IV. COLLECTION SYSTEMS

1. Design

1. 1 Sewer systems shall be designed and constructed to achieve total containment of sanitary wastes and maximum exclusion of infiltration and inflow. Combined sewers will be not be approved under any circumstances.

1.2 The following factors must be considered in the design of sanitary sewers:
1.2.1 Peak sewage flows from residential, commercial, institutional, and industrial sources;
1.2.2 Groundwater infiltration and exfiltration;
1.2.3 Topography and depth of excavation;
1.2.4 Treatment plant location;
1.2.5 Soils conditions;
1.2.6 Pumping requirements;
1.2.7 Maintenance, including manpower and budget;
1.2.8 Existing sewers;
1.2.9 Existing and future surface improvements;
1.2.10 Controlling service connection elevations.

2. Calculations

2.1 Computations and other data used for design of the sewer system shall be submitted to the city engineer as a part of the engineering report. Calculations for system capacity shall utilize the format shown in Table IV - 1 or an approved equivalent.

2.2 New sewer systems shall be designed on the basis of per capita flows or alternative methods. Documentation of the alternative methods shall be provided.

2.3 New sewer systems designed on the basis of an average daily per capita flow may be designed for flow equal to that set forth in Table IV - 2. These figures are assumed to cover normal infiltration and inflow, but an additional allowance should be made where conditions are unfavorable. If there is an existing water system in the area, water consumption figures can be used to help substantiate the selected per capita flow.

2.4 Generally, the sewers should be designed to carry, when running full, not less than the following:
2.4.1 Lateral sewers, submains, main, trunk and interceptor sewers should be designed with a minimum peak design flow as shown in Table IV - 3.
2.4.2 New sewer systems may be designed by alternative methods other than on the basis of per capita flow rates. Alternative methods may include the use of peaking factors of the contributing area, allowances for future commercial and industrial areas, separation of infiltration and inflow from the normal sanitary flow, and modification of per capita flov rates (based on specific data). Documentation of the alternative method used shall be provided. When infiltration is calculated separately from the normal sanitary flow, the maximum allowable infiltration rate shall be 25 gallons per day per inch-diameter of the sewer per mile of sewer.

TABLE IV-1 SANITARY SEWER HYDRAULIC DESIGN SUMMARY SHEET

SHEET ___ OF ___

date: ___________

PROJECT ______________________________

LOCATION ______________________________

DESIGNED BY ______________________________

location	from MH	to MH	length (ft.)	tributary area (ac.)	total area (ac.)	average flow (cfs)	peaking factor	peak flow (cfs)	pipe diameter	upstream MH invert	downstream MH invert	pipe grade (%)	minimum velocity (fps)	velocity flowing full (fps)	capacity flowing full (cfs)	

TABLE IV- 2 DESIGN BASIS FOR NEW SANITARY SEWER CONSTRUCTION

Discharge Facility	Design Units	Flow (gpd)	BOD (lb/day)	TSS (lb/day)	Flow Duration (hr)
Dwellings	per person	100	0.17	0.2	24
School with showers and cafeteria	per person	16	0.04	0.04	8
School without showers and with cafeteria	per person	12	0.025	0.025	8
Boarding School	per person	75	0.2	.2	16
Motels at 65 gal/person (rooms only)	per person	130	0.26	.26	16
Trailer courts at 3 persons/trailer	per trailer	225	0.6	0.6	24
Restaurants	per seat	40	0.2	0.2	16
Interstate or through highway restaurants	per seat	180	0.7	0.7	16
Interstate rest areas	per person	5	0.01	0.01	24
Service stations	per vehicle serviced	10	0.01	0.01	16
Factories	per person per 8 hr shift	25	0.05	0.05	Operating Period
Shopping center (no food)	per 1,000 sq. ft. of ultimate floor	150	0.01	0.01	12
Hospitals	per bed	300	0.6	0.6	24
Nursing home (add 75 gals for laundry)	per bed	120	0.3	0.3	24
Homes for the Aged	per bed	60	0.2	0.2	24
Child Care Center	per child and adult	10	0.01	0.01	Operating period
Laundromats, 9 to 12 machines	per machine	250	0.3	0.3	16
Swimming pools	per swimmer	10	0.001	0.001	12
Theaters, auditorium type	per seat	5	0.01	0.01	12
Picnic areas	per person	5	0.01	0.01	12
Resort camps, day & night with limited plumbing	per campsite	50	0.05	0.05	24
Luxury camps with flush toilets	per campsite	100	0.1	0.1	24
Churches (no kitchen)	per seat	3	.005	0.005	Operating period

*Includes normal infiltration

Note: In all cases use actual data from similar facilities when possible. Note variations due to factors such as age, water conservation, etc. Submit all design data used.

TABLE IV - 3 PEAKING FACTORS

Average Daily Flow Rate (gpm)	Tributary Population	Ratio of Peak Instantaneous Flow Rate to Average Daily Flow Rate
< 70	< 1,000	4.0
> 70 but < 300	> 1,000 but < 5,000	3.5
> 300 but < 650	> 5,000 but < 10,000	3.0
> 650	> 10,000	2.5

3. Gravity Sanitary Sewers

3.1 The minimum pipe size in gravity sanitary sewer systems shall be 8 inches in diameter without a written variance from the city engineer.

3.2 Sanitary sewers located outside of roadways or other traffic loading should be installed wiih at least 30 inches of cover to the top of the pipe, and in all cases must be sufficiently deep to prevent physical damage from surface loading.

3.3 Sanitary sewers located in roadways or subject to other traffic loading should be installed with at least 48 inches of cover to the top of the pipe. In roadways where cover is less than 48 inches, DI pipe or concrete encasement shall be used. In all cases, a minimum of 6 inches of concrete encasement is required. Sewers installed greater than 18 feet in depth shall be DI.

3.4 DI pipe, concrete encasement, or relocation shall be required when culverts or other conduits are laid such that the top of the sewer is less than 18 inches below the bottom of the culvert or conduit.

3.5 Sanitary sewers larger than 3 inches in diameter which are located in roadways or subject to other traffic loading should be installed inside a steel protective casing.

3.6 The roughness coefficient should be documented for the type of pipe used. However, for ease of calculation, an "n" value of 0.0115 may be used in Manning's formula for the design of all new sewer facilities.

3.7 All gravity sanitary sewers shall be designed and constructed to give mean velocities, when flowing full, of not less than 2.0 feet per second. The allowable minimum slopes shown in Table IV - 4 should be provided; however, slopes greater than these are desirable. The desirable minimum slopes in Table IV-4 will provide a velocity of approximately 2.5 feet per second. Sewers shall be laid with uniform slope between manholes.

TABLE IV - 4 MINIMUM ALLOWABLE SLOPES

Sewer Size (inches)	**Minimum Slope (feet per 100 feet)**	**Desirable Minimum Slope (feet per 100 feet)**
8	0.26	0.40
10	0.193	0.28
12	0.151	0.22

3.8 Sewers on 18 percent slope or greater shall be anchored securely with concrete anchors or equal. Maximum anchorage spacing is 36 feet center to center on grades between 18 percent and 25 percent, 24 feet center to center on grades between 25 percent and 35 percent, and 16 feet center to center on grades that exceed 35 percent.

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

3. 10 Where velocities greater than 15 feet per second are expected, special provision shall be made to protect against internal erosion or displacement by shock.

3.11 Manholes shall be installed at the end of each line; at all changes in grade, size, or alignment; at all intersections; and at distances not greater than 400 feet on sewers 15 inches or less. Greater spacing may be permitted in larger sewers with a written variance from the city engineer and provided it complies with State of Tennessee Department of Environment and Conservation Design Guidelines.

3.12 An outside drop connection shall be provided for a sewer entering a manhole at an elevation of 24 inches or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than 24 inches, the invert should be filleted to prevent solids deposition.

3.13 The minimum inside diameter of manholes should be 48 inches, and larger diameters are preferable. The minimum clear opening in the manhole frame should be 24 inches to provide safe access. Manholes connecting significant industries to the system should be larger to provide space for monitoring and sampling equipment.

3.14 Flow channels in manholes shall be of such shape and slope to provide smooth transition between inlet and outlet sewers and to minimize turbulence. A minimum slope of 0. 1 ft. drop across the bottom of the manhole must be provided to maintain cleaning and the hydraulic gradient. Channeling height shall be to the crowns of the sewers. Benches shall be sloped from the manhole wall toward the channel to prevent accumulation of solids.

3.15 Watertight manhole covers shall be used wherever the manhole tops may be flooded. Manholes of brick or segmented block are not acceptable. All new manholes shall be vacuum tested to assure watertightness. Ventilation of gravity sewer systems should be considered where continuous watertight sections greater than 1,000 feet in length are incurred. Vent height and construction must consider flood conditions.

3.16 Line connections directly to the manholes or to short stubs integral with the manholes should be made with flexible joints. Flexible joints are joints which permit the manholes to settle without destroying the watertight integrity of the line connections.

3.17 Materials

3.17.1 Any generally accepted material for sewers will be given consideration. The material selected should be adapted to local conditions such as character of industrial wastes, possibility of septicity, soil characteristics, abrasion, and similar problems. Careful consideration should be given to pipes and compression joint materials subjected to corrosive or solvent wastes. Such pipe and compression joint material should be evaluated for vulnerability to chemical attack, chemical/stress failure, and stability in the presence of common household chemicals such as cooking oils, detergents, and drain cleaners.

3.17.2 The specifications shall stipulate that the pipe interior, sealing surfaces, fittings, and other accessories should be kept clean prior to installation. Pipe bundles should be stored on flat surfaces with uniform support. Stored pipe should be protected from prolonged exposure (six months or more) to sunlight with a suitable covering (canvas or other opaque material). Air circulation should be provided under the covering. Gaskets should not be exposed to oil, grease, ozone (produced by electric motors), excessive heat and direct sunlight. The contractor should consult with the pipe manufacturers for specific storage and handling recommendations.

3.17.3 Rigid Pipe: (Not approved for gravity sewers).

3.17.4 Semi-rigid Pipe: Includes DI. Rubber gasket joints shall be specified. All pipe should meet the appropriate ASTM and/or ANSI specifications.

3.17.5 Flexible Pipe: Includes PVC and HDPE. PVC pipe should have a maximum SDR of 35. All other flexible pipe that is not classified by the SDR system should have the same calculated maximum deflection under identical conditions as the SDR 35 PVC pipe. Flexible pipe deflection under earth loading may be calculated using the formula presented in the ASCE/WPCF publication; *Design and Construction of Sanitary and Storm Sewers*. All pipe should meet appropriate ASTM and/or ANSI specifications. It should be noted that ASTM D-3033 and D-3034 PVC pipes differ in wall thickness and have non-interchangeable fittings.

3.18 Pipe Bedding: All sewers shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the sewer shall be made because of the width and depth of trench. Trench widths should be kept to a minimum. Backfill material up to 3 feet above the top of the pipe should not exceed 6 inches in diameter at its greater dimension.

3.18.1 As a general rule, in roadways where cover is less than 4 feet, DI pipe, solid wall flexible plastic pipe, or concrete encasement shall be used. In such cases, a minimum encasement thickness of 6 inches (12 inches for solid wall flexible plastic pipe) is required. For structural reasons, DI pipe, concrete encasement, or relocation shall be required when culverts or other conduits are laid such that the top of the sewer is less than 18 inches below the bottom of the culvert or conduit.

3.18.2 Uncased borings are not permitted for pipe larger than 3 inches.

3.18.3 Special care shall be used in placing bedding in the haunch region.

3.18.4 Rigid Pipe: (Not applicable).

3.18.5 Semi-rigid Pipe: Bedding Classes I, II, III or IV (ML and CL only) as described in ASTM D-2321 shall be used for all semi-rigid pipe provided with the specified bedding to support the anticipated load. Underground installation of DI shall be as per ASTM A-746.

3.18.6 Flexible Pipe: Bedding Classes I, II, or III as described in ASTM D-2321 shall be used for all flexible pipe, provided the proper strength pipe is used with the specified bedding to support the anticipated load. Bedding, haunching, initial backfill, and backfill shall be placed in accordance to ASTM D-2321. It is recommended that polyethylene pipe be installed with Class I bedding material for bedding, haunching, and initial backfill as described below.

3.18.7 Alternate Bedding Option: As an alternative to the above sub-sections, all sewers shall be bedded and backfilled with a minimum of 6 inches of Class I material over the top and below the invert of the pipe.

3.18.8 Deflection Testing: Deflection testing of all flexible pipe shall be required. The test shall be conducted after the backfill has been in place at least 24 hours. No pipe shall exceed a deflection of 5%. The test shall be run with a rigid ball or an engineer-approved 9-arm mandrel having a diameter equal to 95% of the inside diameter of the pipe. The test must be performed by manually pulling the test device through the line.

3.18.9 Check Dams: Check dams shall be installed in the bedding and backfill of all new or replaced sewer lines to limit the drainage area subject to the French drain effect of gravel bedding. Major rehabilitation projects should also include check dams in the design. Dams shall consist of compacted clay bedding and backfill at least 3 feet thick to the top of the trench and cut into the walls of the trench 2 feet. Alternatively, compacted 33P mix or concrete encasement may be used, keyed into the trench walls. Dams shall be placed no more than 500 feet apart. The preferred location is upstream of each manhole. All stream crossings will include check dams on both sides of the crossing.

3.19 Joints: The method of making joints and the materials used should be included in the specifications. Sewer joints shall be designed to eliminate infiltration and exfiltration to prevent the entrance of roots.

3.20 Elastomeric gaskets or other types of pre-molded (factory made) joints are required. The butt fusion joining technique is acceptable for polyethylene pipe. Cement mortar joints are not acceptable. Field solvent welds for PVC and polyethylene pipe and fittings are not acceptable.

3.21 Leakage Testing: Leakage tests shall be specified.

3.22 Testing Methods: Testing methods may include appropriate water or low pressure air testing. The use of television cameras for inspection prior to placing the sewer into service and prior to acceptance is recommended.

3.23 Low Pressure Air Testing: Low pressure air-testing shall be performed as per ASTM C-828 on all gravity pipe. The time required for the pressure to drop from the stabilized 3.5 psig to 2.5 psig should be greater than or equal to the minimum calculated test time. (The test criteria should be based on the air loss rate.) The testing method should take into consideration the range in groundwater elevations projected and the situation during the test. The height of the groundwater should be measured from the top of the invert (one foot of $H_20 = 0.433$ psi).

Table IV-5 gives the minimum test times and allowable air loss values for various pipe size per 100 ft.:

TABLE IV - 5 MINIMUM TEST TIMES AND AIR LOSS

Pipe Size (inches)	Time, T (sec/100 ft)	Allowable Air Loss, Q (ft^3/min)
6	42	2.0
8	72	2.0
10	90	2.5
12	108	3.0

4. Protection of Potable Water Supplies

4.1 Physical connections between a public or private potable water supply system and a sanitary sewer or appurtenance thereto is prohibited.

4.2 Relation to Water Mains

4.2.1 Horizontal Separation: Whenever <u>practical</u>, sewers should be laid at least 10 feet horizontally from any existing or proposed water main. The distance should be measured edge to edge. Should local conditions prevent a lateral separation of 10 feet, a sewer may be laid closer than 10 feet to a water main if it is laid in a separate trench and if the elevation of the top (crown) of the sewer is at least 18 inches below the bottom (invert) of the water main.

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

4.3 When it is impractical to obtain proper horizontal and vertical separation as stipulated above, the sewer shall be designed and constructed equal to the water main pipe and shall be pressure-tested to assure watertightness. Such arrangements are discouraged and adequate reason shall be provided to justify the design.

4.4 When it is impractical to obtain proper horizontal and vertical separation as stipulated above, the city engineer may grant a written variance to the separation requirements. If such a variance is granted by the city engineer, the sanitary sewer shall be designed and constructed with materials equal to the water main pipe and shall be pressure-tested to assure watertightness.

5. Location of Sewers in or near Streams

5.1 Sanitary sewer systems shall be designed to minimize the number of stream crossings. Sanitary sewer lines entering or crossing streams shall be constructed of DI pipe with mechanical joints, shall be concrete encased, or shall be so otherwise constructed that they will remain watertight.

5.2 Sanitary sewers crossing streams shall be designed to cross the stream as nearly perpendicular to the stream flow as possible. Changes in alignment or grade in a stream are not permitted.

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

5.3.1 1 foot of cover (poured in place concrete) is required where the sewer is located in rock;

5.3.2 3 feet of cover is required in stabilized stream channels;

5.3.3 7 feet of cover or more is required in shifting stream channels.

5.4 Sanitary sewer structures shall be located so they do not interfere with the free discharge of flow of the stream.

5.5 Check dams must be installed at all stream crossings, both upstream and downstream, in the pipe conduit trench. This must be separate from any concrete encasement.

5.6 Check dams must be installed every 500 feet where sanitary sewer runs parallel to streams.

6. Aerial Crossings

6.1 Sanitary sewer pipe attached to piers across ravines or streams shall be allowed when it can be demonstrated that no other practical alternative exists.

6.2 Support shall be provided for all joints. All supports shall be designed to prevent frost heave, overturning or settlement. Expansion jointing shall be provided between above-ground and below-ground sewers.

6.3 The bottom of the pipe should be placed no lower than the elevation of the 50-year flood stage.

7. Inverted Siphons

7.1 Inverted siphons shall not be permitted without special written permission by the city engineer.

8. Force Mains

8.1 Force mains should be not less than 4 inches in diameter, except for grinder pump applications, and should be constructed of pressure-rated PVC (minimum Class 200), HDPE (minimum SDR 17), or DI pipe.

8.2 A minimum self-scouring velocity of 2 feet per second should be maintained during pump operation (4 feet per second velocity is desired), and maximum velocity should not exceed 8 feet per second.

8.3 A sewage air relief valve shall be placed at all high points in the force main to relieve air locking.

8.4 Materials of Construction

8.4.1 The pipe material should be adapted to local conditions, such as character of industrial wastes, soil characteristics, exceptionally heavy external loadings, internal erosion, corrosion, and similar problems.

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

8.4.3 All pipes shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the pipe shall be made because of the width and depth of trench.

8.5 The force main shall enter the receiving manhole with its centerline horizontal and with an invert elevation that will ensure a smooth flow transition to the gravity flow section. The force main must enter the gravity sewer system at a point not more than 1 foot above the flow line of the receiving manhole. The design should minimize turbulence at the point of discharge.

8.6 Protective coatings shall be installed in the receiving manhole to prevent deterioration as a result of hydrogen sulfide or other corrosive chemicals.

8.7 Force mains shall be sufficiently anchored within the pump station and throughout the line length. The number of bends shall be minimized, and thrust blocks, restrained joints, and/or tie rods shall be provided where restraint is needed.

8.8 Before backfilling, all force mains shall be tested at a minimum pressure of at least 50 percent above the design operating pressure for at least 30 minutes. Leakage shall not exceed the amount given by the following formula:

$$L = \frac{ND(P)^{5}}{7{,}400}$$

Where: L is allowable leakage in gallons per hour,
N is the number of pipe joints,
D is the pipe diameter in inches,
P is the test pressure in psi.

8.9 Force mains shall be sufficiently anchored within the pump station and throughout the line length. The number of bends shall be as few as possible. Thrust blocks, restrained joints, and/or tie rods shall be provided where restraint is needed.

8.10 Friction Losses: A "C" factor (surface roughness constant) shall be used that will take into consideration the conditions of the force main at its design usage. A pipe that is coated with grease after several years will not have the same C factor as it did when it was first placed into operation.

8.11 The force main design shall investigate the potential for the existence of water hammer.

9. Pump Stations

9.1 Sanitary sewage pump stations should be located as far as practicable from present or proposed residential areas. Noise control, odor control, and station landscaping design should be taken into consideration.

9.2 Where the wetwell is at a depth greater than the water table elevation, special provisions shall be made to ensure watertight construction of the wetwell. Design of the wetwell shall prevent the wetwell from floating.

9.3 A minimum of two submersible pump units shall be provided in each pump station, with each pump capable of handling the expected maximum flow. Pump head and system head curves shall be submitted to the city engineer for review and written approval prior to construction. Submersible pumps must be from the city's approved list of pump manufacturers and models.

9.4 When the station is expected to operate at a flow rate less than one half the average design flow for an extended period of time, the design shall provide measures to prevent septicity due to extended holding times in the wetwell.

9.5 All pumps, with the exception of grinder pumps, shall be capable of passing spheres of at least 3 inches in diameter. Pump suction and discharge openings shall be a minimum of 4 inches in diameter.

9.6 Pumps shall operate under a positive suction head under normal operating conditions.

9.7 Automatic pump control shall be provided such that pumps will come on and go off as the wetwell level rises and falls. Controls must activate standby pump if water in the wetwell continues to rise. Submerged pressure transducer controls are preferred for all sewage pump stations. Provisions should be made to automatically alternate the pumps in use. Each pump should be equipped with a secure external disconnect switch. Secondary (backup) float switches shall be provided, one for low wetwell level off and one for high wetwell level on. Float switches shall utilize an "intrinsically safe" power source.

9.8 Flow meters shall be provided at all pumping stations with flow capacity greater than 100 gpm. Totalizers shall be provided with graduation in gallons.

9.9 An alarm system for high wetwell levels, pump failures, and power failure shall be provided for each pump station. The system must provide compatibility with the city's telemetry system for relaying the alarm to the Moccasin Bend WWTP. A backup power supply shall be provided for the alarm system, such that a failure of the primary power source will not disable the alarm system.

9. 10 A riser from the force main with rapid connection capabilities and appropriate valving shall be provided for all lift stations to permit hook-up of portable pumps.

9.11 Electrical systems and components shall comply with the National Electrical Code requirements for Class I Division 1 locations.

9.12 Adequate lighting for the entire pump station site shall be provided.

9.13 Provisions shall be made to facilitate removing pumps, motors, and other equipment, without interruption of system service.

9.14 Suitable and safe means of access should be provided to equipment requiring inspection or maintenance. Manhole steps and ladders shall satisfy all OSHA requirements.

9.15 Shutoff valves shall be placed on the discharge line of each pump for normal pump isolation. A check valve should be placed on each discharge line between the shutoff valve and the pump.

9.16 Submersible pumps should be readily removable and replaceable without dewatering the wetwell or requiring personnel to enter the wetwell. Continuity of operation of the other units should be maintained.

9.17 The control panel shall not be mounted on the wetwell but shall be within close proximity of the wetwell and suitably protected from weather, humidity, and vandalism. Control panel must include the following as a minimum:

a. NEMA 4X stainless steel enclosure, deadfront with hinged internal panel;
b. NEMA rated combination starter with ambient compensated overloads for each pump;
c. H-O-A switch and pump run light for each pump;
d. Non-reset elapsed time meter for each pump;
e. Duplex wetwell level controller with automatic pump alternator;
f. Individual alarm lights, hold-in relays, and reset pushbutton for the following:
   (1) High and low wetwell levels;
   (2) Overtemperature for each pump;

(3) Seal failure for each pump;
(4) Loss of phase/undervoltage;

g. Thermostatically controlled condensation heater;
h. External GFI duplex convenience receptacle;
i. Internal light with switch;
j. External red flashing alarm light;
k. External receptacle for portable generator with transfer switch;
l. Heavy duty oil-tight pilot devices (not miniature);
m. Lightening and surge protection;
n. Separate aluminum or stainless steel sun/rain shield;
o. Alarm terminal strip for connection to city telemetry system to monitor the following:
    (1) Low level
    (2) High level
    (3) Power abnormality
    (4) Pump No. 1 status
    (5) Pump No. 2 status
    (6) Pump No. 1 – seal fail
    (7) Pump No. 2 – seal fail
    (8) Pump No. 1 – motor overtemperature
    (9) Pump No. 2 – motor overtemperature
    (10) Control panel intrusion
    (11) Pump failure to start or run
    (12) Analog flow signal (for stations with flow meters)

9.18 All control valves on the discharge line for each pump should be placed in a convenient location outside the wetwell in separate pits and be suitably protected from weather and vandalism. A pressure gauge with shutoff valve shall be provided on the force main. The range of the gauge shall be from 0 to 150% of the pump's normal operating pressure.

9.19 All structures, including electrical and mechanical equipment, shall be protected from physical damage by the maximum 100-year flood, and shall remain fully operational during the 25-year flood.

9.20 All pumping stations shall be accessible by an all-weather road located at or above the 25-year flood elevation.

9.21 All accessories and hardware inside the wetwell shall be constructed of stainless steel or other corrosion-resistant materials.