# Title 10—DEPARTMENT OF NATURAL RESOURCES
## Division 20—Clean Water Commission
## Chapter 8—Design Guides

**10 CSR 20-8.010 Design of Municipal Waste Stabilization Lagoons in Missouri**
(Rescinded August 13, 1979)

*AUTHORITY: section 204.026, RSMo Supp. 1973. Original rule filed July 17, 1961, effective July 27, 1961. Amended: Filed Oct. 3, 1962, effective Oct. 13, 1962. Amended: Filed Dec. 4, 1975, effective Dec. 14, 1975. Rescinded: Filed May 4, 1979, effective Aug. 13, 1979.*

**10 CSR 20-8.020 Design of Small Sewage Works**

*PURPOSE: This rule sets out criteria as a guide in designing and constructing small sewage works. These criteria are not necessarily applicable to the design of works having daily flows in excess of 22,500 gallons per day. For works having larger flows, 10 CSR 20-8.110–10 CSR 20-8.220 reflect the minimum acceptable standards. This rule reflects the minimum requirements of the Missouri Department of Natural Resources for design, submission of plans, approval of plans and approval of completed small sewage works. These criteria are based on the best information presently available but they may be subject to periodic review and revision as additional information and methods appear. Deviation from minimum requirements will be allowed if sufficient documentation justifies the deviation. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. Others wanting to receive addenda or supplements should contact the Missouri Clean Water Commission to be added to the mailing list.*

*Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.*

(1) Definitions. Definitions as set forth in the Missouri Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule unless the context clearly requires otherwise. Where used, the terms mean a mandatory requirement insofar as approval by the department is concerned unless justification is presented for deviation from the requirements. Other terms, such as should, recommend and preferred, indicate discretionary department requirements. Deviations are subject to individual consideration.

(2) General.

(A) Before work on engineering documents has begun, it is recommended that inquiry be made to the appropriate department office as to what effluent limitations the proposed facility will probably be required to meet. The engineer and applicant should also be aware that if a geological evaluation of the receiving stream or lagoon site is required it will take thirty to forty-five (30–45) days to receive the geological evaluation. In general the final engineering documents will not be reviewed until the other elements of a complete application have been received in accordance with 10 CSR 20-6.010 Construction and Operating Permits. All reports, plans and specifications shall be submitted at least sixty (60) days prior to the date upon which approval of the engineering documents by the department is desired or in accordance with NPDES or other schedules. For unusual or complex projects, it is suggested that the engineer meet with the appropriate department office to discuss the project and that preliminary reports be submitted for review prior to preparation of final plans and specifications.

(B) One (1) set of engineering documents should be submitted for formal approval. It shall include the engineer's report, if required, general layout and detailed plans, specifications and summary of design data. All engineering documents shall be prepared by a registered professional engineer licensed to practice in Missouri and shall bear the imprint of his/her seal and signature. If the engineering documents contain known deviations from the criteria contained in this rule, documentation and justification for the deviation should be submitted with the summary of design data. If stamped, approved copies of plans and specifications are desired, additional copies should be submitted with the original documents along with a letter indicating disposition of the extra set of plans and specifications.

(3) Engineer's Report. An engineer's report shall be submitted whenever required by the department, and for sewage works serving subdivisions or other expansible projects, or for projects which might be connected to a comprehensive system at a future date. The engineer's report referenced in subsections (2)(A) and (B) shall contain the information outlined in this section.

(A) Field Survey. The following items shall be determined and reported:

1. Nature and use of schools, resorts, subdivisions or establishments to be served by the proposed facilities;

2. Population to be served, present and ultimate, and in some cases, the twenty (20)-year population projection;

3. Character and quantity of wastes other than domestic sewage which will be discharged through the system, including present method of garbage disposal and the possibility of future disposal of garbage wastes with sewage. (Note: Method of garbage disposal is critical when designing treatment facilities to serve food service establishments.);

4. Existing sewage treatment facilities;

5. Consideration of the various sites available and the advantages of the one selected. The proximity of the site to buildings or developed areas and the possibilities of flooding of the plant site;

6. The proximity of wells, cisterns, supply lines or other water supply structures in relation to the sewage treatment facilities; and

7. The results of geological evaluations, detailed soils investigations and interpretation of any laboratory soils testing data taken from soil borings.

(B) Analysis of Field Survey Data. Review field findings to determine the best possible solution regarding location, type of treatment and population (present, twenty (20)-year projected and ultimate) to be served.

(C) Recommendations. Include recommendations in detail concerning the proposed treatment works and outline a plan for future extension of the works.

1. Alternate plans. Where two (2) or more solutions exist for a particular problem each of which is feasible and practical, discuss the solutions and the reason for selecting the one (1) recommended.

2. Sewer system. Describe the drainage area and extent to which plans provide sewage facilities for future development.

3. Sewage treatment. Discuss the degree and type of treatment, reasons for adopting the proposed method and the provisions made for future needs.

4. Ownership and operation. State ownership and who will be responsible for the facility. Continuing authorities must be in accordance with 10 CSR 20-6.010(3).

(D) Industrial Wastewater Treatment Facilities. Industrial waste treatment facilities shall be designed based on a thorough evaluation of waste characteristics, waste treatability

site characteristics. The content for engineering reports listed in 10 CSR 20-8.110 and the requirements in this rule should be considered. The engineering reports shall contain a detailed waste description, laboratory analyses and documentation of the treatability and potential environmental pathways for each constituent that may be present in the waste and wastewater. The engineering report shall include a discussion of any applicable effluent guidance documents by the United States Environmental Protection Agency. The engineering report shall also contain documentation as to whether the wastewater stream may be classified as a hazardous waste pursuant to 10 CSR 25-4.261. Industrial flows containing hazardous wastes shall comply with the requirements of the hazardous waste regulation in 10 CSR 25.

(4) General Layout. The general plans for sewage works shall show—

(A) Miscellaneous. A suitable title and the name of the school, resort, subdivision or institution, the scale in feet, a graphical scale, the north point, date, the name of the design engineer and the imprint of the engineer's professional seal. The scale for the plans should not be less than one hundred feet (100') or greater than three hundred (300') to the inch. The lettering and figures on the plans must be of appropriate size and of distinct outline. Datum used should be indicated.

(B) Existing or proposed buildings, roadways, recreation facilities and all water surfaces and streams shall be clearly shown. Contour lines at suitable intervals should be included on the general plan. Elevations should be referenced to United States Geological Survey datum. Elevations in flood plain areas shall be based on United States Geological data. The boundary line of the property or area to be served shall be shown.

(C) Existing Facilities. The location, size, length, slope and direction of flow of all existing sanitary and storm sewers affecting the proposed improvements shall be shown. A plot plan of the existing treatment works indicating the topography and arrangement of existing units shall be shown.

(D) Proposed Facilities. The location of all proposed sewers with size, grade, length and direction of flow shall be indicated. All manholes shall be numbered on the layout and subsequently numbered on the profile. The location of outlets, treatment units, manholes, lampholes, siphons, pumping stations and other accessories shall be shown. Suitable symbols appropriately referenced shall be shown in the title of all these works.

(E) Water Supply and Facilities. The location of all existing and proposed wells, cisterns, reservoirs or other sources of public, semi-public or private water supplies located within five hundred feet (500') of the proposed or existing sewerage works should be shown. The location of all existing or proposed pumps, distribution systems and any other water supply structures should be shown.

(5) Detailed Plans. All detailed plans shall be prepared on blue or white prints and shall be drawn to a suitable scale. Detailed plans for sewage works shall be shown.

(A) Sewers. A plan and profile of all sewers to be constructed shall be provided. Profiles should be on a horizontal scale of one hundred feet (100') to the inch and a vertical scale of ten feet (10') to the inch. Show all known structures above and below ground which might interfere with the construction. The manhole stationing, size of sewers, surface and invert manhole elevations and grade of all sewers between adjacent manholes must be shown on the profile. Construction details of all ordinary sewer appurtenances such as manholes, lampholes and inspection chambers must be shown.

(B) Sewage Pumping Stations. Complete details including elevations and provision for future pumps shall be shown.

(C) Sewage Treatment Works. Complete details including elevations shall be given for all treatment units.

(D) Location Map. The exact location of the project shall be shown on a United States Geologic Survey topographic map or other suitable map which provides the exact location.

(6) Specifications. Complete detailed specifications for the construction of sewers, sewage treatment plant and all appurtenances shall accompany the plans. Continuing authorities as described in 10 CSR 20-6.010 or private engineering firms may file for approval of their standard sanitary sewer construction specifications with this department. A minimum of two (2) copies of the proposed standard specifications shall be submitted. The standard specifications must contain the following:

(A) Certification statement by a registered professional engineer licensed to practice in Missouri including signature, number and date; and

(B) If the engineer preparing the specifications is not a permanent, full-time employee of the continuing authority submitting the specifications, then the governing body of the continuing authority submitting the specifications must also submit a resolution adopting the specifications submitted as the official specifications of the continuing authority. Upon arrival and acceptance of standard specifications for sanitary sewer construction, the department will not require submission of specifications with the plans. However, the department will require that all plans contain a statement that all construction shall be in accordance with the approved standard specifications currently on file with the department. Additional special provisions for a particular project can also be utilized in conjunction with approved standard specifications. The applicant should submit copies of the special provisions properly certified by an engineer. When a revision to approved standard specifications is required by revision of departmental standards or governing continuing authority initiative, three (3) copies of the revision, properly certified and adopted, shall be submitted.

(7) Summary of Design Data. A summary of design data shall accompany the plans and specifications and contain the following:

(A) Flow and waste load projections, including estimated daily flow and types of wastes other than domestic;

(B) Type and size of individual process units along with hydraulic and organic loading to each individual unit. Show process diagrams, including flow diagram with capacities. Show the basic calculations and assumptions used to size each unit;

(C) Basic calculations for detention times in each process unit and the process as a whole. Discuss other considerations such as recycle, chemical additive control, physical control, flexibility and flow metering if applicable;

(D) Expected removals and expected effluent concentration of the permit limited contaminants in the discharge from the treatment facility; and

(E) Design calculations, tabulations and assumptions for the sewer lines and pump stations.

(8) Revisions to Approved Plans. Any deviations from approved plans or specifications affecting capacity, flow or operation of units must be approved in writing before these changes are made. Plans or specifications so revised should therefore be submitted well in advance of any construction work which will be affected by these changes to allow sufficient time for review and approval. Structural revisions or other minor changes not affecting capacities, flow or operation will be permitted during construction without approval. As-built plans clearly showing these alterations shall be placed on file with the department after the completion of the work.

(9) Sewers. Sewers serving subdivisions or other properties which might become incorporated into an existing or proposed comprehensive sewerage system at some future date shall be designed and constructed in accordance with 10 CSR 20-8.120 Design of Sewage Works. Privately-owned systems or collection systems for schools, resorts or establishments of similar nature shall meet the following requirements:

(A) General. In general the department will approve plans for new systems, extensions to new areas or replacement of sanitary sewers only when designed upon the separate plan in which rainwater from roofs, streets and other areas and groundwater from foundation drains and springs are excluded.

1. Design period. Sewers should be designed for the estimated ultimate tributary population.

2. Materials. Any generally accepted material for sewers will be given consideration but the materials selected should be adapted to local conditions, special care being given to possibilities of septicity, excessive external loadings, abrasions, soft foundations and similar problems. All sewer pipes shall be covered by an applicable American Society for Testing and Materials (ASTM) standard. All sewers shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the sewer due to width and depth of trench shall be made. All pipe used shall comply with applicable ASTM standards. Thin-walled drain, waste and vent piping shall not be used for sewers.

3. Joints and infiltration. The method of making joints and the materials used shall be included in the specifications. Materials used in jointing shall have satisfactory records for preventing infiltration and the entrance of roots. Portland cement mortar joints are not acceptable. The amount of leakage under wet weather conditions shall not exceed two hundred (200) gallons per inch diameter per mile of sewer per day.

4. Water and sewer separation. There shall be no permanent physical connection between a potable water supply and any sewer, treatment device or appurtenances thereto which will permit the passage of sewage or contaminated water into the potable water supply. Whenever possible, sewers and manholes should be located at least ten feet (10') horizontally from any existing or proposed water line. Should local conditions prevent a lateral separation of ten feet (10'), a sewer may be laid closer than ten feet (10') from a water main if it is in a separate trench or if it is in the same trench with the waterline located at one (1) side on a bench of undisturbed earth. In either case the elevation of the crown of the sewer must be at least eighteen inches (18") below the invert of the water line. Whenever sewers must cross under water lines and the sewer cannot be buried to meet these requirements, the water line shall be relocated to provide this separation or the sewer line constructed of slip-on or mechanical joint cast iron pipe, asbestos cement pressure pipe or PVC pressure pipe for a distance of ten feet (10') on each side of the water line and be pressure tested to assure watertightness.

5. Sewers in relation to streams. The top of all sewers entering or crossing streams shall be at sufficient depth below the natural bottom of the stream bed to protect the sewer line. The top of the sewer pipe should be a minimum of three feet (3') below the natural stream bottom. Sewers crossing streams should be designed to cross the stream as nearly perpendicular to the stream flow as possible. Sewers entering or crossing streams shall be constructed of cast iron or ductile iron pipe with mechanical joints or shall be constructed so they will remain watertight and free from displacement. In stream beds consisting of loose or unconsolidated materials consideration must be given to the possible impeding effect the sewer line will have on water movement in the bed material. The sewer must be designed to present as little impedance as possible while maintaining structural integrity. Aerial sewer line crossing of streams shall be in accordance with 10 CSR 20-8.120.

(B) Sewer Design. The sewer must have sufficient capacity to carry one hundred gallons (100 gals.) per contributing person per day at the established grade with a peaking factor of four (4). Minimum allowable size of pipe for schools, resorts and similar establishments is six inches (6"). For subdivisions located in rural areas, the minimum allowable sewer size is six inches (6"). For subdivisions in metropolitan areas, or in rural areas adjacent to regional systems where incorporation into a regional system is feasible, the minimum allowable sewer size shall be eight inches (8"). In very small installations four-inch (4") diameter sewers may be used to carry raw sewage or settled sewage. No more than three (3) mobile homes or campsites or a four (4)-unit apartment house may be connected to a four-inch (4") line. The use of a four-inch (4") sewer line should be limited to one hundred fifty feet in length.

1. Depth. The sewer should be sufficiently deep to drain basements. Where cover of less than thirty inches (30") is necessary and justified, the sewer must be protected to prevent its being damaged from superimposed loads or freezing.

2. Velocity of flow. All sewers carrying raw sewage shall be so designed and constructed to give mean velocities when flowing full of not less than two feet (2') per second based on Manning's equation using an "n" value of 0.013. The following are the minimum slopes which should be provided:

| Sewer Size (Raw Sewage) | Slope, feet/100 feet |
|---|---|
| 4 inch | 1.0 |
| 6 inch | 0.60 |
| 8 inch | 0.40 |

| Sewer Size (Settled Sewage) | Slope, feet/100 feet |
|---|---|
| 4 inch | 0.5 |
| 6 inch | 0.3 |
| 8 inch | 0.2 |

3. Bedding. Concrete or well graded granular material (bedding classes A, B or C, as described in ASTM C12-74 or WPCF MOP No. 9) should be used for all rigid pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load. Concrete or well graded granular material (bedding classes I, II or III, as described in ASTM D2321) should be used for all flexible pipe, provided the proper strength pipe is used with the specified bedding to support the anticipated load.

(C) Manholes. Manholes shall be installed at all changes in grade, size or alignment at all intersections and at distances of not greater than four hundred feet (400'). Cleanouts may be installed at the ends of laterals not exceeding one hundred fifty feet (150') in length.

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

2. Diameter. The inside diameter of manholes shall not be less than forty-eight inches (48"). The manhole shall be sufficiently large to permit rodding and other maintenance work. Consideration should be given to larger diameters for shallow manholes under four feet (4'). Cleanouts shall be a minimum of eight inches (8") in diameter.

3. Flow channel. The flow channel through a manhole shall be made to conform in shape and slope to that of the sewer and shall be finished to provide a roughness coefficient as nearly as possible equal to that of

the sewer pipe. Where a bend occurs, the channel shall be curved uniformly from inlet to outlet. Changes in direction of flow should generally not exceed ninety degrees (90°). Where a junction of two (2) or more lines occurs, a separate channel shall be constructed for each incoming line with the channels gradually merging together ahead of the outlet using uniform curves. In general, the invert of any branch sewer should be slightly higher than the invert of the main sewer to avoid slack-water areas where solids may accumulate. The bench on either side of the flow channel should provide a secure footing for maintenance personnel and have enough slope to drain. A slope of one-half to one inch (.5—1.0") per foot is recommended.

4. Watertightness. Manholes shall be of the precast concrete or poured in place concrete type. Inlet and outlet pipes shall be joined to the manhole with a gasketed flexible watertight connection or any watertight connection arrangement that allows differential settlement of the pipe and manhole wall to take place. Watertight manhole covers are to be used wherever the manhole tops may be flooded by street runoff or high water. Locked manhole covers may be desirable in isolated locations where vandalism may be a problem.

5. Frame and cover. The frame and cover shall be of standard design with a minimum clear opening of twenty-two inches (22"). The frame and cover shall be designed as a unit. The cover shall be easily removable with the aid of ordinary hand tools, such as a pry bar. The cover shall be tight fitting and exclude surface water. The joint between the frame and manhole shall be watertight.

(D) Pressure Sewer Systems. A pressure sewer system is considered as two (2) or more individual pressurization units, such as grinder pumps, discharging into a common force main. Pressure sewer systems are not to be used in lieu of conventional gravity sewers but may be acceptable when it can be shown in the engineer's report that it is not feasible to provide conventional gravity sewers. When pressure sewer systems are utilized, the operating authority shall be responsible for the maintenance and operation of the individual pressurization units. When considering the use of a pressure sewer system, the problems of extreme flow variation and anaerobic conditions of the wastewater entering the treatment facility must be taken into consideration. Consideration shall also be given to the possible need for odor control facilities at receiving manholes or at the treatment facility. For pressure sewer systems to function as intended, all clear water from footing drains, basement sumps, leaky house connections and any other sources must be eliminated.

1. Design factors. Pressure sewer systems shall be laid out in a branched or tree configuration to avoid flow-splitting at branches which cannot be accurately predicted. The required pipe size shall be determined on the basis of three (3) principal criteria:

A. Velocities adequate to assure scouring should be achieved. A velocity of two to five feet (2—5') per second must be achieved at least once and preferably several times per day based on design flow.

B. Design shall be for peak sewage flow rates and negligible infiltration. Design shall be based on cumulative flow within the system. Infiltration and inflow must be considered when systems are being designed for existing residences where there is a potential for leaky house connections or leaky septic tanks.

C. Head loss should not exceed the pumping pressure capabilities. Head loss determination should be based on total dynamic head under the maximum flow expected to occur infrequently. It is recommended that a Hazen-Williams coefficient of one hundred twenty (120) be used to determine frictional head loss.

2. System arrangement. All pressure sewer pipe shall be installed at a depth sufficient to protect against freezing and mechanical damage. Attention must be given to the necessity for providing automatic air release valves at changes in slope. Release devices are required when the liquid flow velocity is insufficient to purge bubbles of trapped air. Pressure and/or flow control valves shall be installed at the end of all critical surge pipe runs in order to maintain a full pipe system and eliminate lift station flooding or plant washout. Water/sewer line crossings shall be in accordance with paragraph (9)(A)4. of this section.

3. System pressures. Pressure sewer system operating pressures in general should be in the range of twenty to forty pounds per square inch (20—40 lbs. psi) and shall not exceed sixty pounds per square inch (60 lbs. psi) for any appreciable amount of time. Provisions shall be made in both the system and the grinder pumps to protect against the creation of any long-term high pressure situations.

4. Materials. Many types of pipe materials may be used for pressure sewers. However, maximum benefit from the pressure approach can usually be achieved with nonmetallic materials such as polyethylene, fiberglass reinforced plastic and polyvinyl chloride. As a minimum the piping material should be equivalent to SDR 21 PVC pressure pipe. The small diameter service lines may be required to be constructed of a heavier pipe than SDR 21 PVC pressure pipe. Other materials may be used.

5. Service connections. Building service connections from individual grinder pumps to the collectors should be of one and one-fourth inch (1 1/4") PVC pipe and should include a full-ported valve (such as a corporation stop or "u" valve) located in the service line to isolate the pump from the main. Check valves specifically suited to wastewater service should be provided in the pressure service line before it enters the main.

6. Cleanouts and fittings. In place of manholes normally provided in gravity systems, pressure systems shall have cleanouts at intervals of approximately four hundred to five hundred feet (400—500'), at major changes of direction and where one (1) collector main joins another main. These cleanouts shall include an isolating valve and capped Y-branch fitting located on either side of the isolating valve and pointed both upstream and downstream for access during maintenance procedures.

A. Access for cleaning shall be provided at the upstream end of each main branch.

B. All appurtenances and fittings shall be compatible with the piping system used and shall be full bore with smooth interior surfaces to eliminate obstruction and keep friction loss to a minimum.

7. Pumping equipment. Proper system design and installation shall assure that each grinder pump will be able to adequately discharge into the piping system during all normal flow situations including peak design flow. Combined static, friction and miscellaneous head losses during peak design flows for given paths of flow through the system shall be maintained below the recommended operating head of any unit on the given path. The equipment shall be designed and manufactured with materials appropriate to wastewater service and shall meet all applicable safety, fire and health requirements arising from its intended use in or near residential buildings. Inside installations must be examined for freedom from noise, odors and electrical hazards. Both free-standing and below-the-floor type installations are acceptable. Outside installations shall be provided with an access from the surface which is suitably graded to prevent the entrance of surface water and equipped with a vandal-proof cover for safety. Installation of nonsubmersible grinder/macerator pumps must be protected against entrance of surface water into the electrical portions of the equipment. This

may require that a motor breather be run from the interior of the motor and control compartment to a protected location higher than the maximum anticipated water or snow level. Waterproof factory-installed wiring and tamperproof access covers on wiring compartments are required.

A. The pumps shall have a head capability high enough to operate efficiently over the entire range of conditions anticipated in the system. Normally this will consist of a fixed static head component dependent on pump elevation with respect to the discharge point. The head capacity design point should be not more than eighty-five percent (85%) of the maximum attainable pressure. To insure proper operation, the units must be capable of operating under temporary loads above the normal recommended system design operating pressure without a serious reduction of flow or damage to the motor. The pump should be of flooded-suction design to assure that it will be positively primed. The pressure sewer system shall contain integral protection against back siphonage.

B. The grinder pumps shall operate at a noise level sufficiently low to be acceptable for installation inside a residential building. Generally this should be no louder than other motor-operated devices normally found in homes such as furnace blowers, sump pumps and similar equipment. The grinder pump equipment shall comply with National Electrical Code and applicable local building code requirements.

C. Both stable-curve centrifugal and progressing cavity semipositive displacement pumps may be used in pressure sewer systems. The stable-curve centrifugal, a pump having a maximum head at no flow, may be considered for its ability to compensate with reduced or zero delivery against excessive high pressures and the ability to deliver at a high rate during low flow situations in the system, thus enhancing scouring during low flow periods. The progressing cavity semipositive displacement pump may be considered for its relatively constant rate of delivery in situations in which this feature is considered necessary. The semipositive displacement pump has no significant increases in delivery against low-flow system conditions to enhance scour during minimum flow times.

D. The grinding pumping equipment must include an integral grinder capable of handling any reasonable quantity of foreign objects which customarily find their way into building drainage systems as a result of carelessness or accident on the part of building occupants. The particle size produced by the grinder must be small enough to insure that the processed solids will not clog the grinder, the pump or any part of the discharge piping system. The grinder pump must be capable of processing these foreign objects without jamming, stalling, overloading or undue noise. The grinder shall be of a configuration to provide a positive flow of solids into the grinding zone. Open shafts shall not be exposed in the raw waste passageways since this will cause wrapping of cloth, string etc. around the blades or shaft.

E. The pump tank must be made of corrosion-resistant materials which are suitable for contact with sewage and direct burial below grade without deterioration over the projected lifetime (at least twenty (20) years). The tank shall be of a fifty (50)-gallon minimum capacity and be able to accommodate normal peak flows without exceeding its peak flow capacity. The volume between the on and off levels in the tank should be based on a sensible compromise between excessive unit operation and efficient removal of raw sewage into the system. In areas in which the groundwater table is high, tanks should be securely anchored to avoid floating. The geometry of the tank bottom and the pump suction currents generated when the grinder pump is in operation must be adequate to scour solids from the bottom of the tank so that there is no significant long-term accumulation of settleable solids on the tank bottom. The tank shall be vented so that air space above the wastewater is always at atmospheric pressure. Separate vents shall be provided if required by local codes but normally the fill piping connected to the building drain system will provide adequate venting. The tank shall be capable of accommodating connection to all normal building drainage piping systems. This would include three (3) and four (4)-inch sizes of PVC, cast iron, copper, vitreous clay and asbestos-cement pipe. The pump tank shall be furnished with integral level controls which reliably turn the pump on and off at appropriate and predictable levels. The level control shall be as trouble-free as possible with little care required for proper calibration. Mercury control, float type or pressure-type switches are acceptable. An alarm unit, visible or audible, shall be provided to indicate pump failure.

8. Power outages. Provisions must be made for periods of power failure. Alternatives are as follows:

A. Depend upon built-in storage of tank and associated gravity piping;

B. Provide additional storage capacity where power outages occur frequently (twenty-four (24)-hour storage capacity is recommended); or

C. Provide a mobile generator or pump to connect to each household for a short term during an extended outage.

9. Service. A twenty-four (24)-hour repair time either by replacement or repair must be assured. Spare grinder pump units should be stocked according to the following:

| Installations | Spare Unit(s) |
|---|---|
| 1—10 | 1 |
| 10—20 | 2 |
| 20—40 | 3 |
| 40—60 | 4 |
| 60—100 | 5 |
| 100—200 | 6 |
| over 200 | 3% of installations |

10. Instruction manuals. The equipment must be furnished complete with detailed wiring diagrams, suggested piping installations and detailed instructions for use by the contractor at the time of installation.

11. Construction factors. Granular bedding should be provided at least four inches (4") deep but not less than one (1) pipe diameter. The bedding should be smoothed prior to pipe installation. The excavation should be backfilled to a depth of eighteen inches (18") above the pipe with select backfill material. The bedding shall contain no rock greater than one inch (1") in diameter. Native materials may be used for the remainder of the backfill. Thrust blocks must be placed on all lines two inches (2") and larger at intersections and changes of direction of forty-five degrees (45°) or more.

12. Termination of force mains. Force mains and pressure trunks shall terminate in manholes using the following construction procedures:

A. The discharge shall be to the bottom of the manhole in line with the flow if possible;

B. Where piping must be installed to bring the discharge to the bottom of the manhole, the pipe shall be adequately braced to prevent movement, shall be vented on the top and shall allow access to the force main for cleaning purposes; and

C. Consideration shall be given for the possible need for odor control facilities at the termination of force mains and pressure sewer trunks.

13. Testing. Pressure tests shall be made only after the completion of backfilling operations and after the concrete thrust blocks have set for at least thirty-six (36) hours.

A. The duration of pressure tests shall be a minimum of one (1) hour unless otherwise directed by the engineer. Test pressure shall be fifty pounds per square inch (50 lbs. psi) minimum with a recommended pressure of two and one-half (2 1/2) times the maximum system operating pressure. All tests are to be conducted under the supervision of the engineer.

B. The pipe line shall be slowly filled with water. The specified pressure measured at the lowest point of elevation shall be applied by means of a pump connected to the pipe in a manner satisfactory to the engineer.

C. During filling of the pipe and before applying the specified pressure, all air shall be expelled from the pipeline by making taps at the point of highest elevation. After completion of the test the taps shall be tightly plugged at the main.

14. Septic tank effluent pump (STEP) systems. Septic tank effluent pump pressure sewer systems may be considered a similar application of the pressure sewer principle and the criteria contained in this rule may be used for these systems. Deviations from the criteria in this section when designing STEP systems will be judged on a case-by-case basis using substantiating information and material submitted with the design by the consulting engineer.

(10) Sewage Pumping Stations. Pumping stations serving subdivisions or other properties which might become incorporated into an existing or proposed comprehensive sewerage system at some future date shall be designed and constructed in accordance with 10 CSR 20-8.130 Sewage Pumping Stations.

(A) General. Every effort should be made to eliminate the necessity of pumping sewage in installations of the type covered in this rule.

1. Location. Sewage pumping stations should be located above the twenty-five (25)-year flood level and shall be readily accessible for maintenance. As a minimum, an unobstructed all-weather access road should be provided to the pump station.

2. Water supply protection. There shall be no physical interconnection between any potable water supply and a sewage pumping station or any of its components which under any conditions might cause contamination of a potable water supply. Sewage pumping stations shall be located at least one hundred feet (100') and preferably three hundred feet (300') from any potable water supply well.

3. Duplicate pumps required. At least two (2) pumps or pneumatic ejectors shall be provided. Each pump shall be capable of handling the design and maximum flows so that each unit is a duplicate of the other. The pump installation shall be designed to handle as a maximum flow four (4) times the average daily flow. Single pump installations may be given consideration only for very small installations, where average daily flows are less than fifteen hundred (1500) gallons per day, and only if the station is designed to permit the installation of a future duplicate unit without structural change and satisfactory means are provided to detect malfunctions and take corrective actions before an overflow to waters of the state could occur.

(B) Design Considerations. All pumps except suction-lift types shall be placed so that under normal operating conditions they will operate under a positive suction head. Design of the sewage pumping stations shall consider the following:

1. Types of pumps. Sewage pumping units may be categorized as follows: submersible pumps, pneumatic ejectors, vertical pumps and suction-lift pumps.

A. Submersible pumps shall be readily removable and replaceable without dewatering the wet well and with continuity of operation of the other unit(s) maintained. Both standard and cutter/grinder pumps are acceptable. Submersible pump installations shall be equipped with check and shutoff valves on each discharge line located in a box outside of the wet well.

B. Pneumatic ejector station structures constructed of metal shall be coated with an acceptable corrosion-resistant material and shall be supplied with two (2) properly sized anodes for cathodic protection to be buried on opposite sides of the structure and securely connected to the structure by heavy copper or aluminum wire. The air storage chamber and sewage receiving chamber (wet well) shall be capable of withstanding one hundred fifty percent (150%) of the design working pressure.

C. Suction-lift pumps shall be of the self-priming type as demonstrated by a reliable record of satisfactory operation. The total suction lift should not exceed fifteen feet (15');

2. Pump openings. Pumps shall be capable of passing a two and one-half inch (2 1/2") sphere when pumping raw sewage. These pumps shall have suction and discharge openings of at least three inches (3") in diameter. Pumps handling settled sewage need not necessarily meet these requirements depending upon the outflow design from the settling device. If cutter/grinder pumps are used, the previously mentioned requirements may be modified;

3. Accessibility. Adequate openings and facilities to permit maintenance, cleaning and removal of pumps and equipment shall be provided;

4. Protection of motors. Pump motors shall be so located to prevent damage by flooding or corrosion or otherwise satisfactorily protected from this damage;

5. Ventilation. Adequate ventilation shall be provided in all pump stations. Where the pump pit is below the ground surface, mechanical ventilation providing at least twelve (12) complete air changes per hour shall be provided. Portable ventilation equipment should be available when entrance to the wet well is required;

6. Wet wells. The wet well size and control setting shall be appropriate to avoid heat buildup in the pump motor due to frequent starting and to avoid septic conditions due to excessive detention time. The floor of the wet well shall have a minimum slope of one to one (1:1) to a hopper bottom. The horizontal area of the hopper bottom shall not be greater than necessary for proper installation and function of the inlet. The high water level in the wet well during normal operation shall be at least one foot (1') below the invert of the incoming sewer;

7. Controls. Control float bulbs, tubes, wires etc. should be located as not to be unduly affected by flows entering the wet well or by the turbulence created by the suction of the pumps. In stations with duplicate units, provision of automatic alternation of pump use shall be provided. Electrical equipment in enclosed places where hazardous gases may accumulate shall comply with the National Electrical Code for Class I Group D Division 1 locations;

8. Valves. Suitable shut-off valves shall be placed on the suction line of each pump except on submersible or suction-lift pumps. Suitable shut-off and check valves shall be placed on the discharge line of each pump. The check valve shall be located between the shut-off valve and the pump. Check valves shall not be placed on the vertical portion of discharge piping. No valves may be located in the wet well;

9. Overflows. Sewage pumping stations shall be designed to prevent bypassing of raw sewage to waters of the state and to prevent backups of sewage into buildings or property served by the sewerage system. A satisfactory method shall be provided to prevent or treat overflows. If a less preferred method is proposed, justification shall be provided for its choice. The following examples of some of the methods which will be considered are listed in order of their preference:

A. A holding basin with capacity for twenty-four (24)-hour retention of peak flows unless data justifies the use of a smaller

basin. The basin must be designed to drain back into the wet well or collection system as the influent flow recedes;

B. A portable pump capable of being connected to the pumping station or a portable generator; or

C. Storage of excess flow in trunk line sewers provided sufficient capacity for twenty-four (24)-hour storage of peak flows is available and flooding of basements will not occur; and

10. Alarm systems. Alarm systems shall be provided for all pumping stations. The alarm shall be activated in cases of power failure, pump failure or any cause of high water in the wet well. If possible, the alarm should be telemetered to a location that is manned twenty-four (24) hours per day. Audio-visual alarms with self-contained power supply shall be provided as a minimum. A sign shall be posted at each pump station in a clearly visible location, listing a telephone number to be called if the alarm is seen or heard; and

11. 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 spare parts as may be necessary.

(C) Force Mains. Design considerations for force mains are as follows:

1. Velocity. At design average flow, a cleansing velocity of at least two feet (2') per second shall be maintained;

2. Size. In general, three-inch (3") diameter pipe shall be the smallest used for raw sewage force mains. However, use of grinder pumps or similar equipment may allow use of smaller pipe. These instances will be reviewed on an individual basis. Piping materials may be pressure pipe normally used for conveying potable water, however the effects of surges and pressures within the system should be considered in the selection of the piping material. As a minimum SDR 21 PVC pressure pipe or its equivalent should be used. The force main and fittings including reaction blocking shall be designed to withstand normal pressure and pressure surges (water hammer);

3. Air relief valves. An automatic air relief valve shall be placed at high points in the force main to prevent air locking. However, consideration will be given to alternate proposals with proper substantiation;

4. Termination. Force mains should enter the gravity sewer system at a point no more than two feet (2') above the flow line of the receiving manhole; and

5. Water line and sewage force main separation. There shall be at least a ten-foot (10') horizontal separation between water lines and sewage force mains. There shall be an eighteen-inch (18") vertical separation at crossings as required in paragraph (9)(A)4. of this rule. Only in extenuating circumstances will deviations be allowed to these minimum separation distances.

(11) Small Wastewater Treatment Works. Treatment the extent of which will depend on 10 CSR 20-7.015 Effluent Regulations and 10 CSR 20-7.031 Water Quality Standards shall be provided in connection with all installations. Secondary treatment shall be the minimum acceptable degree of treatment. Wastewater treatment plants should be designed to provide for the estimated population and flows to be fifteen (15) or twenty (20) years hence. The following items shall be taken into consideration in planning sewage treatment works:

(A) Plant Location. In general to avoid local objections, the wastewater treatment facilities should be located as far as is practical from any present built-up area or any area which will develop within a reasonable future period. No sewage treatment facility shall be located closer than fifty feet (50') to any dwelling or establishment.

1. The treatment facility shall be located above the twenty-five (25)-year flood level.

2. An all-weather access road shall be provided from a public right-of-way to every treatment facility. Sufficient room shall be provided at the site to permit turning vehicles around. In determining the type of roadway and method of construction, consideration shall be given to the types of vehicles and equipment necessary to maintain and operate the facility. If access is required for heavy sludge trucks, the road must be of more substantial construction than one (1) used only for access of mowing equipment or other light vehicles. Gravel roads to be used by heavy vehicles shall have a minimum depth of six inches (6") of crushed rock material with a bottom layer of four inches (4") of two to three inch (2–3") size material and a top layer two inches (2") thick of three-fourths inch (3/4") size material. In general, the grade of the access road shall not exceed twelve percent (12%).

3. Wastewater treatment facilities shall not be located within one hundred feet (100'), and preferably three hundred feet (300') of any well or water supply structure;

(B) Design.

1. Type of treatment. Careful consideration should be given to the type of treatment before making a final decision. A few of the important factors to consider are the location and topography of the plant site; character and quantity of the wastes to be treated; operating costs and the probable type of supervision and maintenance the plant will receive. Particular care must be used in choosing methods of treatment for seasonal use developments, such as parks and campgrounds, and for developments which produce waste loads which fluctuate between wide extremes from day-to-day. The use of activated sludge type plants is generally not recommended for these developments because a high degree of operating efficiency for these plants is dependent in part upon a relatively stable loading condition. Where all use of the development is confined to a specific season, consideration should be given to designing lagoon systems on the draw-and-fill concept, retaining all wastewaters generated during the season of use and discharging them after an appropriate period during the off season or utilizing the stored water for irrigation.

2. New processes, methods and equipment. The policy of the department is to encourage rather than obstruct the development of new methods and equipment for the treatment of sewage wastes. The lack of inclusion in these standards of some types of wastewater treatment processes or equipment should not be construed as precluding their use. The department may approve other types of wastewater treatment processes or equipment under the following conditions:

A. The operational reliability and effectiveness of the process or device shall have been demonstrated with a suitably sized prototype unit operating at its design load conditions to the extent required by the department; and

B. The department may require test results and engineering evaluations demonstrating the efficiency of the processes or equipment. The department may also require that appropriate testing be conducted and evaluations, other than those employed by the manufacturer or developer, be made under the supervision of a competent process engineer.

3. Sewage flow and strength. Minimum design loadings for all treatment processes shall be calculated using the following table unless the engineer can document the validity of lower per capita figures based on actual waste strength and/or flow data from the development to be served or from similar developments.

**Table I**

| Type of Establishment | Pounds BOD per person (unless otherwise noted) | Gallons per day per person* |
|---|---|---|
| Employee Sanitary Waste | .05 | 15 |

Generally means eight (8)-hour shift employees at institutions, commercial establishments, factories and similar establishments. Total employee waste figure, if applicable, must be added to the appropriate patron or residential total from the following table:

| Residential | | |
|---|---|---|
| Single family dwellings | .17 | 75—100 |
| Apartments or condominiums | .17 | 60—100 |
| Rooming houses | .15 | 45 |
| Boarding houses | .17 | 75 |
| Mobile homes | .17 | 75—100 |

| Food or Drink Establishments (wastes per patron) | | |
|---|---|---|
| Tavern or bar (not serving food) | .01 | 2 |
| Fast-food (paper service) | .02 | 3 |
| Cafe or restaurant | .03 | 5 |
| Restaurant serving alcoholic beverages | .04 | 5 |
| Restaurant grinding garbage | .07 | 6 |

| Schools (wastes per student) | | |
|---|---|---|
| Day school, no cafeteria, gym or showers | .02 | 10 |
| With cafeteria—ADD | .02 | 4 |
| With garbage grinding—ADD | .02 | 1 |
| With gym and showers—ADD | .01 | 10 |
| Boarding schools | .17 | 75 |

| Institutions | | |
|---|---|---|
| Hospitals (per bed) | .22 | 125—200 |
| Institutions other than hospitals | .17 | 100—150 |
| Nursing homes | .17 | 100—125 |

| Commercial and Recreational | | |
|---|---|---|
| Public parks (toilets only) | .02 | 5 |
| Public parks with bath house, showers, toilets | .06 | 15—25 |
| Swimming pools and beaches | .06 | 15—25 |
| Country clubs (per resident member) | .17 | 75—100 |
| Country clubs (per member present) | .06 | 15—25 |
| Service stations (wastes per customer) | .01 | 5 |
| Laundromats (per machine) | 1.25 | 580 |
| Hotels | .15 | 50 |
| Motels (without restaurants) | .10 | 40 |
| Luxury resorts | .17 | 75 |
| Camper trailers | .08 | 30 |
| Work or construction camps | .15 | 60 |
| Churches (per seat) | .01 | 5 |
| Stores, malls or shopping centers (per one thousand (1000) square feet of floor area) | .34 | 200 |
| Stadiums, auditoriums, theaters or drive-in (per seat) | .01 | 5 |

*Note: Gallons per person per day includes normal infiltration for residential systems.

4. Population to be served. Unless satisfactory justification can be given for using lower per-unit occupancies, the following numbers shall be used in determining the population for which to design the sewage works:

| | Persons/ Unit |
|---|---|
| Residences | 3.7 |
| Apartments or condominiums | |
| (1 bedroom) | 2.0 |
| (2 bedroom) | 3.0 |
| (3 bedroom) | 3.7 |
| Mobile homes | 3.0—3.7 |
| Camper trailers without sewer hookup | 2.5 |
| Camper trailers with sewer hookup | 3.0 |
| Motels | 3.0 |

5. Organic loading. Where sewage strengths are expected to be materially greater than normal domestic sewage (three hundred milligrams per liter (300 mg/l) biochemical oxygen demand), consideration shall be given to enlarging settling, digestion and secondary treatment units.

6. Conduits. All piping and channels should be designed to carry the maximum expected flows. The incoming sewer should be designed for free discharge. Pockets, corners and channels where solids can accumulate should be eliminated. Suitable gates should be placed in channels to seal off unused sections which might accumulate solids. Shear gates or stop-planks should be used in preference to gate valves or sluice gates.

7. Arrangement of units. Component parts of the facility should be arranged for greatest operating convenience, flexibility, economy and so as to facilitate installation of future units.

(C) Facility Details.

1. Mechanical equipment. Mechanical equipment shall be used and installed in accordance with manufacturers' recommendations and specifications. Major mechanical units should be installed under the supervision of the manufacturers' representative.

2. Emergency operation. Facilities which enable removal of treatment units from service for cleaning, maintenance or mechanical breakdown without bypassing must be provided.

3. Drains. Means should be provided to dewater each unit. Pumping with portable pumps into a holding basin or other suitable disposal site will be considered a satisfactory means of dewatering. Due consideration shall be given to the possible need for hydrostatic pressure relief devices to prevent flotation of structures.

4. Construction materials. Due consideration should be given to the use of construction materials which are resistant to the action of hydrogen sulfide and other corrosive gases, greases, oils and similar constituents frequently present in sewage.

5. Operating equipment. Specifications should include a complete outfit of tools necessary for proper maintenance of the facility. If required by the department, an operation and maintenance manual shall be provided to explain the operating procedures at a level easily understood by the owner or operator of the facility. The manual, at a minimum, shall address maintenance of mechanical equipment, monitoring, recordkeeping and operating procedures including the amount, frequency and method of sludge disposal.

6. Grading and landscaping. Upon completion of the facility, the ground should be graded to prevent erosion and the entrance of surface water into any unit.

7. Treatment facilities outfalls. The outfall sewer shall be designed to discharge to the receiving stream in a manner acceptable to the department. In general the effluent from the final treatment process shall be conveyed to a defined stream channel via a closed pipe or a paved or rip-rapped open channel. Sheet or meandering drainage is not acceptable. The outfall sewer shall be so constructed and protected against the effects of floodwater, ice or other hazards as to reasonably insure its structural stability and freedom from stoppage. All outfalls shall be designed so that a sample of the effluent can be obtained at a point after the final treatment process and before discharge to or mixing with the receiving waters.

8. Potable water supply protection. No piping or other connections shall exist in any part of the treatment works which, under any conditions, might cause the contamination of a potable water supply. Potable water from a municipal or other supply may be used above grade for water closet, lavatory, drinking fountain or similar fixtures. A reduced pressure backflow preventer or break tank shall be used to isolate the potable system from all plant uses other than the ones provided for in this rule. Where a break tank is used, water shall be discharged to the break tank through an air-gap at least six inches (6") above the maximum flood line, ground level or the spill line of the tank, whichever is higher. Backflow preventers shall be located above the maximum flood line or ground level. A sign shall be permanently posted at every hose bib, faucet, hydrant or sill cock located on the water system beyond the break tank or backflow preventer to indicate that the water is not safe for drinking. Where a separate nonpotable water system is to be provided, backflow prevention will not be necessary but all system outlets shall be posted with a permanent sign indicating that the water is not safe for drinking.

9. Sewage flow measurement. Flow measurement shall be provided for all wastewater treatment facilities. Flow measurement should not be less than pump calibration time clocks or calibrated flume or weir and stilling basins as required.

10. Protection from the elements. All sewage treatment facilities except those which operate only seasonally shall be designed to assure effective operation under all weather conditions. Protection from the elements must be given special consideration since small wastewater treatment facilities will frequently be located in remote areas and may not receive daily attention. Freezing temperatures affect most treatment facilities to some degree. Open sand filters and small extended aeration plants are likely to be affected the most. Provisions for covering exposed process areas with boards or insulating panels may be sufficient in many cases. The use of heat tapes around sludge and scum return piping may be helpful in addition to covering the tanks. Sufficient electrical outlets should be provided at the plant site for this purpose. Tanks which are not completely backfilled on all sides may require additional protective measures during freezing weather. Any such measures taken to comply with these provisions shall not present a hazard to the operator nor hinder the operation of the treatment facility.

11. Safety. Adequate provisions should be made to protect the operator and any visitors from unnecessary hazards.

A. All wastewater treatment facilities must be fenced sufficiently to restrict entry by children, livestock and unauthorized persons as well as to protect the facility from vandalism.

B. Fences shall be a minimum of five feet (5') in height and shall be constructed of durable materials appropriate to the site and nature of the treatment facilities. Posts shall be imbedded to a sufficient depth or otherwise securely anchored to prevent displacement and shall not be spaced more than twenty feet (20') apart. Barbed wire, woven wire fabric or chain link mesh shall be securely fastened to the posts with fasteners designed for the type of material used.

C. Fences shall be located far enough back from all process units to permit easy access for operation and maintenance and for access of mowing equipment, sludge trucks and similar equipment. A minimum four foot (4') clearance from all units is recommended.

D. Woven wire fabric will generally be acceptable for fencing lagoons and other small facilities having a minimum of mechanical equipment. The fabric should nearly touch the ground surface and should have small enough mesh in the lower two feet (2') to prevent passage of small animals. Larger and more complex treatment facilities should be provided with chain link or similar fencing.

E. At least two (2) strands of barbed wire shall be provided above the fence fabric spaced no more than six inches (6") apart.

F. At least one (1) gate shall be provided for access of maintenance equipment and vehicles and each gate shall be provided with a lock. Gates shall be constructed in a manner and of materials comparable to those used for the fence. Gates shall be designed to prohibit entry of the enclosure by crawling underneath. When sizing the gate, consideration must be given to the need for entry of mowing equipment, sludge trucks or other vehicles or equipment necessary for routine maintenance and operation.

G. At least one (1) warning sign shall be placed on each side of the facility enclosure in such positions as to be clearly visible from all directions of approach. A sign shall be placed on each gate. Minimum wording shall be SEWAGE TREATMENT FACILITY—KEEP OUT. Signs shall be made of durable materials with characters at least two inches (2") high and shall be securely fastened to the fence, equipment or other suitable locations.

(12) Primary Treatment. For general requirements applicable to all types of treatment facilities, refer to section (11) of this rule.

(A) Grease Traps. Grease traps shall be provided on kitchen drain lines from institutions, hotels, restaurants, school lunch rooms and other establishments from which relatively large amounts of grease may be discharged to the treatment facility.

1. Grease traps should be located as close to the fixtures being served as possible and should receive only the waste streams from grease-producing fixtures. Sanitary waste streams, garbage grinder waste streams and other waste streams which do not include grease should be excluded from passing through the grease traps. Grease traps must be cleaned on a regular basis and must be readily accessible for this purpose.

2. Sizing of grease traps is based on wastewater flow and can be calculated from the number and kind of sinks and fixtures discharging to the trap. In addition, a grease trap should be rated on its grease retention capacity, which is the amount of grease (in pounds) that the trap can hold before its average efficiency drops below ninety percent (90%). Current practice is that grease-retention capacity in pounds should equal at least twice the flow capacity in gallons per minute. The following two (2) equations may be used to determine the capacity of grease traps for restaurants and other types of commercial facilities:

A. Restaurants.

$$D \times Gl \times Sc \times \frac{Hr}{2} \times Lf = \text{Size of grease trap in gallons, where:}$$

D = Number of seats in dining area;
Gl = Gallons of wastewater per meal, normally 5 gallons;
Sc = Storage capacity factor, minimum of 1.7;
Hr = Number of hours open; and
Lf = Loading factor,

1.25 interstate highways
1.0 other freeways
1.0 recreational areas
0.8 main highways
0.5 other highways.

B. Hospitals, nursing homes, other type commercial kitchens with varied seating capacity.

$$M \times Gl \times Sc \times 2.5 \times Lf = \text{Size of grease trapin gallons, where:}$$

M = Meals per day;
Gl = Gallons of wastewater per meal, normally 4.5;
Sc = Storage capacity factor, minimum of 1.7; and

Lf = Loading factor,
1.25 garbage disposal and dishwashing
1.0 without garbage disposal
0.75 without dishwashing
0.5 without dishwashing and garbage disposal.

3. Grease traps shall be provided with a manhole or opening of sufficient size to permit inspection and cleaning. When the grease trap is located below ground, the access opening shall be extended to grade. The opening shall be fitted with a tight fitting cover which will prevent the entrance of insects and vermin.

4. The grease trap should be constructed of materials similar to septic tanks and be properly baffled on both the inlet and outlet.

(B) Bar Screens. Bar screens should be provided before pumps, shredders or other mechanical equipment. Bar screens should precede imhoff tanks, primary settling basins and extended aeration plants.

1. Bar screens should be located to provide for easy cleaning and adequate drainage of screenings. Design must provide for removal and/or cleaning of bar screens or debris baskets located inside pump station wet wells without entering the wet well.

2. The invert of a bar screen channel or the bottom of a debris basket shall be a minimum of six inches (6") below the invert of the incoming sewer and a minimum of six inches (6") above the highest liquid level in the pump pit or treatment process tank. The channel preceding and following the screen should be filleted to prevent stranding and sedimentation of solids.

3. Clear openings between bars of hand cleaned screens should be from three-fourths to one and one-half inches (3/4–1 1/2"). Construction should be such that the screens can be conveniently raked.

4. The area of the screen openings should be sufficient to provide a velocity of one foot (1') per second through the vertical projection of the screen openings at average flow.

5. Hand cleaned screens should be placed on a slope of thirty to forty degrees (30–40°) with the horizontal.

6. Ample facilities must be provided for the removal, draining and deposit of screenings. Suitable storage facilities shall be provided where temporary storage of screenings is necessary. Screenings may be disposed of in an approved solid waste disposal facility.

(C) Septic Tanks. Septic tanks may be accepted as a satisfactory means of primary treatment for installations receiving flows not in excess of twenty-two thousand five hundred (22,500) gallons per day. Minimum acceptable liquid capacity for septic tanks shall be seven hundred fifty (750) gallons. Septic tanks should be designed and constructed in accordance with 10 CSR 20-8.021(4).

(D) Comminutors. Comminutors may be used in conjunction with bar screens as a means of preliminary treatment upstream of extended aeration plants. A screened bypass channel to a bar screen shall be provided. The use of the bypass channel shall be automatic at depths of flow exceeding the design capacity for the comminutor. Each comminutor that is not preceded by grit removal equipment should be protected by a six-inch (6") deep gravel trap. Provisions shall be made to facilitate servicing units in place and removing units from their location for servicing. Electrical equipment in comminutor chambers where hazardous gases may accumulate shall be suitable for hazardous locations (National Electrical Code, Class 1, Group D, Division 1 location). Grinder pumps may be used in lieu of comminutors. Grinder pumps used for preliminary treatment must be sized to pump the maximum flow unless they are being used as part of flow equalization.

(13) Secondary Treatment. Criteria for design of secondary treatment processes are given for the most commonly used and recognized waste treatment processes applicable for small sewage treatment facilities. They include waste stabilization and aerated ponds, sand filters, extended aeration activated sludge and disinfection. Unit processes not covered by these criteria will be reviewed in accordance with paragraph (11)(B)2. The effluent quality that may be expected from a secondary treatment unit process or combination of processes is related not only to the engineering design but, most important, to the level of operation and maintenance that the units receive. The design criteria established in the rule for the various units are to reflect those features considered necessary for the unit to perform at its best efficiency, to ensure ease in operation and maintenance and to guide designers in selecting materials which will ensure the completed project will be durable. For other requirements applicable to all types of treatment facilities, refer to section (11).

(A) Wastewater Stabilization Ponds. Waste stabilization ponds provide treatment of primarily domestic wastewater by the unaided natural processes of biological activity. The wastewater stabilization pond process requires the least operational and maintenance skill of all processes considered in this rule. The criteria contained in this rule is for facultative and aerated facultative ponds.

1. The summary of design data shall include pertinent information on location, geology, soil conditions, area for expansion and any other factors that will affect the feasibility and acceptability of the proposed project. The following information must be submitted in addition to that required by sections (4) and (7):

A. A layout showing the direction and distance of all cultural features within one fourth (1/4) mile of the proposed site. A seven and one-half (7.5) minute quadrangle map made by the United States Geological Survey of the area under consideration is acceptable, provided the map is field checked for accuracy in depicting present cultural features;

B. A geological evaluation of the proposed pond site prepared by the Missouri Department of Natural Resources, Division of Geology and Land Survey shall be submitted. To obtain this geological evaluation of the proposed site, the engineer shall submit the following information to the appropriate department office:

(I) A layout sheet showing the proposed location. The layout shall include the legal description, property boundaries, roads, streams and other geographical landmarks which will assist in locating the site;

(II) Size of the pond and/or approximate volume of waste to be treated;

(III) Maximum cuts to be made in the construction of the pond; and

(IV) Location and depth of cut for borrow area, if any;

C. A determination as to the compatibility of the proposed site with local zoning ordinances.

D. A description, including maps, showing elevations and contours of the site and adjacent area shall be provided;

E. Location of ponds in watersheds receiving significant amounts of stormwater runoff is discouraged. Adequate provisions must be made to divert stormwater runoff around the ponds and protect embankments from erosion;

F. Construction of ponds in close proximity to water supplies and other facilities subject to contamination should be avoided. A minimum separation of four feet (4') between the bottom of the pond and the maximum groundwater elevation should be maintained where feasible. The four-foot (4') separation distance does not necessarily apply to perched water tables due to impervious strata near the surface;

G. Proximity of ponds to water supplies located in areas of porous soils and fissured rock formation shall be evaluated to

avoid creation of health hazards or other undesirable conditions; and

H. In general, to avoid local objections, the wastewater stabilization pond should be located as far as is practical from any existing built-up areas or existing dwellings. In no case should the pond be located closer than two hundred feet (200') from an existing built-up area or existing dwelling. The pond should be located at least one hundred feet (100') from the building(s) that it serves.

2. Basis for design. A flow-through stabilization pond shall be considered capable of meeting effluent limitations of forty-five (45) mg/l BOD and seventy (70) mg/l suspended solids. Controlled discharge stabilization ponds shall be considered capable of producing an effluent of a quality that is much better than a flow-through stabilization pond when treating normal domestic type sewage.

A. In general, waste stabilization ponds shall be designed on the basis of thirty-four pounds (34 lbs) of applied BOD per day per acre of water surface area in the primary cell. Water surface area shall be computed as area at the three foot (3') operating level. A minimum of one hundred twenty (120) days' detention time should be provided in the total system. To achieve this detention time the use of secondary cells up to five feet (5') deep and the use of third cells up to eight feet (8') deep may be necessary.

B. For aerated wastewater stabilization ponds, the development of final design parameters, it is recommended that actual experimental data be developed. However, the aerated lagoon design for minimum detention time may be estimated using the following formula:

$$t = \frac{E}{2.3\ k_1 \times (100 - E)}$$

where

t = detention time in the aeration cell in days;

E = percent of $BOD_5$ to be removed in an aerated pond; and

k1 = reaction coefficient aerated pond, base 10.

For normal domestic sewage, the $k_1$ value may be assumed to be 0.12 at a temperature of twenty degrees Centigrade (20°C) and 0.06 at a temperature of one degree Centigrade (1°C). A temperature of one degree Centigrade (1°C) must be used for determining the detention time. Other $k_1$ values may be used to determine detention time when pilot test data is obtained by incubating anticipated wastes at critical operating temperatures. A temperature of twenty degrees Centigrade (20°C) may be used for determining aeration requirements. As a minimum, aerated facultative pond systems designed to treat a typical domestic waste (BOD≤300 milligrams per liter) shall consist of one (1) or more aerated cells and one (1) quiescent cell which provide the following minimum hydraulic detention times:

**Minimum Detention Times for Aerated Pond Cells for Typical Domestic Waste (BOD ≤300 mg/l)**

| *No. of Aerated Cells | Days** for Treatment | Quiescent Cell, Days | Total Detention*** Time, Days |
|---|---|---|---|
| 1 | 44 | 2-10 | 46-54 |
| 2 | 26 | 2-10 | 28-36 |
| 3 | 21 | 2-10 | 23-31 |

*For multiple aerated cells, the first two (2) cells shall be of equal size and no one (1) cell shall provide more than fifty percent (50%) of the total required volume.

**Includes three (3) days' detention time for sludge accumulation. Sludge volume is based upon 1.54 days detention time per one hundred milligrams per liter (100 mg/l) of suspended solids in the influent for a twenty (20)-year accumulation of sludge.

***Total detention time for all cells combined.

(I) The design minimum detention time of aerated cells treating domestic type waste of greater strength than three hundred (300) mg/l BOD should be determined utilizing the equation from subparagraph (13)(A)2.B. on a per-cell basis. For aerated facultative pond systems designed to treat greater strength waste with a BOD of four hundred (400) mg/l or more shall consist of two (2) or more aerated cells and one (1) quiescent cell. The first two (2) cells shall be of equal size and no one (1) cell shall provide more than fifty percent (50%) of the total required volume. The following minimum detention times are presented for illustration and result from use of the formula from subparagraph (13)(A)2.B. with provision of additional volume for sludge accumulation.

**Minimum Detention Times for Aerated Pond Cells for Greater Strength Waste**

| Influent BOD mg/l | No. of Aerated Cells | Days for Treatment | Quiescent Cell, Days | Total Detention* Time, Days |
|---|---|---|---|---|
| 400 | 2 | 46 | 2—10 | 48—56 |
| 400 | 3 | 37 | 2—10 | 39—47 |
| 400 | 4 | 32 | 2—10 | 34—42 |
| 1000 | 2 | 87 | 2—10 | 89—97 |
| 1000 | 3 | 67 | 2—10 | 69—77 |
| 1000 | 4 | 58 | 2—10 | 60—68 |

*Total detention time for all cells combined.

C. Where any wastes discharged to a stabilization pond are from a restaurant, institutional kitchen or similar establishment likely to produce large amounts of grease, grease traps shall be provided as discussed in subsection (12)(A) of this rule. If ground garbage is also introduced to the waste stream from these sources, a septic tank having a capacity equal to at least five (5) times the average daily flow of that waste stream shall be provided for primary treatment preceding unaerated pond systems. Septic tanks sized at one and one-half (1.5) times the average may be provided as primary treatment for other waste streams. No reduction in BOD applied to the stabilization pond shall be allowed where the only pretreatment is grease removal. Where complete primary treatment is provided for any waste stream entering the pond system, the BOD loading of that stream may be reduced by thirty-five percent (35%) when determining the required pond system surface area or detention time.

D. Consideration shall be given to the type and effect of industrial wastes contributed to the stabilization pond system. For high strength wastes where the required detention time exceeds nine (9) months for an unaerated stabilization pond, consideration should be given to other processes such as aerated ponds, land application of the effluent or activated sludge treatment plants.

E. A minimum of three (3) cells in series shall be provided for all flow-through pond systems. The second cell shall be three tenths (.3) times the area of the primary cell and the third cell shall be one tenth (.1) times the area of the primary cell. For facultative pond systems where the primary cell will be smaller than ten thousand (10,000) square feet, consideration should be given to the use of land application of the effluent. See section (15) of this rule. If the use of land application methods is not feasible or would present a nuisance, and the primary cell size is between three thousand (3000) and ten thousand (10,000) square feet, the third cell of the series shall have an area of at least one thousand (1000) square feet. Where the primary cell is less than three thousand (3000) square feet, only a secondary cell of one thousand (1000) square feet area is required.

F. A minimum of three (3) cells is required for all controlled discharge pond systems. The first and second cells shall be

sized as in subparagraph (13)(A)2.E. The third cell shall be a minimum of five tenths (.5) times the area of the primary cell. The third cell shall be placed at an elevation so that the primary and secondary cells may be lowered to the two-foot (2') operating level by gravity. Pumping from the secondary cell may be required to meet these criteria. Total detention time for the entire system shall be a minimum of one hundred sixty (160) days. Minimum storage above the two-foot (2') operating level in all the cells shall be one hundred (100) days.

G. Normal operating depths for flow through and controlled discharge pond systems shall be from two to five feet (2–5'). Depth in the third cell for flow-through and controlled discharge ponds shall be a minimum of five feet (5') but no greater than eight feet (8'). The minimum depth for aerated ponds shall be five feet (5'). Actual design depth for aerated ponds shall be based upon consideration of the type of aeration equipment used. Whenever possible each cell in a flow-through or aerated pond system should be designed with the water surface elevation at normal operating depth at least one foot (1') lower than the elevation in the preceding cell to facilitate independent variation of cell depths for maintenance and operational control procedures.

H. The shape of all pond cells should be such that there are no narrow or elongated portions. Round, square or rectangular ponds with a length not exceeding three (3) times the width are considered most desirable. No islands, peninsulas or coves shall be permitted. Dikes should be rounded at the corners to minimize accumulations of floating materials. Common dike construction, wherever possible, is strongly encouraged.

3. Pond construction details.

A. The design and construction of pond dikes is to ensure a stable, water tight structure, that can be easily and safely maintained. The dikes must be constructed of impervious materials and compacted sufficiently to form a stable, water tight structure. The engineering plans and specifications must indicate the type of soils to be used in the construction, the methods of compaction that will be used and the quality control tests, if any, that are required. Compaction methods which would achieve a standard proctor density of ninety percent (90%) of optimum throughout the dike are acceptable.

B. The minimum dike width shall be four feet (4'). If large farm type equipment is to be used for mowing, a top width of eight feet (8') shall be provided. The top of the dike must be at least two feet (') above the maximum depth of the cell.

C. Inner and outer dike slopes shall not be steeper than three to one (3:1). Inner slopes shall not be flatter than four to one (4:1). Consideration may be given to steeper inner slopes provided special attention is given to stabilizing the slope with rip-rap, concrete or other rigid materials. These stabilization methods shall be specified. The flatness of the outer slope is of no concern provided surface water can be diverted around the lagoon. Long outer slopes should be flatter than three to one (3:1) to assist in safe mowing of vegetation.

D. The area on which the dike rests shall be stripped of all organic matter and all tree roots grubbed. Selected organic material should be stockpiled and spread on the outer surface of the completed dike to assist in establishing vegetation. Trees and brush must be removed from the immediate construction site. As a general rule, all trees within one hundred feet (100') of the water's edge of the pond shall be removed. Special consideration will be given to leaving selected trees if—

(I) The trees' location will not result in shading of the pond's surface;

(II) Roots from trees will not imperil the dike structure;

(III) Felling of the tree from a storm or its natural death will not cause the tree to enter the pond; or

(IV) Leaf litter from the tree will not have an adverse effect on the pond's effluent.

E. The pond dikes shall be sufficiently smoothed to allow the passage of mowing equipment without scalping or danger to the operator from tipping. The completed surface shall have all rocks removed which might endanger the mower operator or equipment.

F. Diversion terraces and ditches are required to prevent surface water intrusion into the lagoon. Diversion ditches shall be designed to minimize erosion by incorporation of ditch blocks, paved inverts, rip-rap or sodding as necessary. Long slopes of diversion ditches shall be avoided whenever possible and when necessary shall be protected from excessive erosion by sodding, mulching and terracing techniques. Diversion terraces and paved outlets are recommended whenever runoff from areas adjacent to the diversion ditch will contribute sheet runoff down the ditch slope. Point runoff should be conveyed to the ditch by a paved outlet.

G. The dikes, diversion ditches and terraces shall be seeded and a good vegetative cover established to minimize erosion and aid in weed control. The inner dikes should be seeded down to the normal water line of the structure. Where the structure is not anticipated to reach its normal operating level during the first growing season, consideration should be given to further seeding on the dike slope. Long rooted grasses shall not be used for seeding of dikes. Fertilization needs, mulching and watering must be considered for all wastewater stabilization pond projects to ensure that a good growth of grass occurs rapidly and is sustained. Specifications shall detail specific amounts and variety of seeds to be used, mulching and fertilizer requirements as appropriate and the proper time period for application to be reasonably assured of success.

H. Rip-rap or some other acceptable method of erosion control is required as a minimum around all piping entrances and exits. For aerated cell(s), design should ensure erosion protection on the slopes and bottoms in the areas where turbulence will occur. Additional erosion control may also be necessary on the exterior dike slope(s) to protect the embankment(s) from erosion due to severe flooding of a water course.

4. Pond bottoms.

A. Soil used in constructing the pond bottom (not including seal) and dike cores shall be relatively incompressible, tight and compacted at or up to four percent (4%) above the optimum water content to at least ninety percent (90%) standard proctor density. Any soil borings and tests to determine characteristics of surface soil and subsoil shall be made part of the summary of design data. The bottom should be cleared of vegetation and debris.

B. All ponds shall be sealed so that seepage loss through the seal is as low as possible. The pond seal shall cover the bottom and extend up the inner dike slope to where the side slope intersects with the top of the dike. Seals consisting of soils, asphalt, soil cement or synthetic liners may be used provided the permeability, durability and integrity of the proposed materials can be satisfactorily demonstrated for anticipated conditions. Bentonite, soda ash or other sealing aids may be used to achieve an adequate seal in systems using soil.

(I) The design permeability of the pond seal shall not exceed five hundred (500) gallons per acre per day in areas where potable groundwater might become contaminated or when the wastewater contains industrial contributions of concern. Design seepage rates up to thirty-five hundred (3500) gallons per acre per day may be considered in other areas where potable groundwater contamination is not a problem, provided that the pond cells will maintain adequate water levels to provide treatment and avoid nuisance conditions.

(II) Soils having a permeability coefficient of $10^{-7}$ centimeters per second or less with a compacted thickness of twelve inches (12") will be acceptable as a pond seal for water depths up to five feet (5') and for seepage losses less than five hundred (500) gallons per acre per day. For permeability coefficients greater than $10^{-7}$ centimeters per second (cm/sec) or for heads over five feet (5') such as an aerated pond system, the following equation shall be used to determine minimum seal thickness:

$$t = \frac{H \times K}{5.4 \times 10^{-7} \text{ cm/sec}}$$

where

K = the permeability coefficient of the soil in question;

H = the head of water in the pond; and

t = the thickness of the soil seal.

Units for H and t may be English or metric; however, they must be the same.

(III) Section (17) of this rule contains recommendations for seal design.

C. All ponds shall be prefilled to protect the liner, to prevent weed growth, to reduce odor, to allow measurement of percolation losses and to maintain moisture content of the seal. However, the dikes must be completely prepared as described in subparagraphs (13)(A)3.G. and H. of this rule before introduction of water.

D. If measurement of percolation losses is required by the department, the method of measurement shall be in accordance with section (16) of this rule. In no case shall measured percolation losses exceed thirty-five hundred (3500) gallons per acre per day. In areas where there is a significant potential for groundwater contamination, justification shall be provided before measured percolation losses will be allowed to exceed five hundred (500) gallons per acre per day and in no case shall percolation losses exceed seventeen hundred (1700) gallons per acre per day. Whenever industrial wastes are a significant part of the wastewater flow, the department may require more stringent seepage limitations and liner design considerations.

5. Influent lines.

A. An effort should be made to locate and orient the lagoon and tributary sewers so as to have only one (1) inlet. When multiple inlets are necessary, they shall be located to minimize possibilities of short circuiting and uneven loading of the pond. The inlet line to the primary cell of an unaerated pond system shall terminate at the two-thirds (2/3) point farthest from the outlet on the longest axis of the cell. The inlet line to an aerated pond cell shall discharge within the mixing zone of the aeration equipment.

B. Any type of piping generally used for transmitting sewage under pressure shall be used as the influent piping for a pond system. When plastic pipe or similar low density material is used, extra consideration must be given to anchoring or weighting the pipe to prevent flotation. Special consideration must also be given to the character of the waste, possibility of septicity, exceptionally heavy external loadings, abrasion, the necessity of reducing the number of joints, soft foundations and similar problems.

C. A manhole shall be installed prior to entrance of the influent line to the primary cell and shall be located as close to the dike as topography permits. Its invert shall be at least six inches (6") above the maximum operating level of the pond and provide sufficient hydraulic head without surcharging the manhole.

D. Inlet lines should slope on a uniform grade and straight line beginning at the inlet manhole to a point approximately at the lagoon floor elevation. From this point, the pipe is laid flat to the point of discharge. The pipe may be laid flat on the lagoon bottom and anchored, or a trench of one (1) pipe diameter depth may be constructed with the fill material serving as the anchor. The inlet should discharge into a saucer-shaped depression with depth equal to six inches (6") or the inlet pipe diameter, whichever is greatest. The depression will have an area of approximately one-sixteenth (1/16) of the pond surface area. The inlet shall terminate over a concrete apron with a minimum size of three foot (3') square.

6. Transfer piping between cells and final effluent piping.

A. Minimum piping size shall be four inches (4") in diameter. Any pipe material suitable for transmitting sewage under pressure will be satisfactory provided the pipe is capable of withstanding heavy external loads from mowing equipment, and is resistant to chemical and biological deterioration. Cast iron, ductile iron or steel is recommended.

B. Control of water depth provides a number of benefits including better treatment efficiency during the different seasons, the ability to effectively operate the system on a partial draw- and fill-basis (phase isolation) and the natural control of mosquitoes, midge larvae and weeds. Minimum transfer pipe requirements in the primary cell shall be a single pipe, with gate valve placed to withdraw one-foot (1') below the pond water surface. Second and final cells and primary cells of controlled discharge ponds shall be provided with sufficient individual pipes and gate valves to raise and lower the pond levels in one-foot (1') increments from the two-foot (2') level upward. Final cells of flow through stabilization ponds in excess of five feet (5') deep shall level control piping in one foot (1') increments above five feet (5'). Final cells of controlled discharge ponds in excess of five feet (5') deep shall have level control piping in two-foot (2') increments above the two-foot (2') level. Overflow lines should discharge through anchored concrete structures at a point which will not cause dike erosion. Care shall be taken in location and design of transfer piping, valves and valve boxes to protect these appurtenances from damage by mowing equipment.

C. Transfer piping between aerated cells and from the quiescent cell shall consist of a single pipe equipped with a gate valve and located one foot (1') below the water surface.

D. The point of effluent draw-off from each cell shall be located as remotely as possible from the inlet to that cell.

7. Aeration requirements for aerated ponds.

A. Oxygen requirements generally will depend on the BOD loading, 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 two milligrams per liter (2 mg/l) in the pond at all times. Suitable protection from the weather shall be provided for electrical controls. The aeration equipment shall be capable of providing one and three-tenths pounds (1.3 lbs.) of oxygen per pound of BOD removed. BOD removal shall be based on warm weather rates. Appropriate manufacturer's data on aeration equipment oxygen transfer capability may be requested for review when this information is not available to the department.

B. Aeration equipment shall have sufficient power and shall be located to provide dispersion of oxygen throughout the aerated basin. For an aerated pond utilizing mechanical surface aerators, a minimum of ten (10) horsepower per million gallons of wastewater in the aeration basin shall be provided for mixing. In addition, aeration equipment and aeration basins shall be designed and installed to ensure that mixing patterns are adequate to prevent dead spots within the basin.

C. Shore-mounted diffused aeration systems shall be provided with duplex blowers and motors, with each blower capable of providing air requirements during the critical design condition. Floating surface aeration systems shall be provided with one

(1) spare motor, shaft and impeller of the size equal to the largest as those used in the design.

8. Outfall structures. Materials and design shall be in accordance with paragraph (13)(A)6. of this rule. (For additional requirements refer to paragraph (11)(C)7. of this rule.)

9. Fencing and signs. Fencing and signs for pond systems shall be in accordance with paragraph (11)(C)11. of this rule. In general for pond systems the fence shall be located at the outer toe of the dikes. Consideration may be given to other locations under specific circumstances. In all cases the fence must not be located where it can interfere with access to and mowing of the dikes.

(B) Activated Sludge Treatment Plants. For the range of flows covered by this rule, the extended aeration process is the most commonly used and criteria for this process follows. Criteria for the design of systems using other variations of the activated sludge process may be found in 10 CSR 20-8.180 Design of Sewage Works, Biological Treatment. The extended aeration plant is of the activated sludge type in which primary settling tanks are omitted, where prolonged aeration consumes some of the sludge and produces a relatively stable effluent and where the wasting of sludge is mandatory at varying intervals. The extended aeration process or any activated sludge process should not be considered where there is not at least five (5) days per week of wastewater flow into the plant. It should be noted that daily operation and maintenance attention by experienced plant personnel is absolutely necessary for proper operation. The engineer should carefully evaluate the ability of the owner to provide effective operation before making a recommendation to use the extended aeration process.

1. Location. Plants should be located close enough to the building being served to optimize maintenance of the plant. They should be located to be the least objectionable to actual or potential surrounding land use. A housed treatment plant component shall be located at least fifty feet (50') from any existing or future residence. Exposed treatment plant components, protected by only a fence or open grating, shall be located at least one hundred fifty feet (150') from existing or future residences. Distances to commercial buildings, industrial buildings, schools and similar structures must be evaluated with respect to type of structure being served and the actual use made of that part of the structure adjacent to the sewage treatment plant.

2. General. The side walls of all tanks which are open at the top shall extend at least six inches (6") above the adjacent ground surface with provision for erosion protection and drainage of the area surrounding the plant. All tanks shall have a minimum of ten inches (10") of freeboard above the maximum liquid operating level in each tank. Metal tanks shall be protected from corrosion by installation of anode packs. The location of the anode packs should be marked on the surface of the ground.

A. Riser sections may be used on plants where the invert of the influent sewer line has a maximum depth of four feet (4') below grade. Blower housing and electrical controls must be placed above the level of the riser section and above ground. All valve handles and cleanouts must be brought up to a minimum of one foot (1') from top of riser for easy maintenance. Where the invert of the influent sewer is deeper than four feet (4'), either a lift station should be provided and the plant be set at grade or a retaining wall or excavation with four feet (4') clear distance around the plant with free outfall of the drainage therefrom may be provided.

B. When phased development is proposed, one-half (1/2) the total ultimate capacity should be installed initially. Initial plans shall indicate all future phases of tributary development and ultimate plant capacity.

C. All treatment plant components shall be protected by one of the following methods:

(I) A rugged fence of chain-link, wood or block at least six feet (6') high with locked entrance gates. Plants located in areas where thrown objects or falling leaves might be a problem should be equipped with lightweight open grating over the tanks in addition to the fence described. Four foot (4') of working room must be provided around the plant;

(II) A building or housing constructed over the entire plant shall be provided with adequate means for gravity type ventilation by locating sufficient intake vents near the floor level and allowing the air to discharge out through large louvres or vents at ceiling height or by mechanical ventilation where gravity ventilation is not feasible. Housings over plants should provide at least seven feet (7') of headroom over the walkways. Adequate lighting shall be provided. Plants within buildings or housings shall be equipped with safe walkways providing access to all equipment and working areas housed therein. Access to the plant in a building should be by a door equipped with a lock. A minimum of four feet (4') of working room must be provided around the entire periphery of the plant;

D. The plant should always remain accessible. All-weather access roads are to be provided for all plants in accordance with paragraph (11)(A)2. of this rule; or

E. Plant equipment such as blowers, electrical controls and non-submersible pumps should be protected from foam and moisture. Equipment may be located either on top of the plant or in an adjacent enclosure. Guardrails with kickplates shall be provided at open tanks and along walkways, however, sturdy grating may be substituted over open tanks. Control valves shall be safely accessible from a position where firm footing is available. Motor shafts, pulleys, belts and the like shall be guarded. Above or below ground treatment units shall be accessible by sturdy stairways.

3. Pretreatment. Effective removal or exclusion of grit, debris, oil or grease and comminution or screening of solids shall be accomplished prior to the aeration tank. See section (12) of this rule for criteria applicable to preliminary and primary treatment devices. Stronger wastes from food service operations and wastes containing garbage or other organic matter increases both the hydraulic and BOD loadings and require special consideration. Excess organic materials, such as ground vegetables produced by supermarkets, should not be tributary to this type of plant. Garbage grinders should not be used in commercial facilities tributary to an extended aeration plant.

4. Flow equalization. Flow equalization facilities may be required for extended aeration treatment plants with flows greater than five thousand (5000) gallons per day. Equalization tanks must be located downstream of pretreatment facilities such as grease traps and bar screens.

A. A variety of methods may be employed to achieve flow equalization. Consideration may be given to on-line units, where all the flow passes through the equalization tanks and side-line units, where only that amount of flow above the maximum desired flow is diverted through the equalization tank(s). In addition, on-line treatment units may be utilized to dampen flow variations provided that the units are also capable of providing the required treatment efficiency throughout the entire range of operating wastewater depths.

B. Equalization tank size should be based upon a representative diurnal flow pattern derived from flow records or an acceptable approximation technique. The total equalization tank volume must be large enough to effectively reduce both flow and

load variations. Consideration should be given to dividing the flow equalization tank volume into two (2) compartments. The actual equalization tank volume must be greater than that obtained from the flow pattern in order to accommodate anticipated concentrated plant recycle streams such as supernatant from a digester or sand filter backwash. For new plants or where existing flows are not available to establish a representative diurnal flow pattern, Table I and the following criteria shall be used to approximate the required equalization tank volume.

C. Where existing flows are not available, the design peak flow factor shall be three and one-third (3 1/3) for all treatment plants. The peak daily flow for determining equalization tank volume shall be calculated as follows:

$$\text{Peak Daily Flow (gpd)} = \frac{3\ 1/3 \times \text{Average daily flow (gpd)} \times 24\ \text{(hrs.)}}{\text{Run-off period (hrs.)}}$$

Where the run-off period in hours is:

| | |
|---|---|
| Subdivisions | 16 |
| Schools | 8 |
| Restaurants | 12–16 |
| Institutions | 16 |
| Commercial | 12 |
| Resorts | 16 |
| Motels | 16 |

**Table I**

**Recommended Flow Equalization Tank Volumes**

**As a Percent of the Average Daily Flow**
**Q equ./Q avg.**

| Q max / Q avg. | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 |
|---|---|---|---|---|---|
| 1.0 | 0 | - | - | - | - |
| 1.5 | 13 | - | - | - | - |
| 2.0 | 22 | 8 | - | - | - |
| 2.5 | 29 | 16 | 5 | - | - |
| 3.0 | 33 | 22 | 12 | 4 | - |
| 3.5 | 37 | 27 | 17 | 9 | 3 |
| 4.0 | 40 | 30 | 22 | 14 | 8 |
| 5.0 | 44 | 36 | 29 | 22 | 16 |
| 6.0 | 48 | 41 | 34 | 28 | 22 |
| 7.0 | 50 | 44 | 38 | 32 | 27 |
| 8.0 | 52 | 46 | 41 | 36 | 31 |
| 9.0 | 53 | 48 | 44 | 39 | 35 |
| 10.0 | 55 | 50 | 46 | 41 | 37 |

NOTE: Q max = Design peak daily flow rate tributary to the equalization tank including all backwash. See paragraph (13)(B)4. of this rule.

Q avg. = 24-hour average design flow rate.
Q equ. = Desired equalized flow rate.

D. When pumps are utilized, duplicate pumps shall be provided. With air-lift pumps, this requirement may be fulfilled by a standby air supply.

E. Aeration or mechanical mixing must be provided to prevent deposition of solids in the tank(s) and to maintain aerobic conditions. Normal air requirement is two (2) cubic feet per minute per one thousand (1000) gallons of storage. The air supply shall be independent of plant process aeration facilities to ensure proper control.

F. Corner fillets shall be provided to facilitate the periodic removal of any accumulated sludge or grit.

G. Equalization tanks shall be suitably equipped with accessible external valves, stop plates, weirs or other devices to permit flow control and ensure proper flow equalization. Devices to measure the equalized flow may also be required. The equalization tank shall be equipped with an overflow to ensure that all wastewater flow will pass through the secondary treatment facility before being discharged. The overflow shall be installed ten inches (10") above the normal maximum liquid level and shall interconnect the flow equalization tanks with the aeration chambers of the secondary treatment facility.

H. The equalization tanks should be designed to avoid varying pump rates with changing liquid levels in the tank. However, equalization tanks with varying outflow rates shall provide compensatory additional storage capacity.

5. Flow division. Flow division is required where parallel aeration unit arrangements are planned initially or as part of a future expansion. Proportionate distribution of incoming flow and return sludge shall be provided. The screening, comminuting device or bar screen must precede the flow division. Division of the total plant flow into more than two (2) parallel arrangements is generally unacceptable. If flow division is not accomplished in the equalization tanks, consideration should be given to pumping the flow into a diversion device to prevent deposition of solids where average flows are very low.

6. Aeration tanks. Aeration tanks shall be designed to allow for twenty-four (24) hours of detention time based on the expected twenty-four (24)-hour sewage flow of average strength, domestic sewage. For higher strength wastes, such as those from restaurants, the greater amount of BOD applied should be considered with the detention time increased. The design of tanks shall be based upon the following criteria:

A. The aeration tank shall be sized on the basis of an applied BOD load of fifteen pounds (15 lbs) per one thousand (1000) cubic feet of aeration tank capacity per day. The design BOD loading rate shall include all recycle streams except return activated sludge;

B. Shape and design of the tank should maintain an effective mixture and utilization of air and prevent deposition of solids or short circuiting;

C. Oxygen requirements generally depend on maximum diurnal organic loading, degree of treatment and level of suspended solids concentration to be maintained in the aeration tank mixed liquor. Aeration equipment shall be capable of maintaining a minimum of two (2) mg/l of dissolved oxygen in the mixed liquor at all times and providing thorough mixing of the mixed liquor. In the absence of experimentally determined values, the design oxygen requirement for the extended aeration process shall be one and eight-tenths pounds (1.8 lbs) of oxygen dissolved per pound of diurnal peak carbonaceous BOD. In the case of nitrification the oxygen requirement for oxidizing ammonia shall be four and one-half pounds (4.5 lbs) of dissolved oxygen per pound of ammonia;

D. Twenty-six hundred (2600) cubic feet of air per pound of applied BOD shall be provided for diffused air plants. Additional capacity must be provided for channels, airlifts, aerobic digesters and other air use demands. Diffuser systems shall be capable of providing for the diurnal peak oxygen demand or two hundred percent (200%) of the design average oxygen demand, whichever is greater;

E. Blowers shall be provided in duplicate units, with each blower being capable of supplying all of the air requirements listed in this section. All installed blowers must be operable;

F. Easily removed drop-pipes with shut-off valves should be provided on each tank. A pressure gauge shall be provided on the outlet of each blower;

G. A maximum of four (4) tanks in series or a maximum of two (2) parallel arrangements of two (2) tanks each in series. In parallel arrangements, passports must be provided between tanks to prevent liquid build-up within any tank. Means for balancing air supply to each header must be provided. Means for varying the amount of return sludge, as well as the location of the return sludge discharge, must be provided. Separate blowers and piping plus standby blower(s) must be provided for parallel series arrangements; and

H. Time clocks will generally be approved only if the plant is operating at less than seventy-five percent (75%) of design

load, will be operating with predictable variable loads or will be operating with light loading conditions which will significantly affect operations. Plants equipped with time clocks should be supervised by only trained, experienced personnel.

7. Final settling tanks. Final settling tanks following the aeration units shall be designed to give effective settling and continuous return of sludge. Detention time shall not be less than four (4) hours based on the average flow. Six to eight (6–8) hours may be required to handle peak flows. Design of the settling tanks shall be based on the following requirements:

A. The installation of multiple settling tanks in series is discouraged;

B. The area upstream of any part of the inlet baffle shall not be used in calculating the surface settling area. The maximum surface settling rate at peak rates of flow with flow equalization shall not exceed one thousand gallons (1000 gals.) per day per square foot for domestic type wastewater. For plants without flow equalization, the maximum surface settling rate shall not exceed one hundred fifty gallons (150 gals.) per day per square foot, at the twenty-four (24)-hour average design flow.

C. Tank hoppers should have a minimum side slope of sixty degrees (60°) to the horizontal and bottoms not in excess of one foot (1') square or one foot (1') in diameter. In computing detention capacity of nonmechanical hopper tanks, only the upper one third (1/3) (by height) of the hopper(s) may be included. Tank hoppers should be considered as commencing when two (2) or more sides have a side slope of sixty degrees (60°) to the horizontal. Dual hoppered tanks should provide a minimum water depth of two feet (2') over the junction of sixty degree (60°) walls between hoppers. The installation of more than two (2) hoppers per settling tank will not be accepted.

D. A baffle shall be provided at the inlet to prevent turbulence and short circuiting and to entrap grease and floatable materials (surface skimmer shall be downstream of this baffle). The inlet baffle shall extend across the width of the settling tank and shall extend continuously from a minimum of six inches (6") above normal water level to a minimum depth of two feet (2') below the inlet part to the settling tank. The inlet baffle shall be located no less than twelve inches (12") from the tank end wall nor more than twenty inches (20") to allow an effective collecting area for floatable materials without infringing on the clear surface settling area of the settling tank;

E. A baffle shall be provided at the outlet, within six inches (6") of the effluent trough and extending four to eight inches (4–8") below and six inches (6") above the liquid level;

F. The outlet from the settling tank shall consist of an overflow trough equipped with an adjustable plate weir. The weir length shall be at least twice the narrow dimension of the settling tank and the weir overflow rate shall in no case exceed twenty-five hundred gallons (2500 gals.) per day per lineal foot at the twenty-four (24)-hour design flow nor seventy-five hundred gallons (7500 gals.) per day per lineal foot at peak flow. The overflow trough should be located a sufficient distance from the end wall of the final tank to offset the effect of end wall currents;

G. Sludge withdrawal shall be based on a return rate of fifty to two hundred percent (50–200%) of the average daily flow with variable control of the return rate provided. Positive visible return should be provided. Each hopper shall have separate sludge withdrawal and transfer equipment. Piping and valving shall be at least six inches (6") above the liquid level. Sludge return airlifts shall be at least three inches (3") in diameter. Discharge piping should be at least four inches (4") in diameter and should be designed to maintain a velocity of not less than two feet (2') per second when operating at normal return rates. Suitable devices for observing, sampling and controlling return sludge flow from each settling tank hopper shall be provided;

H. Scum skimmers capable of continuously removing floating scum from the clarifier and returning it to the aeration zone shall be provided. The devices shall be easily adjustable. The design of air lift type scum removal devices must take into account the effect that the air lifts will have on the overflow rate in the settling tank. On food service operations, skimmers must discharge to a separate scum holding tank of no less than five percent (5%) of the food service daily hydraulic flow and be provided with a means of recirculating the subnatant to the aeration tank; and

I. Hosing facilities for routine flushing of walls and walkways at all facilities over five thousand gallons (5000 gals.) per day and at all food service operations shall be provided. Where water supply is not available, a pump with hose connection may be used. (See paragraph (11)(C)8. for requirement concerning potable water supply protection.)

8. Waste sludge facilities. An on-site sludge holding facility shall be provided at each extended aeration treatment plant designed under this rule. For normal domestic type wastewater, the holding tank shall have a minimum capacity of three (3) cubic feet per population equivalent served. For higher strength wastes, the basis for design shall consider that sixty-five hundredths pounds (0.65 lbs) of solids per day must be wasted for every pound of influent BOD removed per day. Solids concentration in the holding tank may average two percent (2%) and a minimum of forty-five (45) days' storage must be provided. Suitable piping and valves shall be provided to allow wasting of excess activated sludge from the plant to the holding tank. The holding tank shall be provided with aeration at a minimum rate of four (4) cubic feet per minute per one thousand (1000)-gallon capacity. A means of returning supernatant from the sludge holding tank to the inlet end of the plant aeration zone or flow equalization tank shall be provided. A positive means for decanting the supernatant must be provided as an overflow port is not acceptable. Since all plants must waste sludge, the summary of design data shall indicate where waste sludge will be disposed. Sludge should be hauled to a municipal wastewater treatment facility or other suitable sludge disposal facility. Typically a twenty thousand gallon (20,000 gal.)-per day plant may produce from seven hundred to one thousand gallons (700–1000 gals.) of concentrated waste sludge per week. Failure to provide for proper handling of waste sludge may lead to plant failure and evidence of sludge in the receiving stream. For the size of facilities covered by this rule, on-site sludge disposal is not recommended. If on-site sludge disposal is proposed, an engineer's report shall be submitted which addresses the requirements of 10 CSR 20-8.170.

9. Filtration of effluent. All activated sludge treatment facilities that are required to produce effluents with less than ten (10) mg/l BOD and fifteen (15) mg/l suspended solids or remove ninety-five percent (95%) or more of the influent BOD shall have filtration of the effluent in accordance with subsection (13)(C) of this rule. Filtration is recommended for all activated sludge plants that must remove ninety percent (90%) or more of the influent BOD. These plants must be designed so that filtration, if required at a later date, can be added.

(C) Sand Filters. Sand filters are generally considered suitable for treatment of small flows or for flows which are highly intermittent or seasonal. Sand filters are considered capable of producing an effluent that meets advanced secondary treatment requirements. Sand filters may be used following a septic tank or activated sludge treatment facility.

The possibility of intermittent objectionable odors occurring during dosing of open filters should be considered when locating these systems. The criteria contained in this section is for buried, open and high rate backwashed type sand filters.

1. Location. Sand filters following activated sludge treatment plants shall be subject to the same setback distances as the treatment plant (see paragraph (13)(B)1. of this rule). Open sand filters following septic tanks shall be located a minimum of two hundred feet (200') from future or existing residences or other establishments. Buried sand filters shall be located a minimum of one hundred feet (100') from any water supply structure and fifty feet (50') from any residence or establishment. Siting of buried sand filters shall consider access needed for maintenance and repairs by construction equipment.

2. General. Sand filter bottoms are generally constructed of unfilled earth, however liners or poured concrete bottoms may be required in areas subject to potential groundwater contamination. All buried and open intermittent sand filters shall be dosed. Sand for sand filters may be either natural sand or manufactured sand. Manufactured sand shall be chat sand produced from flint chat in the Joplin area, fines manufactured from igneous rocks or chert gravel may be used. Finely crushed limestone or dolomite is not acceptable.

3. Buried sand filters. A buried sand filter shall consist of one filtering bed or two (2) or more filtering beds connected in series and separated by a minimum of six feet (6') of undisturbed earth. Two (2) or more filter beds are required where a high degree of treatment is required or where sand filter media with an effective size of one millimeter (1 mm) or greater is utilized. Each bed shall contain horizontal sets of distribution lines and collector lines. These lines shall be equivalent to schedule 40 PVC pipe or other suitable materials.

A. One (1) collector line shall be provided for each six feet (6') of width or fraction thereof. A minimum of two (2) collector lines shall be provided. The upper end of each collector line shall be sealed or plugged. The collector lines shall be laid to a grade of one inch (1") in ten feet (10'). The tops of open joints in the collector lines may be covered with tarred felt (tar paper) to prevent intrusion of the media.

B. Gravel three-fourths inch to two and one-half inches (3/4"–2 1/2") in size shall be placed around and over the lower collector lines until there is a minimum of four inches (4") of gravel over the pipes. The gravel shall be overlain with a minimum of three inches (3") of washed pea gravel one-eighth inch to three-eighth inch (1/8–3/8") size interfacing with the filter media.

C. A minimum of twenty-four inches (24") of coarse washed sand shall be placed over the pea gravel. The sand shall have an effective size of one-half to two milliliters (.5–2 ml.) with a uniformity coefficient of less than three and one-half (3.5). Not more than one percent (1%) of the media shall be less than thirteen hundredths millimeters (.13 mm.) in size.

D. Six inches (6") of gravel three-fourths to two and one-half inches (3/4–2 1/2") in size shall be placed upon the sand in the bed.

E. Distribution lines shall be level and shall be horizontally spaced a maximum of three feet (3') apart center to center. Enough gravel shall be carefully placed to cover the distributors.

F. Venting shall be placed on the downstream end of the distribution lines with each distribution line being vented or connected to a common vent. Vents shall extend at least twelve inches (12") above the ground surface with the outlet screened or provided with a perforated cap.

G. A layer of material such as unbacked, rolled three and one-half inches (3 1/2") thick fiberglass insulation, untreated building paper of forty to sixty pound (40–60 lb.) weight, synthetic drainage fabric or four to six inches (4–6") of straw shall be placed upon the top of the upper layer of gravel. A minimum of twelve inches (12") of backfill shall be provided over the beds.

H. A distribution box shall be provided for each filter bed. The distribution boxes shall be placed upon undisturbed earth outside the filter bed. Separate watertight lines shall be provided leading from the distribution boxes to each of the distributor lines in the beds.

I. All buried sand filters shall be dosed by use of either pumps or dosing siphons. The dosing system shall be designed to flood the entire filter during the dosing cycle. A dosing frequency of greater than two (2) times per day is recommended. The dosing volume should be sufficient to fill the voids in the gravel to a depth of at least four inches (4").

(I) A pump shall be installed when adequate elevation is not available for the system to operate by gravity. A pump is also required when two (2) filters are required in order to dose the effluent from the first filter to the second filter. The pump shall be of corrosion-resistant material. The pump shall be installed in a watertight pit.

(II) Dosing siphons may be used between the septic tank and first filter bed when elevation permits their use. Dosing siphons shall be installed with strict adherence to the manufacturer's instructions. The dosing tank shall be of such size that the siphon will flood the entire filter during the dosing cycle.

J. Septic tank effluent application rates for buried sand filters shall not exceed one gallon (1 gal.) per day per square foot for single bed filters using sand media with an effective size less than one millimeter (1 mm) and not more than one and one-half gallons (1/2 gals.) per day per square foot when using two (2) or more filters with sand that has an effective size of greater than one millimeter (1 mm). The maximum organic loading for a buried sand filter shall be one and seventy-five hundredths pounds (1 7/5 lbs.) of BOD per day per one thousand (1000) square feet. Extended aeration treatment plant effluent may be applied to buried sand filters at a rate of up to one and one-half gallons (1 1/2 gals.) per day per square foot. Total surface area for any sand filter shall not be less than two hundred (200) square feet.

K. There shall be no construction, such as buildings or concrete driveways, covering any part of a buried sand filter.

4. Open sand filters. Media characteristics and underdrain systems for open sand filters are similar to those for buried sand filters. Distribution is often provided through pipelines and directed on splash plates located at the center or corners of the sand surface. Occasionally troughs or spray nozzles are employed as well and ridge and furrow application has been successful during winter operation in severe climatic conditions. Dosing of the filter should provide for flooding the bed to a depth of approximately two inches (2") or one and one fourth gallons (1 1/4 gals.) per square foot. Dosing frequency is usually greater than two (2) times per day. For coarser media (greater than five tenths millimeters (0.5 mm)), a dosing frequency greater than four (4) times per day is desirable. Higher acceptable loadings on these filters as compared to buried filters relate primarily to the accessibility of the filter surface for maintenance. Gravel is not used on top of the sand media and the distribution pipes are normally exposed above the surface.

A. The media used in the filters should be from locally available sources, however, the effective size should be at least three-tenths millimeters (0.3 mm) and the uniformity coefficient must be less than three and one-half (3 1/2) and there shall be no more than one percent (1%) smaller than thirteen hundredths millimeters (.13 mm).

The media should have an effective size of less than one and two tenths millimeters (1.2 mm) or treatment efficiency will be impaired. The sand must be free of any clay, limestone or appreciable amounts of organic material. The operating authority or owner of the treatment facility should be aware that the smaller the effective size of the sand, the more maintenance of the filter bed will be required. No sand shall be used unless a sieve analysis has been performed on the material delivered to the site. A copy of the report on sieve analysis shall be submitted to the department with the final operating permit application.

B. Filter walls shall be of concrete or masonry. They shall extend at least six inches (6") above the top of the sand bed and at least six inches (6") above the adjacent ground surface. The filter surface should be protected from runoff and diversion ditches. Berms will be required as the need indicates.

C. Distribution to the filter may be by means of troughs laid on the surface, pipelines discharging to splash plates located at the center or corners of the filter or spray distributors. Care must be taken to insure that lines discharging directly to the filter surface do not erode the sand surface. The use of curbs around splash plates or large stones placed around the periphery of the plates will reduce the scour. When troughs or point discharges are used, they should be located so that the maximum lateral travel over the sand is not more than twenty feet (20'). The design of the distribution system shall assure that the effluent will be evenly distributed from each point discharge or trough or spray nozzle. Dosed distribution boxes may be appropriate in some situations. A layer of washed pea gravel placed over the filter media may also be employed to avoid surface erosion. This practice will create maintenance difficulties when it is time to rake or remove a portion of the media surface.

D. Open sand filters may be covered to protect against severe weather conditions and to avoid encroachment of weeds or animals. The cover also serves to reduce odor conditions. Covers may be constructed of treated wooden planks, galvanized metal or other suitable materials. Screens or hardware cloth mounted on wooden frames may also serve to protect filter surfaces. Where weather conditions dictate, covers should be insulated. A space of twelve to twenty-four inches (12–24") should be allowed between the insulated cover and sand surface.

E. The hydraulic loading for open sand filters shall be from two to five gallons (2–5 gals.) per day per square foot when treating septic tank effluent and less than eight gallons (8 gals.) per day per square foot when treating the effluent from an extended aeration treatment plant. In choosing what loading rate to use, the engineer should consider effective size of the media and maintenance requirements. The maximum organic loading rate to open sand filters shall be five and thirteen hundredths pounds (5.13 lbs.) of applied BOD per day per one thousand (1000) square feet.

F. Dual filters each sized for the design flow are required for treating septic tank effluent. Single filters are adequate for extended aeration plant effluent except that plants receiving and treating wastewaters stronger than domestic type waste (less than three hundred (300) mg/l influent BOD) shall be provided with dual filters. A diversion box shall be provided where two (2) or more beds are used.

G. Open sand filters shall be fenced in accordance with subsection (11)(A) of this rule.

5. High rate sand filters. High rate sand filtration may be used following extended aeration type treatment plants with flow equalization. Design of high rate sand filters shall be in accordance with 10 CSR 20-8.210 Supplemental Treatment Processes, section (4).

(D) Disinfection. Disinfection shall be provided when required by 10 CSR 20-7.015 Effluent Regulations. Disinfection can be accomplished with chlorine gas, calcium hypochlorite, sodium hypochlorite, iodine, bromine, ozone, chlorine dioxide and ultraviolet irradiation. For the range of flows covered by this rule, calcium or sodium hypochlorite are the most commonly used. Criteria for their use follow:

1. Design capacity. Chlorinators shall be designed to have adequate capacity to produce a total chlorine residual of one-half milligram per liter (1/2) mg/l after fifteen (15) minutes of contact time at the peak rate of flow. For typical domestic wastewater the following dosing capacity is recommended:

| Pond Effluent | Extended Aeration Effluent | Sand Filter Effluent |
|---|---|---|
| 20—30 | 10—25 mg/l | 1—5 mg/l |

2. Contact tanks. The chlorine contact tank shall be constructed to provide a minimum of fifteen (15) minutes of contact at the peak flow rate. For slow rate sand filter effluent, consideration should be given to an orifice-controlled discharge to the chlorine contact tank in order to avoid excessive size tanks. No orifice shall be less than one and one-half inches (1 1/2") in diameter. Baffling for serpentine flow shall be provided to minimize short circuiting. Baffles shall be designed to provide a length-to-width ratio of at least forty to one (40:1). Provisions shall be made for draining the tank to remove sludge with the sludge to be returned to either process or sludge holding facilities. Duplicate tanks are recommended.

3. Chlorinator housing. Chlorinators, with the exception of tablet type chlorinators, shall be housed in a separate enclosure which is properly ventilated and heated if winter operation is required. The chlorinator housings shall be equipped with mechanical ventilation with the inlet located near the floor. Ventilation equipment shall have sufficient capacity for providing a minimum of one (1) air change per minute; and

4. Dechlorination. Dechlorination shall be provided when required by 10 CSR 20-7.015 Effluent Regulations. Dechlorination chemicals shall be thoroughly mixed with the effluent, however no contact tank is required. Effluent reaeration may be required after dechlorination to insure adequate dissolved oxygen concentration. Special care should be taken not to allow calcium or sodium hypochlorite to mix with dechlorination chemicals during storage or handling. Dechlorinated effluent shall be monitored for chlorine residual and dissolved oxygen in accordance with discharge permit requirements.

(14) On-site Wastewater Treatment and Disposal. On-site wastewater treatment and disposal is a method of treatment involving pretreatment with a septic tank or extended aeration unit and further treatment and final disposal through soil adsorption. Soil adsorption is usually accomplished with the use of subsurface trenches, beds and elevated sand mounds. Land application of effluent from ponds is another method for a no-discharge system, however criteria for land application may be found in section (15) of this rule. This section also covers the criteria for engineering reports as required by 10 CSR 20-6.030 Disposal of Wastewater in Subdivisions.

(A) Engineer's Report—Single Family Wastewater Treatment Systems. An engineer's report required by 10 CSR 20-6.030 must demonstrate to the satisfaction of the department that the lot sizes, topography and soils in the subdivision are such that single family residence wastewater treatment systems may be used without causing a violation of the Missouri Clean Water Law and regulations. Also the design of the single family residence wastewater treatment systems will be in accordance with this rule. Criteria for an engineer's report that addresses these requirements are as follows:

1. General. A drawing or preliminary plat of the proposed subdivision that shows the individual lots and lot sizes must be submitted with the engineer's report. A copy of the geological evaluation, as required by 10 CSR 20-6.030, must be included with the report also. If county soils maps are available, the approximate soil boundaries must be shown on the plat or drawing.

A. The drawing or preliminary plat should show any existing water supplies or wastewater treatment systems. The proposed type of water supply must be indicated. If the development went from nonregulated to the number of lots to be regulated, the engineer should report on the method of wastewater treatment and disposal on the existing homes, whether or not the systems are surfacing and whether or not the effluent is crossing property lines. In areas of existing homes and potential groundwater contamination, the engineer should report on whether or not the wells serving the existing homes have had any history of contamination.

B. If no well records are available, the engineer should strive to have at least twenty-five percent (25%) of the wells tested. The wells should be tested for parameters recommended by the Missouri Department of Health. All information pertaining to failing systems or contaminated wells shall be shown on the plat or drawing. In these situations, the engineer should make recommendations for any deficiencies in the existing systems;

2. Lot sizes. The engineer's report must demonstrate that the lot sizes are large enough to satisfy the required set-back distances as required in 10 CSR 20-6.030 and 10 CSR 20-8.021. The lot size must be large enough for a soil adsorption system and repair area that is the same size as the original system in suitable soils;

3. Topography. The engineer's report must indicate that the areas where the soil adsorption systems will be sited are within the limits for slope as required in 10 CSR 20-8.021;

4. Soils. The location of all soil borings, percolation tests, backhoe pits or depth to bedrock determinations must be indicated on the drawing or plat. All these sites must be marked in the field by placing a lath at the hole or boring and writing on the lath whether the soil is suitable or unsuitable. The location of all these soils investigations must be at the most probable location of the sewage disposal area and based upon the most probable location of the residence.

A. There must be at least one (1) percolation test or soils investigation boring or pit on each lot in the subdivision. The soils investigation or percolation testing must continue on a lot until suitable conditions are found or the lot will not be considered for approval. Percolation tests and soils investigations must be in accordance with 10 CSR 20-8.021.

B. In some cases, where there are severe geological limitations for groundwater contamination, percolation tests and determination of soil morphological characteristics will not be sufficient. Particle size analysis or the percentage of rock fragments and depth to bedrock or seasonally high water table will be required in addition to the normal site evaluation. In some cases the additional requirements may apply when the geological limitations are moderate;

5. The proposed method of treatment and disposal, including soil loading rates and design, shall be in accordance with 10 CSR 20-8.021. The engineer's report must demonstrate that, based upon the site evaluations, there are sufficient suitable site conditions to design systems in accordance with 10 CSR 20-8.021. The report must also show the generic sizing of the different type of systems proposed;

6. The engineer's report must contain the name(s) and address(es) of the owner(s) and/or developer(s) with supporting documentation of the owner(s) and/or developer(s) approval of the report; and

7. The department may require provisions such as restricted covenants to assure that the proposed single family residence wastewater treatment systems will be constructed in accordance with 10 CSR 20-8.021 and the engineer's report unless other site evaluations by a person with the qualifications contained in this rule determines that the requirements of 10 CSR 20-8.021 can be met with a different design.

(B) On-site Systems Other Than Single Family Residences. On-site systems serving more than a single family residence or commercial establishment shall be designed in accordance with 10 CSR 20-8.021 provided that the design flow is less than fifteen hundred gallons (1500 gals.) per day. For on-site systems that are designed for more than fifteen hundred gallons (1500 gals.) per day, the criteria in this section shall be used in addition to the criteria contained in 10 CSR 20-8.021.

1. Engineer's report. An engineer's report is required for all on-site systems with design flows greater than fifteen hundred gallons (1500 gals.) per day. The engineer's report must contain the following in addition to the requirements of section (3) of this rule:

A. A geological evaluation of the proposed soil adsorption site must be performed by the Department of Natural Resources, Division of Geology and Land Survey;

B. For design flows greater than fifteen hundred gallons (1500 gals.) per day but less than three thousand gallons (3000 gals.) per day. The use of percolation tests at depths of three feet (3') in addition to soil pit observations to a depth of six feet (6') are the minimum site evaluation requirements. Analysis of the soil morphological characteristics may be used in place of percolation tests. Depth to bedrock from the bottom of the soil adsorption system must be six feet (6'). The following design parameters must be used:

(I) The slowest acceptable percolation rate is forty-five minutes (45 min.) per inch or a minimum permeability of six tenths to two inches (.6-2") per hour;

(II) Depth to seasonally high water table shall be a minimum of four feet (4') from the soil adsorption bottom. Depth from the soil adsorption system bottom to a restrictive layer or impermeable bedrock or mottling is six feet (6');

(III) The system shall be divided into a minimum of two (2) soil adsorption areas with each area sized for seventy-five percent (75%) of the design flow. The systems must be dosed with either a siphon or pump in order to achieve distribution between the lines or beds;

(IV) Slopes shall not exceed fifteen percent (15%). Linear loading rates and landscape drainage shall be sufficient to prevent oversaturation of the soil adsorption system at the lowest elevation in the system; and

(V) In areas of highly permeable bedrock and where there is groundwater contamination potential, the chert content must be less than forty percent (40%) for a depth of ten feet (10'). In areas where the chert content is less than sixty percent (60%) for ten feet (10') below the soil adsorption system and the total depth to bedrock is greater than thirty feet (30'), soil adsorption may be used. In these areas of potential groundwater contamination, groundwater monitoring wells may be required if recommended by the Division of Geology and Land Survey. In some cases where Karstification is well developed, monitoring of area springs may be required; and

C. For design flows greater than three thousand gallons (3000 gals.) per day, all requirements and limitations previously mentioned in this section shall apply and the following limitations shall apply:

(I) In general, sites will not be approved where the geological limitations are severe and in some cases where the geological limitations are moderate;

(II) Groundwater monitoring may be required in areas where potable drinking

water exists and there is a significant potential for contamination. The recommendations as to the number and construction details for groundwater monitoring wells from the Division of Geology and Land Survey will be followed;

(III) Soils shall be evaluated to a restrictive layer, bedrock or seasonally high perched water table. Calculations shall be submitted which show the predicted maximum height of the groundwater mound under the system or a perched groundwater mound. The minimum distance between the soil adsorption bottom and the maximum groundwater mound shall be four feet (4'); and

(IV) All hydraulic calculations on the pumps, siphons and distribution system shall be submitted.

(15) Land Application of Wastewater. This section applies to two (2) methods of land application which are slow rate (irrigation) and overland flow. The summary of design data and general layout shall contain pertinent information on the proposed site including location, geology, soil conditions, area for expansion, groundwater conditions and any other factors which may affect the feasibility and acceptability of the proposal. The summary of design data shall also include pretreatment and storage requirements, the design application rates and monitoring, application equipment, and operation and maintenance requirements. The source should be given for any information used by the consultant in design.

(A) Site Considerations. The following information concerning the site shall be provided:

1. Legal description of the disposal site;

2. The location of all existing and proposed residences, commercial or industrial developments, roads, ground or surface water supplies and wells within one-half (1/2) mile of the proposed site;

3. Available land area, both gross and net areas (excluding roads, right-of-way encroachments, stream channels and unusable soils);

4. Distance from the pretreatment and the storage facilities to the application site including elevation differential;

5. Proximity of site to industrial, commercial, residential developments, surface water streams, potable water wells, public use areas such as parks, cemeteries and wildlife sanctuaries;

6. Present and future land and groundwater uses;

7. A summary describing the existing vegetation of the area;

8. A description including maps showing elevations and contours of the site and adjacent areas which may be suitable for expansion. Specific information on the maximum and average slopes of the site must be provided; and

9. The department may require a geological evaluation of the proposed land application site prepared by the Department of Natural Resources, Division of Geology and Land Survey. A geologic report is not required for application rates that will not exceed twenty-four inches (24") of applied wastewater per year for typical domestic wastewater lagoon effluent.

(B) Wetted Application Area. The wetted application area is the land area which is normally wetted by wastewater application. The wetted application area must conform to the following criteria:

1. Flood-prone areas which flood at a frequency greater than once every ten (10) years should not be the sole source of land application;

2. The wetted application area shall be established at least one hundred fifty feet (150') from existing dwellings or public use areas, excluding roads or highways. In addition the wetted application area shall be at least fifty feet (50') inside the property line. Distances may be reduced depending upon the extent of pretreatment and operational techniques. One-half (1/2) the required distances may be used if the wastewater is disinfected in accordance with section (13) of this rule;

3. The wetted application area should be at least three hundred feet (300') from any sinkhole, losing stream or other structure or physiographic feature that may provide direct connection between the ground water table and the surface;

4. The wetted application area shall be at least three hundred feet (300') from any existing potable water supply well not located on the property. Adequate protection shall be provided for wells located on the application site; and

5. The application area should be fenced and posted along public roads and public use areas. Fencing is not required if the wastewater is disinfected prior to application or if other suitable barriers are provided or if the wetted application area is located in areas where access is limited. A minimum of one (1) sign should be placed on each side of the application area. The perimeter distance between any two (2) signs should not exceed five hundred feet (500'). Each sign should clearly identify the nature of the facility and advise against trespassing in letters not less than two inches (2") high.

(C) Soils Information. The department may require that the soil types and characteristics for the top five feet (5') of soil be investigated if applied wastewater will exceed twenty-four inches (24") per year. Unless required otherwise by the department, soils information shall include soil series name, soil texture, soil permeability and water-holding capacity. If a county soils map is available, the approximate boundaries of the different soils shall be shown. If a published soil survey is not available, the soils shall be classified by a professional soil scientist. In areas of soluble limestone and dolomite, where there is a potential for groundwater contamination, chert or stone content shall be determined to a depth of five feet (5'). Depth to restrictive layers such as fragipans or claypans shall be determined. Recommendations by the Division of Geology and Land Survey for further soils investigations shall be complied with.

1. The wetted application area should have a soil mantle of at least five feet (5') overlying any sand or gravel strata.

2. The topography of the site and adjacent land shall be evaluated for areas of potential erosion. The effects of both applied wastewater and storm runoff shall be considered. Special consideration should be given to the period of construction and system start-up when vegetative cover may be lacking or not fully developed.

(D) Preapplication Treatment. As a minimum, treatment prior to land application shall provide treatment equivalent to that obtained from a primary wastewater pond cell designed and constructed in accordance with section (13) of this rule, except that the pond depth may be increased to include wastewater storage on top of the primary volume. Separate storage cells may also be used. The maximum organic loading on the primary cell(s) at a water depth of three feet (3') shall not exceed thirty-four pounds (34 lbs.) of BOD per acre per day. The normal operating level for all ponds should be between the two-foot (2') level and the high water level. A permanent depth measurement gauge or marker shall be installed in the pond(s) and shall be easily readable at one-foot (1') increments or smaller. The gauge shall be placed in a suitable location where it is easily accessible during routine operations.

(E) Operation and Maintenance Plan. An operation and maintenance plan shall be provided to explain the key operating procedures at a level easily understood by the owner and the operator of the facility. An outline and brief summary of operations shall be provided as part of the engineering report. A detailed operation and maintenance plan shall

be included as part of the engineering plans and at a minimum shall address maintenance of mechanical equipment and vegetative cover, monitoring, recordkeeping, operating procedures, application scheduling and winterization of the system.

(F) Land Application Facility. This rule provides design criteria for a standardized conservative land application system. For the range of flows covered by this rule, the maximum application rate for typical domestic wastewater shall be forty to one hundred inches (40"–100") of applied wastewater per year depending on soil characteristics. For higher application rates, additional soils and geologic information, detailed site specific design proposals and supporting documentation shall be submitted to justify the proposed design. These designs should follow the requirements in 10 CSR 20-8.220. For irrigation the recommended design procedures for domestic wastewaters may be found in the *U.S. Environmental Protection Agency Process Design Manual for Land Treatment of Municipal Wastewater* (EPA 625/1-81-013).

1. Crops and vegetation. A description of the crops or vegetation to be grown is required for all systems in which vegetation is to be an integral part of the treatment system. This includes all slow rate and overland flow systems. The use of wastewater for irrigation of truck farms growing vegetables will not be approved. The following information shall be provided:

A. Compatibility of the crop with site characteristics and design hydraulic loading rates;

B. Cultivation and harvesting requirements; and

C. Crop management.

2. Storage facility. Storage requirements shall be based on the design wastewater flows and net rainfall minus evaporation expected for a one (1) in ten (10) year return frequency for the storage period selected. The storage volume for wastewater stabilization ponds shall be calculated based on the useable volume above the two-foot (2') level. The minimum total days' storage required for no discharge ranges from sixty (60) days in southern Missouri to one hundred twenty (120) days in northern Missouri. These requirements assume that a permanent cover crop is in place and the primary purpose of the system is wastewater treatment. If the system uses row crops, or crop production is the primary goal, storage should be increased to correspond with crop planting and harvesting schedules. An exception to this is a system where flows are generated only during the application period. A storage capacity of forty-five (45) days or the flow generated during the period of operation, whichever is less, must be provided.

3. Equipment. The following shall be considered in the design of the land application equipment:

A. Any spray application equipment specified shall minimize the formation of aerosols;

B. The pumping system and distribution system shall be sized for the flow and operating pressure requirements of the distribution equipment and the application restrictions of the soils and topography;

C. Provisions shall be made for draining the pipes to prevent freezing if pipes are located above the frost line;

D. A suitable structure shall be provided for either a portable pumping unit or a permanent pump installation. The intake to the pumping system shall provide the capability for varying the withdrawal depth. The intake elevation should be maintained twelve to twenty-four inches (12–24") below the wastewater elevation. The intake shall be screened so as to minimize clogging of the sprinkler nozzle or distribution system orifices. For use of a portable pump, a stable platform and flexible intake line with flotation device to control depth of intake will be acceptable;

E. Thrust blocking of pressure pipes shall be provided. For use of above ground risers for sprinklers, a concrete pad and support bracing should be considered; and

F. Automatic or semi-automatic controls should be considered for shut off of the system after a prescribed wastewater application period. Manual start-up of the application system is recommended.

4. Soil permeability. Soil permeability shall be based on the most restrictive layer in the top five feet (5') of soil. Soils having permeability rates of two tenths to two inches (.2–2") per hour are most suitable for irrigation. Values below two-tenths inch (.2") per hour may generally require special application equipment, reduced application rates or overland flow approach. Values above two inches (2") per hour will require reduced application rates to provide adequate residence time within the soil profile or will require additional soils and geologic information for depth to bedrock, depth to water table and recharge areas.

5. Slope. The maximum allowable slope of the wetted application area is twenty percent (20%).

6. Application rate. The application rate consists of an hourly application rate in inches per hour and daily, weekly and annual application rates in inches per acre. Application of wastewater will not be allowed during periods of ground frost, frozen soil or during rainfalls. The following shall apply to design application rates:

A. The hourly application rate should not exceed the design sustained permeability rate except for short periods when initial soil moisture is significantly below field capacity. The hourly rate shall not exceed one-half (1/2) the design sustained permeability for slopes exceeding ten percent (10%). However, in no case should the application rate be greater than one-half inch (1/2") per hour. For soil permeability of less than two-tenths inch (.2") per hour, the designed maximum application rate should be as low as practicable and shall not exceed two-tenths inch (.2") per hour;

B. The daily and weekly application rates should be based on soil moisture holding capacity, antecedent rainfall and depth to the most restrictive soil permeability. The application rate shall in no case exceed one inch (1") per day and three inches (3") per week; and

C. The design maximum annual application rate shall not exceed a range from four percent to ten percent (4%–10%) of the design sustained soil permeability rate for the number of days per year when soils are not frozen. The following shall apply to typical domestic wastewater lagoon effluent:

(I) Soil permeability less than two-tenths inch (.2") per hour. The maximum application rate shall be forty inches (40") of applied wastewater per year. The department may require lower application rates when there is evidence of fragipans, claypans or zones of seasonal saturation within the top two feet (2') of the soil profile;

(II) Soil permeability range from two-tenths inch (.2") per hour to two inches (2") per hour. The maximum application rate shall be one hundred inches (100") of applied wastewater per year. Lower rates may be required if there is evidence of seasonal saturation in the top five feet (5') of the soil profile or if there is a significant potential for groundwater contamination;

(III) Soil permeability ranges from two inches (2") per hour to six inches (6") per hour. The maximum application rate shall be sixty inches (60") of applied wastewater per year. The department may require lower rates if there is a significant potential for groundwater contamination; and

(IV) Soil permeability over six inches (6") per hour. The maximum application rate shall be twenty-four inches (24") of applied wastewater per year.

D. In no case shall the application rate result in the runoff of applied wastewater during or immediately following application.

7. Nitrogen Loading. Nitrogen application rates shall not exceed the amount of nitrogen that can be utilized by the vegetation to be grown. Typical domestic wastewater after lagoon storage can be expected to contain from five to eight milligrams per liter (5—8 mg/l) of ammonia nitrogen and less than one (1) mgl of nitrate nitrogen as N. Ammonia nitrogen can be adsorbed onto soil particles and retained in the soil for later use by plants and microorganisms. However, nitrate nitrogen is mobile and will readily leach through the soil profile if wastewater is applied faster than the vegetation or soil microbes can utilize the nitrates. If the applied wastewater is expected to provide more than one hundred fifty pounds (150 lbs.) of total nitrogen per acre annually or if the applied wastewater exceeds ten (10) mg/l of nitrate nitrogen as N, then calculations shall be submitted to show the amount of plant-available nitrogen provided and the amount of nitrogen that will be utilized by the vegetation to be grown.

8. Trace element loading. Consideration shall be given to the type and influence of any industrial wastes contributed to the wastewater stabilization pond. Typical domestic wastewater does not contain amounts of trace substances which are of concern for land application of wastewater under this rule. However, introduction of substances, such as excess sodium, chlorides, boron or other constituents, can have an adverse impact on soils and vegetation. Timber is more sensitive to these substances than grass or grain species. Wastewater suitable for general land application shall not exceed the trace element concentrations in Table 4-5 of the *U.S. Environmental Protection Agency Process Design Manual for Land Treatment of Municipal Wastewater* (EPA 625-1/81-013).

9. Public use areas. The following shall apply to the irrigation of public use areas with wastewater:

A. The wastewater shall be disinfected prior to land application (not storage) in accordance with section (13) of this rule. The wastewater shall contain as few of the indicator organisms as possible and in no case shall the irrigated wastewater contain more than two hundred (200) fecal coliform organisms per one hundred milliliters (100 ml);

B. The public shall not be allowed into an area when application is being conducted; and

C. For golf courses utilizing wastewater, all piping and sprinklers associated with the distribution or transmission of wastewater shall be color-coded and labeled or tagged to warn against the consumptive use of contents.

10. Grazing and harvesting deferment. Grazing of animals or harvesting of forage crops should be deferred for up to thirty (30) days following wastewater irrigation depending upon ambient air temperature and sunlight conditions. The following deferments shall be considered:

A. During the period from May 1 to October 30 of each year, the minimum deferment from grazing or forage harvesting shall be fourteen (14) days;

B. During the period from November 1 to April 30 of each year, the minimum deferment from grazing or forage harvesting shall be thirty (30) days;

C. Grazing of sewage irrigated land is generally not recommended for lactating dairy animals unless there has been a much longer deferment period. The recommendations of the State Milk Board shall be followed; and

D. Deferment may not be required for irrigation water that has been disinfected so that the water contains less than four hundred (400) fecal coliform organisms per one hundred milliliters (100 ml).

(G) Overland Flow. Overland flow distribution is accomplished by applying wastewater uniformly over relatively impermeable sloped surfaces which are vegetated. Part of the flow percolates into the ground, a portion is lost to evapotranspiration, while the remaining is collected and either discharged to a stream or reapplied on land.

1. Groundwater. The maximum groundwater elevation shall be at least two feet (2') below the application surface.

2. Slope. The land slope should be relatively uniform to prevent ponding and shall be in the range of two to eight percent (2–8%). For all overland flow systems, the slope must be nearly equal to a plane surface as possible and sloped in such a way as to prevent short-circuiting of the wastewater. No swales, depressions or gullies are permitted. The minimum length of slope for overland flow treatment is one hundred feet (100'). Two hundred feet (200') is the maximum length over which distribution of wastewater can be maintained.

3. Storage. The minimum amount of storage will range from forty-five (45) days in southern Missouri to ninety (90) days in northern Missouri. The applicant shall increase the storage facility to accommodate rainfall on the application site. The storage is then to be increased to accommodate any recirculation needed to comply with the discharge permit limitations.

4. Hydraulic loading. The recommended design hydraulic application rate is one and six-tenths inches (1.6") per day. The distribution system shall be designed to permit application on each field for eight to twelve (8–12) hours per day. Optimum wetting to drying cycle should range from a maximum of eight to twelve (8–12) hours on and a minimum of twelve to sixteen (12–16) hours off.

5. Distribution system. The system should be valved and manifolded to permit a portion of each application area to be taken out of service for grass mowing and/or harvesting. For facilities with flows less than fifteen thousand gallons (15,000 gals.) per day, the need to divide the overland flow plot into more than one (1) field is not necessarily required.

A. Sprinklers shall be placed downslope from the highest point on the application area at a distance equal to the radius of the sprinkler.

B. For surface distribution methods, such as gated pipe or bubbling orifice, gravel may be necessary to dissipate energy and insure uniform distribution of water.

6. Vegetation. Grasses must be selected for their resistance to continuously wet root conditions. Their growth should not be in clumps as this will result in the formation of rivulets of flow rather than a uniform sheet flow. Common grasses for this purpose have been reed canary grass, Italian rye, red top, tall fescue and Bermuda grass. Application is not allowed until a full grass cover has been established.

A. Vegetation harvest and removal is recommended. The vegetation must be cut just prior to maturity (every four to six (4–6) weeks) and physically removed from the site. Harvesting should be conducted when the soil conditions are dry enough to avoid creating ruts that would short-circuit the flow.

7. Collection ditches. A network of ditches must be constructed to intercept the runoff and channel it to the point of discharge or storage. They must be graded to prevent erosion yet at the same time they shall have sufficient slope to prevent ponding in low spots. The collection system must be designed to accept the added flow from rainfall runoff. If the collection ditch discharges to a stream, the effluent must meet the limitations and monitoring required in the discharge operating permit.

(16) Appendix I. This water balance study criteria is specific to newly-constructed ponds and to existing ponds when required by the department to perform a water balance. New ponds must be prefilled to at least the two-foot (2') level with clear water and this test conducted prior to the introduction of sewage to the ponds. The water level in the ponds must always remain above the two-foot

(2') riser during the test period to insure the measurement of pond level in the control structure will be accurate. It is advised to begin the test with a pond level several inches above the two-foot (2') riser level. Existing ponds must have at least three feet (3') of water in them for the test period. The study shall contain pertinent information that will be sufficient to establish the seepage rate of each cell within the pond system. All raw data should be presented along with the calculations used to formulate the conclusion.

(A) Two (2) methods for conducting this study are offered here. One method utilizes a Class A Weather Pan to measure evaporation. Standard procedures for setup and data gathering must be practiced where using a Class A Pan. The other technique, referred to as the Barrel Method, uses a simpler data gathering task and reduced calculations. Either method may be used to perform the water balance study. Due to the ease of data gathering and calculation, the Barrel Method is recommended. The following information must be generated and used in the calculation of the seepage rate of each cell individually within the pond system. The procedures identify data needed for using the Barrel Method or the Class A Weather Pan:

1. An accurate determination of the square footage of the cell must be made. Dimensions from the as built plans, if available, should be used to calculate this area at the height of the water level used during the water balance study. Pond floor measurements are usually given inside toe of dike to inside toe. Therefore, use the side slope ratio to calculate the added horizontal distance from the toe of slope to the dike at the water level used for the study;

2. No sewage inflow to the pond should be allowed until the test has been completed and approved. Inflow to the pond during the test period should be zero (0) and the inflow factor F will have a zero (0) value. If an unavoidable discharge or transfer of water to a cell must occur during the study period, that inflow must be accurately measured by either a flow recorder or by time clocks on pumps that have been calibrated at least twice during the study period. If an accurate measurement of flow cannot be made the test must be redone. If control structure slide gates or valves leak, they must be plugged for the duration of the test;

3. Rainfall measurement must be taken from a reliable rain gauge installed at the pond system. This data will be used directly in the seepage calculation when using the Class A Weather Pan or will be used as substantiation data if the Barrel Method is used. Rainfall measurements must be used to account for runoff from the top of the berms and side slopes. An appropriate runoff coefficient shall be used. The runoff coefficient should consider the antecedent conditions, amount of rainfall and duration of rainfall. Rainfall shall be measured daily during the normal work week;

4. Water losses through evaporation must be incorporated into the seepage calculation either by the use of a United States Weather Bureau Class A Land Evaporation Pan or by the use of barrels. Standard methods for use and placement of a Class A Weather Pan must be followed. The Barrel Method does not directly calculate the value of evaporation but gives a joint value for rainfall and evaporation. If a Class A Pan is used, an evaporation pan factor (to obtain a realistic value for actual pond evaporation) should be used;

5. In order to provide the highest degree of accuracy for the water balance test, no discharges should be made from the cells during the test period. Therefore, the outflow factor O in the seepage calculation should be zero (0). If discharge transfer from a cell is unavoidable during the test period, accurate flow measurements must be made by either flow recorder, time clocks or pumps (that have been calibrated at least twice during the discharge period) or some other form of accurate measurement; and

6. The water level of each cell should be recorded to the nearest one-sixteenth (1/16) of an inch. The measurements should be made within the manhole control structure from a fixed measuring device. This fixed device may be a temporarily fixed ruler installed for the test period only. Water level measurements shall be taken daily during a normal five (5)-day work week.

(B) A large (approximately fifty-five gallon (55 gal.)), clean (no oil or grease film), light-colored (inside and outside) barrel can be used to measure the rainfall and evaporation on a pond cell. At least three (3) barrels must be strategically located within the pond system with a surrounding baffle on each to avoid possible splash over. Barrels should be placed all in one (1) cell if only that cell is being tested at the time. If more than one (1) cell is being tested during the test period, the barrels should be arranged throughout the cells with a minimum of one (1) barrel per cell. Place the barrels where they are accessible for reading the water depths. The top of the barrel should extend at least one foot (1') but not more than two feet (2') above the water level in the cell. The barrel top should be cut (if necessary) to within these dimensions to accurately reflect the evaporation and rainfall changes to the pond contents. A measuring device should be fixed to the inside of the barrel to facilitate accurate water depth measurement to the nearest one-sixteenth (1/16) of an inch. In case splash over or overturning of a barrel occurs, the close results of the other two (2) barrels will validate the test. If one (1) barrel provides invalid data, that data should be presented but not included in the calculation. If all sets of data are reasonable to use, the data from the three (3) barrels should be averaged for the final calculation of the individual seepage rate for each cell.

1. The barrel must be on a firm footing with the bottom of the barrel on the bottom of the pond. The top of the barrel should always remain level.

2. The water level in the barrel should be initially set as close as possible to the water level outside the barrel. At the daily readings this water level in the barrel may need to be adjusted up or down to again be as close as possible to the outside water level. These resettings of the water levels in the barrel should be closely measured and recorded so that they are not included in the overall increase or drop of the barrel water elevation for the length of the study. Keeping the water level inside the barrel close to the water level outside the barrel will increase the reliability that the evaporation inside the barrel will match that of the rest of the pond. However, do not adjust the water level in the barrel during the test unless it varies from the water level outside the barrel by more than five inches (5").

(C) The necessary data should be obtained on a daily basis for a period of thirty (30) days during a period of time when no freezing can occur or when air temperatures go above ninety to ninety-five degrees Fahrenheit (90–95°F). If realistic estimates of surface runoff into the pond cannot be made, the data taken on days with rainfall should not be used in the calculations. In any case there must be thirty (30) days of data.

1. The net seepage rate should be given in gallons per acre per day calculated for each cell over the cell bottom and dike areas by using the following equation:

$S = F + R—E—O—WL$

Where:

WL = change in height of water level in a pond cell given in inches after taking rainfall and evaporation into account. WL will be a positive number for an increase in pond depth and will be a negative number for a decrease in pond depth. Reading will be taken in the control structure. When using the Barrel Method, WL will be calculated in the following manner:

WL = Hp—Hb

Where:

WL = the pond water elevation change accounting for rainfall and evaporation. A positive number indicates an increase in the pond level and a negative number will indicate a drop in the pond water level;

Hp = the change in the water level within the pond. A positive number is an increase in the water level and a negative number equals the drop of water level. This measurement should be made in the control structure;

Hb = the change of water level measured in the barrel. A positive number is an increase in water level and a negative number equals a drop in the water level. This measurement should be made in the barrel;

S = net seepage rate from a cell calculated to inches of water elevation and converted to gallons per acre per day. A positive number equals the amount of seepage the pond experiences; a negative number would indicate a negative seepage rate which is a net gain of water in the pond system;

F = wastewater flow into the cell during the study period should be zero (0). If there is an inflow, however, it would be given in gallons and should be converted to inches of water elevation over the cell;

R = rainfall directly on pond system calculated in inches during the study period. When the Barrel Method is used, this factor will not be included in the seepage calculations as it is automatically accounted for in the barrel measurement. However, runoff from the berms must be accounted for and calculated as inches of water in the pond;

E = evaporation from the pond surface measured in inches over the duration of the study period. When the Barrel Method is used, this factor will not be included in the calculation as it is automatically accounted for in the barrel measurement; and

O = outflow from the pond cell and/or transfer of contents from a cell should not occur during the study period. If a discharge does occur, however, it should be given in gallons and converted to inches of water elevation over the cell.

Note: When data taken on rainfall days is eliminated, the days between rainfall events essentially become short separate water balance studies. In this case the seepage rate will become the average of the studies.

(17) Appendix II. This appendix contains additional criteria for design and construction of liners in wastewater stabilization ponds.

(A) Site Evaluation. A preliminary investigation for a pond site should be undertaken to screen a study area for potential sites before a detailed site investigation, if required, is undertaken. The purpose of the investigation is to assemble available information to determine if soil borings and soil tests are required to design a pond which will meet the seepage requirements. The investigation should be done using data such as Soil Conservation Service (SCS) County Soil Surveys, U.S. Geological Survey topographic maps and the required geological evaluation from the Department of Natural Resources, Division of Geology and Land Survey. Visual inspection of the area noting topography, wet areas, vegetation and ditching is useful and may be necessary, particularly if maps are not detailed and/or soil maps do not exist. Information gathered from this investigation should be particularly useful in evaluation of the site with regard to estimating possible soil variability and suitability.

1. All potential pond sites will receive a rating from the geological evaluation. The rating will infer the relative geological limitations for designing and constructing a pond at the site in question. Whenever the geological evaluation indicates that a site has slight limitations, the requirements for additional site investigation as set forth in subsection (17)(B) of this rule, may not be required by the department. The department may require that the results of density tests, taken on the finished pond liner, be submitted and approved prior to putting the pond into operation.

2. Whenever a site has moderate geological limitations, the department may require one (1) or all of the requirements for a detailed site investigation as set forth in subsection (17)(B) of this rule. The department may require density tests, taken on the finished pond liner, be submitted and approved prior to putting the pond into operation.

3. Sites that have severe geological limitations for construction of wastewater stabilization ponds will be reviewed on a case-by-case basis. The department may require artificial liners in these situations. In general, where there is high collapse potential due to bedrock and soil conditions, the use of ponds will not be allowed. Exceptions may be granted dependent upon the type of liner proposed and where the geological considerations have been thoroughly evaluated so that the risk of groundwater contamination is minimized.

4. Where liners are used in storage or treatment basins for wastewaters of an industrial nature, the summary of design data shall document that the liner or storage structure material is capable of containing the wastewater for at least twenty (20) years and shall specify repair or replacement procedures in the event of leakage or damage to the seal. Secondary containment or leakage detection and collection devices shall be considered for corrosive or reactive wastewaters and for toxic materials. The department may require leakage testing in accordance with section (16) of this rule and submittal of density tests and/or coefficient of permeability on the finished liner prior to placing the structure into operation.

(B) Detailed Soils Investigation. If a detailed site investigation is needed to substantiate feasibility and design of a project at a selected site with regard to design requirements, the quantity and quality of soil materials on site (and borrow) must be identified and evaluated for use in the pond and/or liner construction. The design concepts and objectives of the investigation should be made clear by the consulting engineer to the qualified soil engineering party doing the field work so that an investigation strategy can be developed and sufficient data collected. Most important, an identification of the volume of the soil needed for the liner must be determined. The department may require the following to be included in the soils investigation:

1. Exploration shall be sufficient to identify and define the quantities and quality of the soil liner materials. The use of test pits, split barrel or thin wall sampling or a combination of these techniques may be used depending on the total area of investigation and the depth to which exploration is needed. The following information, in whole or in part, may be required by the department:

A. Atterburg limits;

B. Standard Proctor density (moisture/density relationships);

C. Coefficient of permeability (undisturbed and remolded);

D. Depth to bedrock;

E. Particle size analysis; and

F. Depth to seasonal high groundwater table; and

2. Information gathered from the investigation should be presented on a base map drawn to scale and referenced to U.S. Geological Survey datum. Slope, landscape position and other surface features should also be included. Stratigraphy of soils should be shown using cross sections or fence diagrams when soil liner material is to be identified. Copies of original boring and other soil test logs shall also be included. An interpretation of the collected data shall be incorporated into the report. Any site constraints and how they will be dealt with should be discussed.

(C) Design. The following criteria are for design and construction of soil liners. Engineering reports, plans and specifications should address these criteria.

1. The soils used for construction of a wastewater stabilization pond liner should meet the following minimum specifications:

A. Be classified under the Unified Soil Classification Systems as Cl, Ch, Gc or Sc;

B. Allow more than fifty percent (50%) passage through a No. 200 sieve;

C. Have a liquid limit equal to or greater than thirty (30);

D. Have a plasticity index equal to or greater than twenty (20); and

E. Have a coefficient of permeability equal to or less than 1 x 10-7 centimeters per second when compacted to ninety percent (90%) of standard proctor density with the moisture content between two percent (2%) below and four percent (4%) above the optimum moisture content;

2. The minimum thickness of the liner is twelve inches (12"). For soils which have a coefficient of permeability greater than 1 x $10^{-7}$ centimeter per second, liner thickness of more than twelve inches (12") may be required as set forth in subparagraph (13)(A)4.B. of this rule;

3. Normal construction methods will include scarification and compaction of base material to ninety percent (90%) standard proctor density at a moisture content that allows the material to be plastic. Construction of the liner material should be at a moisture content between two percent (2%) below and four percent (4%) above optimum and compaction of lifts generally not exceeding six inches (6") to greater than ninety percent (90%) standard proctor density. Maximum rock size should not exceed one-half (1/2) of the thickness of the compacted lift. The completed seal shall be maintained at or above the optimum water content until the pond is prefilled in accordance with subparagraph (13)(A)4.C. of this rule; and

4. If bentonite is proposed to be part of the liner construction, the following must be considered:

A. The bentonite should be high swelling and free flowing for uniform application. The application rate should be a minimum of two pounds (2 lbs.) per square foot. The water content of the soil-bentonite mixture should be at or up to four percent (4%) above the optimum for maximum compaction;

B. The bentonite should be spread with equipment that provides uniform application and minimizes wind drift. The application shall be split, so that one-half (1/2) is applied in one direction and the remaining half in a perpendicular direction on the pond floor and dikes. The bentonite shall be mixed into the soil to a uniform depth of at least four inches (4") and the liner should be compacted to at least ninety percent (90%) standard proctor density without the use of a sheepsfoot roller. The completed liner shall be covered with at least four inches (4") of fine textured soil and the liner shall be hydrated with fresh water prior to introduction of wastewater and kept at or above optimum water content until the pond is prefilled; and

C. At sites where the soils are considered to be aggregated cherty clays, the pond bottom below the bentonite seal should be either constructed as embankment or scarified to a depth of twelve inches (12") and compacted in six-inch (6") lifts to at least ninety percent (90%) standard proctor density. At least four inches (4") of fine soil shall be placed on top of the compacted pond bottom for mixing with the bentonite. The maximum size of rocks in the fine soil used for covering the soil-bentonite liner and in the soil-bentonite mixture should be one inch (1").

(D) Synthetic Liners. Requirements for thickness of synthetic seals may vary due to liner material but the liner thickness shall be no less than two hundredths inch (.02") or twenty (20) mil. Consideration should also be given to liners containing reinforcement in appropriate situations, such as sidewall slopes steeper than one to three (1:3) or pond depths greater than six feet (6'). Also in areas of cherty or gravelly soils, consideration should be given to using a geotextile under the liner or very thick polyethylene (80 mil) liners. Special care must be taken to select the appropriate material to perform under existing conditions.

1. Proper site preparations for synthetic liners are essential. The subsoil bed shall be sufficiently prepared to insure that all holes, rocks, stumps and other debris are eliminated. The subsoil shall be sieved or the area raked after grading to provide a smooth, flat surface free of stones and other sharp objects. A bedding of two to four inches (2-4") of sand or clean soil free of stones greater than three-eighths inch (3/8") or other sharp objects shall be provided. Soil shall be well compacted and sterilized to kill vegetation. If gas generation from decaying organic material or air pumping from a fluctuating groundwater table is a potential problem, a method of gas venting must be proposed. The method utilized will be dependent on the existing conditions at the site.

2. Liner panels should be laid out to minimize seams with an overlap of four to six inches (4-6"). Careful application of the seaming method is essential. The anchor trench should have a minimum six-inch (6") depth and be placed at least nine to twelve inches (9-12") beyond the slope break at the dike. Care must be exercised in the backfilling of the anchor trench to insure the liner is not damaged. To prevent erosion, mechanical damage to the liner and hydraulic uplifting of the liner, a minimum backfill of twelve inches (12") of sand or finely textured soils on the top of the liner is recommended on the pond floor. On the side slopes this should consist of a minimum twelve-inch (12") primary fill of finely textured soil and possibly a minimum six-inch (6") secondary fill of rip-rap.

3. All seams should be inspected and the inspection reports should be submitted to the department prior to seepage testing if required. It is recommended that installation be done by contractors familiar with potential problems which can be encountered.

(E) Asphalt Liners. Asphalt liners have not been tried extensively in Missouri and may be approved on a case-by-case basis. If proposed, the following hydraulic asphalt mix conditions will apply at a minimum. Other conditions may be indicated as requirements based on the project specific review. Due to the potential of the seal lifting and cracking from groundwater and/or from the frost cycles, the groundwater depth and subsurface drainage in the dikes must be carefully considered in the design phase for the asphalt liner to be successful:

1. The aggregate for the mixture shall meet the quality requirements of *Missouri Standard Specification for Highway Construction*, Missouri Highway and Transportation Commission, 1986, section 1002 and shall meet the following gradation requirements of (The Asphalt Institute) Hydraulic Mixtures A and B:

| Sieve Size | Percent Passing | |
|---|---|---|
| | A | B |
| 3/4" | | 100 |
| 1/2" | 100 | 95—100 |
| 3/8" | 95—100 | 84—94 |
| #4 | 70—84 | 63—93 |
| #8 | 52—69 | 46—65 |
| #16 | 38—56 | 34—53 |
| #30 | 27—44 | 25—42 |
| #50 | 19—33 | 17—32 |
| #100 | 13—24 | 12—23 |
| #200 | 8—15* | 8—15* |

*Mineral filler may be required to meet the gradation requirements on the No. 200 sieve.

2. The asphalt incorporated into the mixture shall meet the requirements of AC-20, Table 2 of AASHTO designating M226, viscosity graded asphalt cement, except that the minimum penetration shall be eighty (80) rather than sixty (60).

3. Mix design criteria shall be as follows (Marshall Method ASTM D 1559):

A. Marshall Stability (35 blows/side) five hundred pounds (500 lbs.) minimum;

B. V.M.A., % 15 minimum;

C. Air Voids, % 0–2 (target value—1%);

and

D. Asphalt Cement, %
(wt. of total mix) 6.5–9.5.

4. The liner should be constructed in accordance with the requirements specified in *Missouri Standard Specification for Highway Construction*, Missouri Highway and Transportation Commission, section 403, Asphaltic Concrete Pavement, except as modified or supplemented by the following:

A. The liner shall be four inches (4") thick at a minimum;

B. The liner shall be constructed in two (2) lifts, with each lift being approximately equal to one-half (1/2) the total surface thickness to within plus or minus one-half inch (1/2") tolerance;

C. Longitudinal joints between paver passes for the second layer should be offset from the joints in the lower layer by three feet (3');

D. Transverse joints in the second layer shall be offset from joints in the lower layer by at least three feet (3');

E. A tack coat of an emulsion such as CSS-1 or CSS-1h diluted one to one (1:1) with water and applied at an approximate rate of ten hundredths gallons (.10 gals.) per square yard should be applied between asphaltic lifts and on all vertical joints prior to placement of the next and/or adjacent lift. The tack coat between two (2) lifts should be uniformly distributed. All tacking should be done in accordance with MSSHC section 407, except as modified as described here; and

F. Placement of the hot-mix asphalt mixture shall be accomplished when the ambient temperature is above and fifty degrees Fahrenheit (50°F.);

5. Upon completion of the construction of the hot-mix asphalt concrete liner and prior to filling of the basin with water or sewage, a surface treatment of asphalt cement should be applied to the entire basin to ensure a watertight basin and to reduce the rate of oxidation of the surface of the lining. An AC-20 should be used and applied at a rate of about twenty-five hundredths gallons (.25 gals.) per square yard. Two (2) applications may be necessary to achieve this rate. The surface should be clean, dry and free from loose material prior to the application;

6. The sides of the basin should be designed so that paving equipment may operate or on a four to one (4:1) slope (horizontal to vertical). The asphaltic surface should be extended up and onto the berm of the basin for a distance of at least three feet (3') beyond the point of intersection of the berm and side slope. This asphalt cap should be constructed around the basin; and

7. The subgrade or base for the slopes and bottom shall be constructed of MSSHC type 2 base material and shall be a minimum of one and one-half inches (1 1/2") and compacted to ninety-five percent (95%) standard proctor density. Prior to construction of the asphaltic concrete liner, the subgrade soil (type 2 base) on all side slopes should be treated with soil sterilants to prevent weed growth through the lining.

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**Original authority 1972, amended 1973, 1987, 1993.*

**10 CSR 20-8.021 Individual Sewage Treatment Systems Standards**
(Rescinded March 30, 1999)

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**10 CSR 20-8.030 Design of Sewage Works**
(Rescinded August 13, 1979)

*AUTHORITY: section 204.026, RSMo Supp. 1973. Original rule filed July 17, 1961, effective July 27, 1961. Amended: Filed Oct. 3, 1962, effective Oct. 13, 1962. Amended: Filed Dec. 4, 1975, effective Dec. 14, 1975. Rescinded: Filed May 4, 1979, effective Aug. 13, 1979.*

***Op. Atty. Gen. No. 92, Bockenkamp (3-24-75).** The City of Farmington may impose user charges pursuant to section 204.026(18), RSMo (Supp. 1973), to cover costs of operation and/or future expansion of a public sewer treatment facility constructed pursuant to a grant of federal funds under 33 USC, Sections 1281-1292, without the necessity of an election as provided in section 71.715, RSMo (1969).*

***Op. Atty. Gen. No. 229, Smith (8-20-73).** Municipalities and sewer districts have authority to make the user charges to industries required by the Federal Water Pollution Control Act amendments of 1972 and to establish the reserves for future expansion or reconstruction.*

**10 CSR 20-8.110 Engineering—Reports, Plans and Specifications**

*PURPOSE: The following criteria have been prepared as a guide for the preparation of engineering reports or facility plans and detail plans and specifications. This rule is to be used with rules 10 CSR 20-8.120—10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed sewage works. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers* ***Recommended Standards for Sewage Works*** *and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that names can be added to the mailing list.*

*Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.*

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms shall and must are used, they are to mean a mandatory requirement insofar as approval by the agency is concerned, unless justification is presented for deviation from the requirements. Other terms, such as should, recommend, preferred