately supported on or attached to the shaft.

f. Air cups attached around the outer perimeter of the media on an air driven unit shall be 6 inches in depth.

3. *Drive Systems*

a. Mechanically driven RBC units shall have high efficiency motors and drive equipment which shall include variable speed capability. The electric motors used for mechanical drive RBCs shall be either 5 or 7.5 hp depending upon the actual energy requirements. The actual energy requirements for mechanically driven RBC units should be in the range from 1.05 kw/shaft to 3.76 kw/shaft. To evaluate the actual energy requirements for mechanically driven units, the design engineer must take into consideration the influences of drive train efficiency, biofilm thickness, media surface area, temperature, and rotational speed.

b. Air drive RBC units shall have high efficiency motors and blower systems which shall include variable air flow requirements for rotational speed. The specific energy requirements for air driven units can only be determined on a case-by-case basis and cannot be measured directly. For comparative purposes, an approximation can be made by dividing the blower KW by the number of driven shafts. The actual energy requirements should be within the range of 3.8 kw/shaft to 8.3 kw/shaft. To evaluate the actual energy requirements for air driven units, the design engineer must consider the desired rotational speeds, air flow, piping configurations, and blower efficiency.

c. Energy estimates used for planning and design should be based on anticipated operating conditions rather than general energy data supplied by equipment manufacturers which may not be current or reflect actual field energy usage. If manufacturers energy guarantees or similar projected energy usage is considered, then testing procedures and calibration of equipment shall be included in the specifications.

d. The design engineer should consider providing power factor correction capacitors for all RBC mechanical and air drive systems.

e. All drive components shall be properly aligned.

4. *Bearings*

a. Bearings shall be moisture resistant and self-aligning with oversize grease cups to increase lubrication intervals.

b. Bearings should be located outside the media covers and protected with cover plates on the idle end of the shaft.

c. Center-carrier bearings with supports should be provided for shafts in excess of 20 feet in length.

5. *Load Cells* (Hydraulic or Electronic)

a. Load cells shall be provided for all first and second row and/or stage shafts. Load cells are desirable for all shafts.

b. Hydraulic load cells shall be installed on the idle end of a mechanically driven shaft. A spare hydraulic load cell shall be provided as a back-up.

c. The electronic strain gage cell with a companion converter unit is most desirable because it has continuous and direct read-out of total shaft weight.

F. Miscellaneous Considerations

1. Stop motion detectors, rpm indicators, and clamp-on ammeters are desirable monitoring devices for individual RBC shafts.

2. Media, when stored on-site for installation, shall be properly protected from direct sunlight. Media can also be severely impacted by high wastewater temperatures above 95^{o}F.

3. An O&M manual shall be provided specifying schedules for reading load cells, visual inspections of biofilm growth, media integrity, and determining the status of mechanical and structural components. The manual shall outline remedial procedures to resolve identified operating problems. The manual should include provisions for daily and analytical log recording.

4. All RBC units shall be equipped with appropriate safety features for protection of operators. Such features shall include drive mechanism enclosures, lighting, stairways, walkways, handrails, deck gratings, and slip-resistant surfaces.

5. Treatment plant operators should be supplied with sampling equipment, tools, and spare parts as may be necessary.

G. Deviations from Design Criteria

The Department may consider and allow deviations where adequate documentation is provided to prove the need for such deviation.

CHAPTER XI: Recommended Design Criteria For Oxidation Ditches And/Or Systems

CHAPTER XI

RECOMMENDED DESIGN CRITERIA FOR OXIDATION DITCHES AND/OR SYSTEMS

A. General Considerations

Since the "oxidation ditch" is the more commonly used system, the design criteria will be promulgated on that basis.

1. *Applicability*

Oxidation systems may be used where the treatment of wastewater is amenable to aerobic biological treatment and the plant design capacities generally do not exceed 1.0 mgd. The oxidation ditch is a form of an aeration basin where the wastewater is mixed with return sludge. The oxidation ditch is essentially a modification of a completely mixed activated sludge system used to treat wastewater from small communities. This system can be classified as an extended aeration process and is considered to be a low loading rate system. This type of treatment facility can remove 90 percent or more of the influent BOD5. Oxygen requirements will generally depend on the maximum diurnal organic loading, degree of treatment, and suspended solids concentration to be maintained in the aerated channel mixed liquor suspended solids (MLSS).

2. *Aeration Unit Selections*

For an oxidation ditch or alternate system to function satisfactorily, the velocity gradients and dissolved oxygen throughout the entire area of the ditch or channel should be relatively constant. This can be accomplished by various types of mechanical aerators and channel arrangements in such systems as the Orbal, Carrousel, or the more commonly known oxidation ditch. For selection purposes, each system will be briefly described.
The oxidation ditch system combines the processes of oxidation and sedimentation by means of mechanical aeration and final clarification. The system involves a closed ring-shaped ditch in which untreated wastewater is introduced into the ditch where it is mechanically aerated by a paddle wheel or brush aeration rotor. The rotor is mounted on a revolving horizontal shaft that is partly submerged in the wastewater for oxygenation and circulation of the ditch contents. The ditch effluent is clarified and the settled sludge is returned to maintain a desirable MLSS concentration. The MLSS concentration generally ranges from 3,000 mg/l to 5,000 mg/l; however, this is dependent upon the surface area provided for sedimentation, the rate of sludge return, and the aeration process.

The Carrousel system involves the same principles as the oxidation ditch, but utilizes vertical shaft, surface-type mechanical aerators for aeration and to impart a spiral flow through the channels. The aerators, installed adjacent to each other, operate in adjacent parallel channels with a concentric 180 degrees bend at the remote end. Each channel contains a baffle wall and a turning vane to redirect the flow direction to the next aeration unit and to form a closed circuit. The organic loading limit in this ditch system utilizing vertical aeration units is approximately 30 pounds BOD5 applied daily per 1,000 cubic feet. Within the immediate area of aeration units, the depth of the channel is 9 to 10 feet greater than the diameter of the aerator and freeboard is approximately 4 feet.

Another system somewhat similar to the oxidation ditch is the Orbal system. This system consists of several concentric ovaloid channels which are inter-connected for stage aeration of wastewater and mixed liquor and for sludge stabilization. Mechanical aeration consists of rotors mounted with large perforated disks rotating on horizontal shafts that have about 40 percent of disks diameter submerged in the liquid to provide the aeration and liquid movement in the channels.

3. *Pretreatment*

Generally, no primary clarifiers are used in this process. Bar screens and comminutors are required for the protection of the mechanical equipment such as the rotors and pumps. A grit chamber will be required unless the design engineer can demonstrate through field data that grit removal is not necessary. The screened debris shall not be returned to the plant process.

B. Design Considerations

1. *Oxidation Ditch*

a. The volume of the oxidation ditch shall be based on a maximum loading of 15 pounds of BOD5 applied daily per 1,000 cubic feet of channel or on retention time; whichever requires the greater volume.

b. A hydraulic retention time or aeration period of 24 hours is recommended based on an average daily wastewater flow rate exclusive of recirculation. The retention time may be reduced to a minimum of 16 hours where the raw influent BOD5 is less than 200 mg/l or when adequate rotor aeration and efficient suspended solids separation in the final clarifier are provided. In the cold climates, the temperature drop in the system must be considered when selecting long retention times. Liquid temperatures below 40 degrees F will reduce the bacterial activity in the channel and increase the clarifier effluent suspended solids concentration.

c. The channel configuration shall be such that it forms a closed ring-shaped circuit which will not create eddies or dead areas. It is recommended that the channel cross-section be trapezoidal rather than rectangular in shape.

d. The channel should be designed to be operated between 3 and 5 feet of depth. Inlet and outlet control devices should be provided for adjusting the liquid levels and to allow the oxidation ditch to be operated intermittently or continuously. Inlets should be submerged and directed downstream from the outlet or overflow device to minimize short-circuiting.

e. A minimum of 1 foot of freeboard shall be provided at the maximum liquid depth. It is recommended that the freeboard be increased within the immediate area (10 feet or more on each side) of the aeration units. The top of the channel walls shall be at least 6 inches above the surrounding terrain or 100-year floodplain; whichever is higher.

f. The ends of the channel should consist of 180 degrees or well-rounded bends to prevent eddying and stagnant zones. The median strip should be such that the radius of curvature will not severely increase the frictional resistance to retard the liquid flow. Baffling and turning vanes may be utilized to prevent settling and provide more uniform velocities.

g. A minimum flow through velocity of 1 foot per second shall be provided throughout the entire cross- sectional area of the channel. The travel time between the aerator(s) should not exceed 3 to 4 minutes.

h. The channel shall be constructed of concrete, except when package plants are utilized for small installations; then other impervious, durable, and corrosion resistant materials may be considered.

i. Oxidation ditches not designed with grit chambers should have provisions in the channel design for a sludge collection hopper or basin to facilitate draining and the removal of grit and sludge buildups. The collection point should be located downstream between the first aeration unit and the first bend.

j. The raw wastewater inlet to the channel and the return activated sludge flow, when provided, should be immediately upstream from the rotor(s). The outlet should be located at least one-third (1/3) the length of the channel upstream from the raw wastewater inlet where one rotor is provided or just upstream of the rotor on the opposite end from the raw wastewater inlet where two rotors are provided.

k. The outlet from the channel shall be of the overflow type to allow foam and floatables to be removed from the ditch and separated in the clarifier.

2. *Rotor Aerators*

a. A minimum of two complete rotor installations are desirable such that each rotor installation is designed to meet the oxygen demand with average design conditions. Under average design conditions, it is desirable that the rotor installations maintain a dissolved oxygen (DO) content of 2 mg/l except between the raw wastewater inlet and the immediate downstream rotor. The DO content in the ditch should never be less than 1.0 mg/l.

The combined rotor installation shall supply required oxygen demand at peak organic and/or hydraulic load conditions which should be at least 1.8 pounds oxygen per pound of BOD5 applied to the system. If only one rotor installation is provided, the rotor unit shall be designed such that it can be readily maintained and/or spare parts and/or spare unit shall be provided on the site.

b. The rotor(s) should be located such that a long straight section is provided downstream of the rotor. The rotor(s) should direct the flow toward the long straight section of the channel.

c. The rotor mechanism should be capable of being easily adjusted for varying the liquid level and for the depth of immersion. A 3 to 12 inch adjustment variability for rotor immersion should be provided for flexibility, oxygenation, and circulation.

3. *Sedimentation and Sludge Recycling*

Refer to Chapter VIII for applicable requirements other than:

a. Extended aeration systems shall have provisions for holding and/or disposal of excess sludge that must be wasted periodically. Sand-bed drying is a permissible method of handling the wasted sludge, although other techniques may be permitted.

C. Miscellaneous Considerations

1. *Access, Safety, and Security*

Convenient walkways and accessways should be provided for maintenance of the channel and equipment. All oxidation ditches shall be equipped with appropriate safety features for the protection of operators. Walkways shall not be placed above rotor installations or close enough to be affected by spray, ice, or hinder removal of the rotor(s). The oxidation ditch shall be enclosed with non- climbable chain-link fence.

2. *Housing*

Consideration should be given to protecting, to the greatest extent possible, the rotor unit(s) from excessive ice buildup during cold weather operation. It is recommended that removable covers constructed of durable and corrosion-resistant materials be provided rather than enclosed building structures. Enclosed structures shall be well lighted and ventilated. In addition, electrical heaters should be considered for vertically mounted mechanical aerator motors and oil-filled gear cases.

3. *Electrical Equipment and Controls*

Electrical equipment and controls shall meet the requirements of the National Electrical Code.

4. *Treatment Plant Operator(s)*

Treatment plant operator(s) should be supplied with a complete set of operation procedures, including maintenance schedules, tools, sampling equipment, and spare parts as may be necessary.

D. Deviations from Design Criteria

The Department may consider and allow deviations where adequate documentation is provided to prove the need for such deviation.

CHAPTER XII: Recommended Design Criteria For Disposal Of Effluent By Irrigation

A. Administrative Considerations
B. General Information
C. Storage
D. Location of Disposal Site
E. Design of Disposal Area
F. Safeguards and Monitoring
G. Operation and Reporting
H. Miscellaneous
I. Deviations from Design Criteria

CHAPTER XII

RECOMMENDED DESIGN CRITERIA FOR DISPOSAL OF EFFLUENT BY IRRIGATION

A. Administrative Considerations

Effluent for final disposal through irrigation equipment should first be preceded by a secondary treatment works, including disinfection when required. If the effluent, after treatment, cannot meet the requirements of ARSD 74:03:15 of the Ground-water Quality Standards, a Ground-water Discharge Plan may be required. The Department's Ground-water Quality Program staff should be contacted to determine the necessity of a Ground-water Discharge Plan (The Division of Water Rights should be contacted to determine if a Water Permit is required)*. Water Management Board definition of irrigation ARSD 74:02:01:01(2) "Irrigation," the artificial application of water for the purpose of supplying sufficient moisture for plant growth. Disposal of contaminated water is not considered to be irrigation unless other water is used along with the contaminated water. A Water Permit and/or a Ground-water Discharge Plan, if required, must be approved by the South Dakota Board of Water Management prior to initiation of the Step 4 grant. The State Conservation Commission must approve the compatibility of the soil and water for crop irrigation purposes. This approval must be obtained before an application for a Water Permit can be advertised for consideration by the Water Management Board.

The following procedure is recommended before considering disposal of wastewater through irrigation equipment as a method of treatment:

1. At least one representative sample of the wastewater should be collected and submitted to the Water Quality Laboratory, Brookings, South Dakota, for analysis and a preliminary interpretation of irrigability. If the wastewater is not suitable for irrigation, alternate methods of treatment should be considered. If the effluent water could be used for irrigation, Step 2 should be followed.

2. If a soil classification study has been completed by the Soil Conservation Service, the soils information should be reviewed to determine if the soil in the proposed area is suitable for irrigation, using waters of the quality as determined in Step 1.

3. If a soils classification study of the proposed irrigation site has not been completed, the applicant should contact the local Conservation District and request that the Soil Conservation Service complete a soils classification for the proposed site. The soils information should then be analyzed to determine if the soil at the proposed site is suitable for irrigation using the waters in question.

**Water Management Board definition of irrigation ARSD74:02:01:01(2) "Irrigation," the artificial application of water for the purpose of supplying sufficient moisture for plant growth. Disposal of contaminated water is not considered to be irrigation unless other water is used along with the contaminated water.*

4. After the water quality information and the soils information has been obtained, the Cooperative Extension Service, S.D.S.U., Brookings, South Dakota, should be contacted for advice on application rates and irrigation practices.

   The engineering report must contain pertinent information on location, geology, soil conditions, area for expansion, hydrology and any other factors which may affect the feasibility and acceptability of the proposal.

   The following specific information is to be submitted prior to initiation of the Step 4 grant or final approval of plans and specifications by the Department staff. The process design manual for Land Treatment of Municipal Wastewater, October, 1981, or latest edition, U.S. EPA, should be used as a reference.

B. General Information

1. Legal description of the disposal site.

2. The location of all existing and proposed residences, commercial or industrial development, roads and ground or surface water supplies within one-half mile of the proposed site.

3. Analytical data of the wastewater showing as a minimum: total dissolved solids, electrical conductivity, pH, total suspended solids, 5-day biochemical oxygen demand (BOD5), ammonia nitrogen, total kjeldahl nitrogen, nitrates, phosphorus, chlorides, sulfates, carbonates, bicarbonates, calcium, magnesium, sodium, fecal coliform, adjusted sodium adsorption ratio and percent sodium. When industrial wastes are involved, analytical data showing the following should also be included: aluminum, arsenic, beryllium, boron, cadmium, chromium, cobalt, copper, fluoride, iron, lead, lithium, manganese, molybdenum, mercury, nickel, selenium, silver and zinc.

4. Representative percolation and infiltration data of the top soil and the subsoil layers between the surface and the ground-water table.

5. Representative data on the chemical and bacteriological quality of the ground-water as well as its elevation and the rate and direction of flow under existing and proposed conditions of use.

6. A description including maps showing elevation and contours of the site and adjacent areas which may be suitable for expansion.

7. Climatoligical data for the area.

8. Location, depth and outlet of underdrains on the site.

9. Representative soil boring data to a depth of at least 25 feet, to ground-water, or to bedrock. Information, including a detailed description of the properties of the major soil types present and any soil survey information, available from the Soil Conservation Service of the U.S. Department of Agriculture.

C. Storage

1. An effluent storage pond system shall have a minimum of 210 days capacity without consideration for evaporation.

2. The pond shall be designed and constructed in accordance with the applicable criteria for wastewater stabilization ponds found in Chapters IV and V.

D. Location of Disposal Site

1. The disposal site should be at least one mile from any municipal water supply and one-fourth mile from any private domestic water supply, except that in limestone or other unusual geological areas, a greater distance may be required.

2. The disposal site should be at least one- fourth mile from any human habitation or area which is likely to be developed for the same within the proposed use period of the project.

3. The disposal site should be at least one- fourth mile from state parks or recreation areas, unless disinfection is provided.

4. The disposal site shall be at least 100 feet from neighboring property lines or road right-of-ways.

5. The disposal site should be at least one- fourth mile from lakes.

6. Conditions 1-5 may be disregarded when the wastewater has undergone extensive treatment and could be considered reclaimed water suitable for human consumption.

7. A statement from the local planning agency on the planned uses of the disposal site and adjacent land and compatibility with other uses.

8. Wastewater used for the irrigation of golf courses, parks, playgrounds, lawns, and in other areas where the public has access shall be provided with disinfection sufficient to ensure that a geometric mean number of total coliform organisms does not exceed 200 organisms per 100 milliliters which should be adequate to protect human health. It should be realized, however, that this level probably will not eliminate all pathogenic viruses.

E. Design of Disposal Area

1. The vertical distance between the surface of the disposal fields and the maximum height of the ground- water table should be a minimum of six feet, or more if possible, except where it is necessary that the site be provided with underdrains to intercept the percolate for discharge to surface waters, in which case the distance between the surface of the disposal field and the underdrains should be a minimum of four feet.

2. Separation of underdrains will be dependent on soil types and flow gradients. The process design manual for Land Treatment of Municipal Wastewater, October, 1981, or latest edition, U.S. EPA, may be used as a reference.

3. Flow measuring devices shall be provided for disposal sites when underdrains are utilized to intercept and collect percolate for discharge to surface waters.

4. The disposal period for design purposes should be a maximum of 18 weeks. This time may be exceeded during operation of the facility if weather conditions permit.

5. The effluent shall be applied at a rate not to exceed the following:

Soil Type	**Application Rate in Inches/Hour**
Light Sandy	1/2 - 3/4
Medium	1/4 - 1/2
Heavy	1/10 - 1/4

   or in accordance with the maximum application rate for the soil type and method of application as given in the South Dakota Soil Conservation Irrigation Guide.

6. For the purpose of determining land requirements, a maximum application of wastewater shall be limited to 2 inches/acre/week or a total of 24 inches/acre/year. To prevent ground saturation and runoff, no applications are permitted during periods of heavy or prolonged rainfall, snow cover or when the ground is frozen.

7. A nitrogen mass balance shall be performed. The total annual load should be determined by using the process design manual for Land Treatment of Municipal Wastewater, October 1981, U.S. EPA, as a reference.

8. To the extent possible, a buffer zone around the land disposal site shall be provided through purchase of additional land and/or control of the land use through zoning ordinances. To protect downwind, adjacent land usage from mist and/or aerosol contamination, provisions should be made for a wind break or an increase in the buffer zone, or increased disinfection.

9. The effluent shall be applied so as not to have an adverse effect on vegetation. In the absence of suitable natural vegetation, provisions shall be made for establishing and maintaining an acceptable vegetative cover on the site. The Conservation District, Soil Conservation Service or Cooperative Extension Service, S.D.S.U., should be consulted for this information.

10. Computation of the area required for disposal shall be based upon soil types, representative percolation and infiltration data, evapotranspiration data, available rainfall data, the maximum disposal period and application rates plus an allowance for system maintenance and for drying and harvesting cover crops where applicable.

11. The disposal area shall be diked to prevent any surface runoff of effluent and/or provisions made for its recapture by a system of ditches, storage and pumping facilities or other acceptable means.

12. Extraneous surface water shall be prevented from entering the disposal area.

13. The distribution pressure and devices for the sprinkler or big gun type equipment shall, to the extent feasible, be installed in such a manner as to minimize wind drift of effluent and formation of aerosols.

F. Safeguards and Monitoring

1. The site shall be enclosed with a fence capable of discouraging the entrance of unauthorized persons.

2. Appropriate warning signs shall be provided on the fence around the site to inform the public of the nature of the facility and advise against trespassing. At least one sign shall be provided on each side of the site and one for every 500 feet of its perimeter.

3. Shallow observation wells shall be placed in all directions of major ground-water flow from the site. The wells shall not be more than 200 feet outside of the site perimeter, spaced not more than 500 feet apart, and extending into the ground-water table. The shallow wells shall be no deeper than 5 feet below the seasonal low water table and will be screened to intercept the water table. The spacing and depth of the wells may be varied in any particular situation, depending upon circumstances. Shallow wells within the disposal site are also recommended. The wells shall be constructed in accordance with the South Dakota well drilling regulations.

4. Provisions shall be made for measurement of the quantity and quality of the effluent discharging to the disposal area and measurement of the static water level and quality of the water in the observation wells.

5. The application operation should cease during strong winds if the spray is carried toward nearby human habitations, pastures used for dairy grazing, public access areas, or food crops such as produced in gardens, orchards or vineyards.

6. If disinfection is required, chlorine residuals shall be at levels non-toxic to the grasses, plants, fisheries, or aquatic life. Most grasses can tolerate a 2.0 mg/l total residual chlorine level.

G. Operation and Reporting

1. NPDES and ground-water permit conditions may require any or all of the following tests every month on samples from all observation wells and the flow from field underdrain outlets: conductivity, chlorides, dissolved solids, nitrates, nitrites, ammonia, fecal coliform, sulfates, BOD5, phosphorus, suspended solids, and pH.

2. Other tests or samples from observation wells or underdrain outlets also may be required as recommended by the Department staff, such tests to be made and reported to the Department before, during and after periods of use of the site.

3. Pertinent operation information shall be submitted monthly to the Department.

H. Miscellaneous

1. The quality of the treated wastewater effluent discharged to ground-water must conform with the current recommended State and Federal Drinking Water Standards pursuant to the Federal Safe Drinking Water Act, and the Ground-water Quality Standards, whichever is the better water quality. Discharges to the surface waters shall conform to the South Dakota Surface Water Quality Standards. Any expected departure shall be noted in the engineering report, together with proposed means for conforming, or justification if remedial measures are not proposed.

2. No detrimental change in the ground-water quality shall be allowed without obtaining a Ground-water Discharge Plan. Unpermitted degradation of the ground-water shall require remediation.

3. Adequate pre-operational baseline data on the ground-water quality and other environmental aspects as may be requested, shall be obtained and submitted for review before the site is placed in operation.

4. Leases of farm land for disposal of effluent by irrigation should be for the design life of the project. It is recommended that the design life of the project be at least 20 years.

5. If disinfection is required, the following features should be provided:

   a. Alarm device for malfunction of disinfection system.

   b. Automatic switch-over devices for chlorine cylinders.

   c. Automatic shut-off of irrigation unit if chlorination system malfunctions.

I. Deviations from Design Criteria

The Department may consider and allow deviations where adequate documentation is provided to prove the need for such deviation.

Water Management Board definition of irrigation ARSD 74:02:01:01(2) "Irrigation," the artificial application of water for the purpose of supplying sufficient moisture for plant growth. Disposal of contaminated water is not considered to be irrigation unless other water is used along with the contaminated water.

CHAPTER XIII: Recommended Design Criteria For Ground Water Monitoring Wells (WWTF) Waste Water Treatment Facilities

CHAPTER XIII

RECOMMENDED DESIGN CRITERIA FOR GROUND WATER MONITORING WELLS

A. GENERAL

The installation of ground water monitoring wells at wastewater treatment facilities may be essential when facilities such as infiltration-percolation systems, stabilization and/or aeration ponds, wetlands, or employ land application techniques, have the potential for degrading the State's ground water quality. Discharge to ground water at these facilities is caused by seepage or direct discharge of effluent through the soil profile. The necessity for monitoring wells and/or ground water discharge plans is based on a number of factors, including the soil type, depth to ground water, strength of the waste, mobility of the waste, and general quality of the ground water. If the potential for ground water degradation is high, monitoring wells are necessary to insure that these discharges are not degrading the State's ground water quality beyond the ground water quality standards, especially when they are in close proximity to water supplies and other facilities which can be impacted by ground water contamination.

B. MONITORING WELL DRILLING METHODS

1. *Criteria for Drilling Method Selection*

The following factors should be considered when selecting an appropriate drilling method:

a. Hydrologic Information

   1) Type of formation

   2) Depth of drilling

   3) Depth of desired screen setting

b. Types of pollutants expected

c. Location of drill site, i.e., accessibility

d. Design of monitoring well desired

e. Availability of drilling equipment

2. *Overview of Various Drilling Methods*

<u>a. Hollow-Stem Augering</u>

Hollow-stem augering is one of the most desirable drilling methods for constructing monitoring wells. No drilling fluids are used and disturbance to the geologic material penetrated is minimal. Auger rigs are not generally used when consolidated rock must be penetrated and drilling depths are usually limited to less than 150 feet. In formations where the borehole will not stand open, the monitoring well can be constructed inside the hollow-stem augers prior to their removal from the borehole. The hollow-stem has the advantage of allowing continuous in situ geologic sample collection without removal of the augers.

b.   Solid-Stem Augering

The use of solid-stem augering is most useful in fine grained, unconsolidated materials that will not collapse when unsupported. The method is similar to hollow- stem except the augers must be removed from the borehole to allow insertion of the well casing and screen. In situ geologic samples are difficult to collect when using a solid-stem. In many cases it is necessary to rely on the cuttings, which come to the surface, for geologic sampling. This is an undesirable method since the exact depth at which the cuttings come from is not known.

c.   Cable-Tool Drilling

Cable-tool drilling is one of the oldest methods used in the water well industry. Even though the rate of penetration is slow, this method offers many advantages for monitoring well construction. With the cable-tool method, excellent formation samples can be collected and the presence of thin permeable zones can be detected. As drilling progresses, a casing is normally driven which provides temporary support for the borehole allowing construction of the monitoring well within the casing.

d.   Air Rotary Drilling

In air rotary drilling, air is forced down the drill stem and back up the borehole to remove the cuttings. This type of drilling is particularly well suited for fractured rock formations. If ground water monitoring for volatile organics is planned, the drilling air must be filtered to insure that oil from the air compressor is not introduced to the formation being monitored. Air rotary should not be used in highly contaminated environments because the water and cuttings blown out of the hole are difficult to control and can pose a hazard to the drill crew and observers. Where volatile compounds are of interest, air rotary can volatilize these compounds causing water samples withdrawn from the borehole to be unrepresentative of in situ conditions. The use of foam additives to aid cuttings removal can introduce organic contaminants into the monitoring well.

e.   Mud Rotary Drilling

Mud rotary drilling is probably the most popular method used in the water well industry. However, mud rotary drilling does have some disadvantages for monitoring well construction. With mud rotary, a drilling fluid (usually a bentonite water mix) is circulated down the drill stem and up the borehole to remove cuttings. The drilling mud creates a wall on the sides of the borehole which must be removed from the screened area by development procedures. With small diameter wells, complete removal of drilling mud is not always achieved. The ion exchange potential of most drilling muds is high and may effectively reduce the concentration of trace metals in water entering the well. In addition, the use of biodegradable organic drilling muds (i.e. Baroid, Revert, etc.) can introduce organic components to monitoring well samples.

C. PERMITS AND LICENSING

The well driller shall be a licensed water well contractor in the State of South Dakota. The well driller must apply for a variance if the monitoring wells will not meet the South Dakota Well Construction Standards, ARSD 74:02:04:23.

D. DECONTAMINATION OF DRILLING EQUIPMENT AND MATERIALS

1. Condition of Drill Rig and Equipment

Prior to entering the work site the condition of the drill rig and equipment shall be such that it is not a potential source for monitoring well contamination. Leaking equipment seals or leaking tanks containing fluids should not be brought on-site.

2. Procedures to be Used for Cleaning Equipment

All steam cleaning must be done on-site or at an approved off-site location. Any equipment that will not be used at the site should be removed prior to entering the site. The drill rig must be steam cleaned with water that is from a potable source. All drill rods, bits, casing, samplers, pipe wrenches, etc., should be laid on supports and cleaned until all visible signs of grease, oil, mud, etc. are removed. Cleaned equipment should not be handled with soiled gloves. Surgeon's gloves or new clean cotton work gloves should be used.

The use of new painted drill bits and tools is not recommended since paint chips could be introduced into the borehole. All water tanks, pumps, mud pans, hoses, including hoses and tanks used to transfer water from the potable source must be cleaned. Fittings on the drilling equipment may be lubricated with non-petroleum based substances, such as vegetable oil. Every precaution must be taken to prevent contamination of the well with oil, grease or any other substance. Lubricants must not be used on drilling and sampling tools or fittings.

3. Decontamination of Materials

At a minimum, casing and well screen should be washed with detergent and rinsed thoroughly with clean water. To ensure that these materials are protected from contamination prior to placement in the borehole, materials should be covered (with plastic sheeting or another material) and kept off the ground.

4. Decontamination of Well Development Equipment

All pumps used in well development must be steam cleaned prior to developing each monitoring well. Pumps which leak or may otherwise cause contamination must not be used. Electrical tape should not be used to attach wires to the discharge pipe of submersible pumps. Wire should be attached using stainless steel or plastic clips. Air compressors used for development must be equipped with operable oil traps and a filter. Nitrogen gas if used for development must be regulated and passed through an oil trap and filter before it enters the well.

E. MONITORING WELL DESIGN COMPONENTS

1. Location and Number

A minimum of three (3) monitoring wells must be installed to determine ground water flow direction. One well should be located in an area upgradient of the facility with two located downgradient. However, the number of monitoring wells will also depend on the size of the facility. The downgradient wells should not be spaced more than 500 feet apart and should not be located more than 200 feet outside of the site perimeter.

2. Diameter

Monitoring wells can be constructed of casing and screen materials that are a minimum of two inches inside diameter. The borehole into which the monitoring well is to be installed must be a minimum of four inches greater in diameter than the casing (i.e. a two inch well must be installed in a six inch borehole).

3. Casing and Screen Material

Well casing and screen can be made of stainless steel, teflon, or polyvinyl chloride (PVC). If PVC is selected for well construction only those materials that meet or exceed the National Sanitation Foundation (NSF) Standard 14 must be used. Rigid PVC materials used for casing and well screen which meet or exceed NSF Standard 14 are essentially free of plasticizers. All casing and screen must be supplied with threaded flush joints or threaded couplers, PVC casing and screen must not have glue joints. The well casing should extend two feet above the ground surface when the well is completed.

4. Screen Length, Depth of Placement and Gravel Packing

The monitoring well(s) must be drilled to a depth that will monitor the first water encountered. The well screen should extend 5-15 feet into the water table with sufficient screen above the water table to detect any substances less dense than water. The well screen length should be based on water table fluctuations and other site conditions (such as confining layers). The well screen must be installed into a stable borehole. If the borehole tends to cave in or "blowout" steps must be taken to stabilize the hole prior to screen installation.

The screen gravel-pack must be composed of prewashed, uniform (graded) quartz sand. The size of the gravel-pack chosen must be compatible with the slot size of the well screen. For natural-packed wells (no gravel-pack), where relatively homogeneous, coarse materials predominate, the screen slot size must be compatible with the formation.

Placement of the gravel-pack should be done carefully to avoid bridging in the borehole and to allow uniform settling around the screen. A tremie pipe can be used to guide the sand to the bottom of the hole and around the screen. If the well is shallow the sand can be poured from the surface. The gravel pack must extend a minimum of 1-2 feet above the top of the screen. Field measurements should be taken to confirm the gravel-pack has reached this level prior to grouting.

5. *Sealing Materials and Procedures*

The seal used directly above the gravel-pack should be of bentonite in the pelletized form. Enough pelletized bentonite should be added so that a seal two feet thick is formed directly above the gravel-pack. If no water is present in the borehole where the pellets were installed, water from a potable source must be added to fully expand the pellets. If it is not possible to install the bentonite seal as described above, an alternate procedure of installing the seal via tremie pipe may be used. The seal must be composed of pure bentonite and mixed with potable water. The bentonite mixture should be thick enough to provide an adequate seal while remaining pliable enough to be pumped.

The annular space remaining above the seal must be grouted. The grout mixture should be composed of Portland cement and powdered bentonite. The use of Hi Early Type III cement in the mixture is prohibited due to the high heat of hydration. The grout mixture proportions must be six gallons of water to one 94 pound sack of cement. Two pounds of powdered bentonite should be added per sack of cement to control grout shrinkage. The grout must be thoroughly mixed until a consistent slurry is reached throughout. Under <u>NO</u> circumstances should the grout be added to the well annulus dry, it must be premixed and injected as described below.

Grout must be injected via tremie pipe immediately above the bentonite seal that was placed above the well screen. All hoses, pipes, tubes, water swivels, drill rods or passageways through which the grout is to be pumped should have an inside diameter of at least 0.5 inches. Grout injection must continue until clean grout reaches the ground surface. The well must not be disturbed for at last 48 hours after grouting to allow the grout time to set up.

6. *Well Development*

All monitoring wells must be developed to produce representative formation water. Representative formation water is assumed to have been obtained when, pH, temperature and conductivity readings are stable and the water is turbid free, and the minimum periods of development specified below have been reached. Various methods of well development are described below:

<u>a. Submersible Pumps</u>

Submersible pumps include centrifugal or positive displacement type pumps which are operated under submergence. If a submersible pump is utilized for well development, it must be of a type and capacity such that it can pump water from the well continuously for a period of at least five minutes without shutting off. Back pressure or other methods may be utilized to accomplish the desired pumping rate. The pump must be capable of being turned off and on instantaneously to create a surge in the well. When using a submersible pump it is recommended the well be developed for a minimum of four hours.

b. Bladder Pumps

A bladder or diaphragm pump is the type of pump which operates under the cycling of compressed air. The compressed air cycling inflates and deflates a diaphragm which creates a pumping action. Bladder pumps capable of well development must pump a minimum of 2 gallons per minute (GPM) continuously when installed in the well. Development with a bladder pump should be done for a minimum of eight hours.

c. Jet Pumps

A jet pump utilizes the Venturi principle to create sub-atmospheric pressure which allows a suction pump to be utilized below a depth at which suction alone would not normally lift water. Jet pumps capable of well development must pump a minimum of 3 GPM continuously when installed in the well. The recommended development time with a jet pump is four hours.

d. Suction Pumps

Suction pumps cannot be used in wells which are deeper than 25 feet. Suction pumps used to develop wells less than 25 feet deep must be capable of pumping at least 5 GPM continuously without pumping the well dry in less than five minutes. The recommended minimum development time with a suction pump is four hours.

e. Bailers

Bailers used in well development must be constructed of teflon, stainless steel or PVC. Bailers must have a lower check valve and be lowered into the well with non water absorbing cable. Wells developed using a bailer must be bailed until a turbid free discharge is attained. If the well has insufficient recharge to permit continuous bailing, then the well should be bailed dry and allowed to fully recharge. This cycle should be repeated five times or until a turbid free discharge is attained.

f. Compressed Air

Compressed air supplied by an engine-driven compressor equipped with an oil trap may be used; provided the source of compressed air is capable of evacuating 50 percent of the water column from the well once every minute. The recommended well development time for compressed air is four hours with cycling at two minute intervals.

7. Security

All monitoring wells must be fitted with an outer protective casing. This protective casing must be constructed of steel and be supplied with a steel locking cap. The steel casing must be securely set in cement and should extend a minimum of two inches above the top of the monitoring well casing. As additional protection, it is recommended that three (3) posts be installed around each monitoring well. The posts should be constructed of five- inch steel casing and extend a minimum of two feet into the ground with three feet above ground. Each post should be filled and grouted in place with concrete.

F. GEOLOGIC SAMPLING OF FORMATION

Each monitoring well boring must be sampled via split spoon sampler at five foot intervals or when a change in lithology is encountered. The split spoon sampling must be performed in accordance with ASTM method D-1586. Samples must be placed in one pint glass jars and labeled as to location, depth, blow counts, and soil classification. A detailed geologic log must be generated from these samples and submitted to the Department.

G. SAMPLING OF MONITORING WELLS

Parameters to be sampled for at a facility should be based on the character of the effluent being discharged but should at a minimum include the following:

1. Temperature (degrees C)
2. pH, standard units
3. Conductivity (adjusted to 25 degrees C)
4. Nitrate, mg/l as N
5. Ammonia, mg/l as N
6. Fecal Coliform, N/100 ml
7. Nitrites, mg/l
8. Chlorides,mg/l
9. Total Dissolved Solids, mg/l
10. Sulfate, mg/l
11. Ground water elevations, measured from top of well casing

As for proper procedures for collection of monitoring well samples, the Ground Water Quality Program of the Department of Water and Natural Resources has a guidance document available which outlines the proper procedures for sampling a monitoring well.

H. DEVIATIONS FROM DESIGN CRITERIA

The Department may consider and allow deviations where adequate documentation is provided to prove the need for such deviation.

CHAPTER XIV: Land Application and Treatment of Wastewater Sludge (References)

1. General Statement:

CHAPTER XIV

A. Land Application and Treatment of Wastewater Sludge (References)

1. General Statement: The recommended design criteria and guidance for land application and treatment of wastewater sludge for this chapter are intended to suggest limiting values for items upon which an evaluation of such plans and specifications will be made by this reviewing authority; and to establish, as far as practicable, uniformity of practice as provided for in the following references.

References:

2. State Sludge Management Program Regulations (for non-NPDES States) 40 CFR Part 257 and 501, U.S. EPA, 1987.

3. Recommended Standards for Sewage Works, Chapter 70 of the 1978 Edition or the latest Edition.

4. Recommended Guidelines for the Land Application of Sludge, S.D. DWNR, December 1981 draft supplement to 40 CFR Part 257 and 503, U.S. EPA, 1989 or latest Rules.

CHAPTER XV: Recommended Design Criteria For Disinfection

A. Engineer's Report, Plans, and Specifications
B. Equipment, Piping, Housing and Storage Facilities
C. Forms, Application and Effectiveness Evaluation of Disinfectant

CHAPTER XV

RECOMMENDED DESIGN CRITERIA FOR DISINFECTION

A. Engineer's Report, Plans, and Specifications

Information for disinfection must be submitted as required by Chapter 10, Recommended Standards for Sewage Works, 1978 or latest Edition.

B. Equipment, Piping, Housing and Storage Facilities

1. Equipment, piping, housing and storage facilities for disinfection of the effluent when required shall be provided as outlined in Chapter 90 of the Recommended Standards for Sewage Works, 1978 or the latest Edition and, in addition, those requirements that may be applicable as outlined in Part 4 and Part 5 of the Recommended Standards for Water Works, 1982 or the latest Edition.

C. Forms, Application and Effectiveness Evaluation of Disinfectant

1. The forms of disinfectant in conjunction with the application and evaluation for disinfection of the effluent when required shall be provided as outlined in Chapter 90 of the Recommended Standards for Sewage Works, 1978 or the latest Edition.

CHAPTER XVI: Recommended Design Criteria For Artificial Wetland Systems

CHAPTER XVI

RECOMMENDED DESIGN CRITERIA FOR ARTIFICIAL WETLAND SYSTEMS

A. INTRODUCTION

The artificial wetland treatment system is a relatively new technology. Like other land application systems artificial wetlands are site specific, consequently, all proposals will be reviewed on a site-by-site basis.

Plans and Specifications proposals shall contain the pertinent information as required in Chapter IV for Wastewater Stabilization Ponds.

B. BASIS OF POND DESIGN (PRE-TREATMENT):

1. The maximum design loading on the primary cell(s) shall be 30 lbs BOD5 per acre per day.

2. The design average flow rate shall be used to determine the volume required to provide a minimum combined storage capacity of 180 days in the stabilization ponds (pre-treatment system) and the artificial wetland areas. The minimum recommended storage capacity in the stabilization pond system shall be 150 days. The storage in the pre-treatment system shall be provided above the two (2) foot level. The maximum normal liquid level should not exceed five (5) feet in the primary cell or six (6) feet in the secondary cell.

3. The seepage rate for the primary cell(s) shall not exceed 1/16 inch per day. Seepage of up to 1/8 inch per day may be allowed in secondary cells, considered on a case- by-case basis.

4. The minimum number of cells for the pre- treatment system shall be two when the system is designed to discharge.

5. The shape of the cells shall be such that there are no narrow, L-shaped or elongated portions. Round or rectangular ponds are most desirable. Rectangular ponds shall generally have a length not exceeding three times the width. Dikes shall be rounded at the corners to minimize accumulation of floating material.

6. Refer to Chapter IV Design Criteria for pond location, construction details, pond bottom details, influent lines, control structures and other miscellaneous criteria.

C. BASIS OF WETLAND DESIGN

1. Design

a. No discharge is recommended from the artificial wetland treatment system during the 180-day winter storage period unless it can be shown that the discharge meets NPDES permit limits.

b. The maximum hydraulic design loading flow through rate on the artificial wetland(s) shall be 25,000 gallons per acre per day.

c. The minimum recommended detention time for treatment in the artificial wetland system may be 7 days with 14 days being the most desirable.

d. The recommended depth of flow in the wetland system shall be between 6 and 24 inches, with nine (9) inches as the recommended optimum depth.

e. A rectangular configuration is recommended to enhance treatment efficiency in the system with a length to width ratio of between 5 and 10 to 1. However, irregular shorelines offer substantially better support for wildlife.

f. Seepage rates in the artificial wetland areas will be addressed on a site-by-site basis based upon in-situ material, groundwater depth and the groundwater use. Generally, no compaction will be required on wetland pond bottoms. The berms shall be compacted to at least 90 percent of Standard Proctor Density.

g. The bottom of the artificial wetland treatment units shall not have a slope greater than 0.2%.

h. Due consideration shall be given to multiple wetland cells and to possible future expansion on suitable land when the original land acquisition is made for flexibility and for maximum operational capability.

2. *Construction*

a. The project site should be protected from surface inflow waters. The site should also be protected to one foot above the 100 year flood elevation.

b. In order to prevent erosion and channelization at the inlet of the wetland, a discharge header should be utilized. The header should be equipped with removable end-plugs so the line may be drained to prevent freeze-up. Uniform distribution of wastewater to prevent short-circuiting through the wetland shall be assured. It is recommended that the header outlet elevation be at or above the maximum design depth.

c. It is recommended that pipes and flumes located in or near inlet and discharge structures will not be in a completely submerged condition to maintain the integrity of the system and reduce freeze-up problems.

d. A suitable discharge structure from the wetland shall be utilized. The structure shall be adjustable so that the depth in the wetland may be modified as needed. It is recommended that the discharge or interconnecting structure outlet flow lines be 6 inches off the bottom to maintain the minimum depth.

e. Care should be taken to establish the vegetation as soon as possible after construction. The emergent vegetation, once established, should prevent the erosion of the berms of the system. Riprap may be required around the inlet and outlet structures of the wetland. A cover crop may be planted on the interior slopes to prevent erosion prior to the establishment of the emergent vegetation. Consideration may be given to the use of excelsior blanket over seeding.

f. The exterior and interior slopes of the wetland berms surrounding the wetland basins shall not be steeper than 3H:1V.

g. The top width of the berms shall be a minimum of eight feet.

h. Following the final grade, the substrate should consist of a minimum of one foot of clean inorganic/organic material of which 80-90% will pass a number 10 sieve.

i. The dike elevation should be a minimum of two feet above the high water level in the wetland.

j. If groundwater contamination is a potential problem, the bottom of the wetland may be sealed with a suitable material. However, generally no liner will be necessary in the artificial wetland.

k. Aluminum, concrete, or PVC pipe or other material generally accepted for sewers shall be specified for the piping requirements in the wetland. Provisions may be required to prevent the settling of the piping structures under load. It is recommended where structures are partially or completely submerged in ice conditions that a flexible piece of pipe be installed to allow for some movement of structure.

l. The effluent discharge structure shall be equipped with a suitable flow monitoring device, such as a flume or V-Notch weir, to monitor flows leaving the treatment site. Staff gages for measuring depths in structures should be provided where flow monitoring is required.

m. In order to accurately monitor influent flows to the artificial wetland system, an influent measurement structure shall be included.

n. The entire wetland area shall be enclosed with a suitable fence to provide public safety, exclude livestock and to discourage trespassing.

o. Warning signs shall be provided along the fence around the treatment facility. There shall be at least one sign on each side of the facility, with a minimum spacing of 500 feet.

p. Removable screens should be provided on pipe ends to prevent entrance of trash and wildlife.

3. *Vegetation Establishment*

a. Specifications for the seeding of the artificial wetland shall as a minimum include:

1) Plant species and propagule type

2) Plant distribution (vegetative zonation)

3) Planting (including time restraints)

4) Fertilization

5) Water level control and site maintenance.

b. Topsoiling the graded wetland area is generally not required. Substrate properties generally do not limit the establishment of a wetland.

c. Only indigenous plant species shall be used, preferably collected within a 100 mile radius. Preferred species include, but are not limited to:

1) Typha Latifolia - Common cattail,

2) Typha Angustifolia - Narrow leaf cattail,

3) Scirpus spp. - Bullrush, and/or

4) Phragmites communis - Reed.

d. Seeding should generally be accomplished in the spring. Also, at least one fertilization should be required, preferably shortly after seed germination or at one month. The recommended fertilizer is the standard 10- 10-10 or 20-10-10 mixture at a rate of 600 lbs/ac or 300 lbs/ac, respectively. Where wastewater stabilization ponds exist, fertlilization may not be necessary, as the nutrients in wastewater may suffice.

e. For seeding, the following is recommended:

The seed should be broadcast uniformly over the substrate at a rate of 10 viable seeds per square foot. The seeds should be cultivated to subsurface depths of 0 to 1 inch followed by lightly packing, rolling or dragging the tilled surface. Flood the site with 1-2 inches of water until the seeds germinate and become several inches tall. At this time, the area should be fertilized.

f. For transplanting (the recommended method of vegetation establishment) the propagule should be transplanted, as a minimum, on a two foot grid. The number of transplants required may be calculated from the equation:

$$N = (L/D +1) \text{ X } (W/D + 1)>$$

where:

N = Number of transplants
D= Distance between transplants
L = Length of site (ft.)
W = Width of site (ft.)

Transplanting on a two foot grid should provide a uniform vegetative cover in one growing season. Transplants should be kept moist, but not flooded to submerged conditions. The transplants should also be fertilized, preferably with controlled release fertilizer such as Osmocote 18-5-11 for fall and winter planting, Osmocote 18-6-12 for spring planting, and Osmocote 19-6-12 for summer planting. Refer to suppliers instructions when transplanting.

4. *Wildlife Enhancement* (optional)

   a. Some method of detritus removal should be considered to prevent aging of the wetland. Harvesting or burning are two options available.

   b. To provide the greatest potential for wildlife enhancement, 25 to 35% of the artificial wetland surface should be open water with a depth no greater than five feet. However, care should be taken to prevent a large open water area, which could influence treatment efficiency. Several small pools are most desirable. Of the 25 to 35% open water area, approximately 10% should be reserved for the construction of erosion protection bars.

   The emergent vegetation of the artificial wetland system should comprise 65 to 75% of the available surface area with a water depth of less than two feet deep.

   c. In order to prevent mosquito-production problems, wetland systems should be designed so that the occurrence of hydraulically static areas is minimized. The majority of the natural predators of mosquitoe larvae are strictly aerobic, and as such, anaerobic conditions in wetlands should be avoided.

5. *Water Quality Monitoring*

   a. Surface Water - Refer NPDES permit limits and requirements.

   b. Ground Water - Refer to Chapter XIII.

6. *Deviations from Design Criteria*

   The Department may consider and allow deviations where adequate documentaiton is provided to prove the need for such deviation.

CHAPTER XVII: Recommended Design Criteria For Ground Water Monitoring Wells (AWMS) Animal Waste Management Systems

CHAPTER XVII

RECOMMENDED DESIGN CRITERIA FOR GROUND WATER MONITORING WELLS

A. Recommended Design Criteria for Ground Water Monitoring Wells

1. *General*

The installation of ground water monitoring wells at animal wastewater pollution control facilities may be essential when storage facilities such as evaporation or holding ponds, or sediment basins have the potential for degrading the State's ground water quality. Discharge to ground water at these facilities is caused by seepage or direct discharge of effluent through the soil profile. The necessity for monitoring wells and/or ground water discharge plans is based on a number of factors, including the soil type, depth to ground water, strength of the waste, mobility of the waste, and general quality of the ground water. If the potential for ground water degradation is high, monitoring wells are necessary to insure that these discharges are not degrading the State's ground water quality beyond the ground water quality standards, especially when they are in close proximity to water supplies and other facilities which can be impacted by ground water contamination.

2. *Monitoring Well Drilling Methods*

   a. <u>Criteria for Drilling Method Selection</u>

      The following factors should be considered when selecting an appropriate drilling method:

      1) Hydrologic Information

         a) Type of formation

         b) Depth of drilling

         c) Depth of desired screen setting

      2) Types of pollutants expected

      3) Location of drill site, i.e., accessibility

      4) Design of monitoring well desired

      5) Availability of drilling equipment

   b. <u>Overview of Various Drilling Methods</u>

      1) Hollow-Stem Augering

Hollow-stem augering is one of the most desirable drilling methods for constructing monitoring wells. No drilling fluids are used and disturbance of the geologic material penetrated is minimal. Auger rigs are not generally used when consolidated rock must be penetrated and drilling depths are usually limited to less the 150 feet. In formations where the borehole will not stand open, the monitoring well can be constructed inside the hollow-stem augers prior to their removal from the borehole. The hollow-stem has the advantage of allowing continuous in situ geologic sample collection without removal of the augers.

2) Solid-Stem Augering

The use of solid-stem augering is most useful in fine grained, unconsolidated materials that will not collapse when unsupported. The method is similar to hollow-stem except the augers must be removed from the borehole to allow insertion of the well casing and screen. In situ geologic samples are difficult to collect when using a solid-stem. In the many cases it is necessary to rely on the cuttings, which come to the surface, for geologic sampling. This is an undesirable method since the exact depth at which the cuttings come form is not known.

3) Cable-Tool Drilling

Cable-tool drilling is one of the oldest methods used in the water well industry. Even though the rate of penetration is slow, this method offers many advantages for monitoring well construction. With the cable-tool method, excellent formation samples can be collected and the presence of thin permeable zones can be detected. As drilling progresses, a casing is normally driven which provides temporary support for the borehole allowing construction of the monitoring well within the casing.

4) Air Rotary Drilling

In air rotary drilling, air is forced down the drill stem and back up the borehole to remove the cuttings. This type of drilling is particularly well suited for fractured rock formations.

5) Mud Rotary Drilling

Mud rotary drilling is probably the most popular method used in the water well industry. However, mud rotary drilling does have some disadvantages for monitoring well construction. With mud rotary, a drilling fluid (usually a bentonite water mix) is circulated down the drill stem and up the borehole to remove cuttings. The drilling mud creates a wall on the sides of the borehole which must be removed from the screened area by development procedures.

With small diameter wells, complete removal of drilling mud is not always achieved. In addition, the use of biodegradable organic drilling muds (i.e. Baroid, Revert, etc.) can introduce organic components to monitoring well samples.

3. *Permits and Licensing*

The well driller shall be a licensed water well contractor in the State of South Dakota. Governmental agencies involved in water well drilling operations are not required to obtain a South Dakota well driller's license, but must adhere to all South Dakota Well Construction Standards set forth in ARSD 74:02:04. The well driller must apply for a variance if the monitoring wells will not meet any of the criteria of the above standards.

4. *Decontamination of Drilling Equipment and Materials*

a. <u>Condition of Drill Rig and Equipment</u>

Prior to entering the work site the condition of the drill rig and equipment shall be such that it is not a potential source for monitoring well contamination. Leaking equipment seals or leaking tanks containing fluids should not be brought on-site.

b. <u>Procedures to be Used for Cleaning Equipment</u>

The use of new painted drill bits and tolls is not recommended since paint chips could be introduced into the borehole. All water tanks, pumps, mud pans, hoses, including hoses and tanks used to transfer water from the potable source must be cleaned.

5. *Monitoring Well Design Components*

a. <u>Location and Number</u>

A minimum of three (3) monitoring wells must be installed to determine ground water flow direction. One well should be located in an area upgradient of the facility with two located downgradient. However, the number of monitoring wells will also depend on the size of the facility. The downgradient wells should not be spaced more than 500 feet apart and should not be located more than 200 feet outside of the site perimeter.

b. <u>Diameter</u>

Monitoring wells can be constructed of casing and screen materials that are a minimum of two inches inside nominal diameter. The borehole into which the monitoring well is to be installed must be a minimum of four inches greater in diameter than the casing (i.e. a two inch well must be installed in a six inch borehole).

c. Casing and Screen Material

Well casing and screen can be made of stainless steel, teflon, or polyvinyl chloride (PVC). All casing and screen must be supplied with threaded flush joints or threaded couplers, PVC casing and screen must not have glue joints. The well casing should extend two feet above the ground surface when the well is completed.

d. Screen Length, Depth of Placement and Gravel Packing

The monitoring well(s) must be drilled to a depth that will monitor the first water encountered. The well screen should extend 5-15 feet into the water table with sufficient screen above the water table to detect any substances less dense than water. The well screen length should be based on water table fluctuations and other site conditions (such as confining layers). The well screen must be installed into a stable borehole. If the borehole tends to cave in or "blowout" steps must be taken to stabilize the hole prior to screen installation.

The screen gravel-pack must be composed of prewashed, uniform (graded) quartz sand. The size of the gravel-pack chosen must be compatible with the slot size of the well screen. For natural-packed wells (no gravel-pack), where relatively homogeneous, coarse materials predominate, the screen slot size must be compatible with the formation. Placement of the gravel-pack should be done carefully to avoid bridging in the borehole and to allow uniform settling around the screen. A tremie pipe can be used to guide the sand to the bottom of the hole and around the screen. If the well is shallow the sand can be poured from the surface. The gravel pack must extend a minimum of 1-2 feet above the top of the screen. Field measurements should be taken to confirm the gravel-pack has reached this level prior to grouting.

e. Sealing Materials and Procedures

The seal used directly above the gravel-pack should be of bentonite in the peletized form. Enough pelletized bentonite should be added so that a seal two feet thick is formed directly above the gravel-pack. If no water is present in the borehole where the pellets were installed, water from a potable source must be added to fully expand the pellets. If it is not possible to install the bentonite seal as described above, an alternate procedure of installing the seal via tremie pipe may be used. The seal must be composed of pure bentonite and mixed with potable water. The bentonite mixture should be thick enough to provide an adequate seal while remaining pliable enough to be pumped.

The annual space remaining above the seal must be grouted. The grout mixture should be composed of Portland cement and powdered bentonite. The use of Hi Early Type III cement in the mixture is prohibited due to the high heat of hydration. The grout mixture proportions must be six gallons of water to one 94 pound sack of cement. Two pounds of powdered bentonite should be added per sack of cement to control grout shrinkage. The grout must be thoroughly mixed until a consistent slurry is reached throughout. Under NO circumstances should the grout be added to the well annulus dry, it must be premixed and injected as described below.

Grout must be injected via tremie pipe immediately above the bentonite seal that was placed above the well screen. All hoses, pipes, tubes, water swivels, drill rods or passageways through which the grout is to be pumped should have an inside diameter of at least 0.5 inches. Grout injection must continue until clean grout reaches the ground surface. The well must not be disturbed for at least 48 hours after grouting to allow the grout time to set up.

f. Well Development

All monitoring wells must be developed to produce representative formation water. Representative formation water is assumed to have been obtained when pH, temperature and conductivity readings are stable and water is turbid free, and the minimum periods of development specified below have been reached. Various methods of well development are described below:

1) Submersible Pumps

Submersible pumps include centrifugal or positive displacement type pumps which are operated under submergence. If a submersible pump is utilized for well development, it must be of a type and capacity such that is can pump water from the well continuously for period of at least five minutes without shutting off. Back pressure or other methods may be utilized to accomplish the desired pumping rate. The pump must be capable of being turned off and on instantaneously to create a surge in the well. When using a submersible pump it is recommended the well be developed for a minimum of four hours.

2) Bladder Pumps

A bladder or diaphragm pump is the type of pump which operates under the cycling of compressed air. The compressed air cycling inflates and deflates a diaphragm which creates a pumping action. Bladder pumps capable of well development must pump a minimum of 2 gallons per minute (GPM) continuously when installed in the well. Development with a bladder pump should be done for a minimum of eight hours.

3) Jet Pumps

A jet pump utilizes the Venturi principle to create sub-atmospheric pressure which allows a suction pump to be utilized below a depth at which suction alone would not normally lift water. Jet pumps capable of well development must pump a minimum of 3 GPM continuously when installed in the well. The recommended development time with a jet pump is four hours.

4) Suction Pump

Suction pumps cannot be used in wells which are deeper than 25 feet. Suction pumps used to develop wells less than 25 feet deep must be capable of pumping at least 5 GPM continuously without pumping the well dry in less than five minutes. The recommended minimum development time with a suction pump is four hours.

5) Bailers

Bailers used in well development must be constructed of teflon, stainless steel or PVC. Bailers must have a lower check valve and be lowered into the well with non water absorbing cable. Wells developed using a bailer must be bailed until a turbid free discharge is attained. If the well has insufficient recharge to permit continuous bailing, then the well should be bailed dry and allowed to fully recharge. This cycle should be repeated five times or until a turbid free discharge is attained.

6) Compressed Air

Compressed air supplied by an engine-driven compressor equipped with an oil trap may be used; provided the source of compressed air is capable of evacuating 50 percent of the water column from the well once every minute. The recommended well development time for compressed air is four hours with cycling at two minute intervals.

g. Security

All monitoring wells must be fitted with an outer protective casing. This protective casing must be constructed of steel and be supplied with a steel locking cap. The steel casing must be securely set in cement and should extend a minimum of two inches above the top of the monitoring well casing. As additional protection, it is recommended that three (3) posts be installed around each monitoring well. The posts should be six-inch pressure treated wood posts and extend a minimum of two feet into the ground with three feet above ground. Each post should be grouted in place with concrete.

6. *Geologic Sampling of Formation*

Each monitoring well boring must be sampled via split spoon sampler at five foot intervals or when a change in lithology is encountered. The split spoon sampling must be performed in accordance with ASTM method D-1586. Samples must be placed in one pint glass jars and labeled as to location, depth, blow counts, and soil classification. A detailed geologic log must be generated from these sample and submitted to the Department

7. *Sampling of Monitoring Wells*

Parameters to be sampled for at a facility should be used on the character of the effluent being discharged but should at a minimum include the following:

a. Nitrate, mg/l as N

b. Ammonia, mg/l as N

c. Fecal Coliform, N/100 ml

d. Chlorides, mg/l

e. Total Dissolved Solids, mg/l

f. Sulfate, mg/l

g. Ground water elevations, measured from top of well casing

As for proper procedures for collection of monitoring well samples, the Ground Water Quality Program of the Department of Water and Natural Resources has a guidance document available which outlines the proper procedures for sampling a monitoring well.

B. Deviations From Design Criteria

The Department may consider and allow deviations where adequate documentation is provided to prove the need for such deviation.