# CHAPTER TWO

## SEWER DESIGN GUIDELINES

## I. GENERAL GUIDELINES

A. Public sewer collection system design and construction shall be in accordance with the requirements of Title 15A of the North Carolina Administrative Code, Department of Environment and Natural Resources, Subchapter 2T .0200 "Waste Not Discharged to Surface Waters" (latest revision), and this Manual, including the Master Specifications. Where conflicts occur in the PWC and State design requirements, the more stringent requirement shall apply. The City of Fayetteville Public Works Commission shall review and issue permits for all new construction, extensions into new areas, and replacement sewers. Design submittals shall not include flow from rainwater, storm sewers, streets or groundwater.

B. Private sewer collection system design and construction shall be in accordance with the standards and requirements of Title 15A of the North Carolina Administrative Code, Department of Environment and Natural Resources, Subchapter 2T .0200 "Waste Not Discharged to Surface Waters" (latest revision) and this Manual. All private sewer mains that connect to the PWC system, for which PWC will **NOT** own, operate or maintain, shall be tested in accordance with PWC requirements. Where conflicts occur in the PWC and State design requirements, the more stringent requirement shall apply. PWC shall review and issue permits for all new sewer construction, sewer extensions into new areas within the service area, and replacement sewers. Design submittals shall not include flow from rainwater, storm sewers, streets or groundwater.

C. Private collection systems that connect to a subsurface treatment and disposal facility shall be permitted through the County Health Department or NCDEH. Low-pressure sewer systems and projects involving an Environmental Assessment shall be permitted through NCDWR with prior approval from PWC.

D. Operations that involve routine maintenance or the rehabilitation of existing sewer lines may not require a permit. In situations where existing sewer lines are undergoing routine maintenance, the existing sewer lines are being rehabilitated by constructing or installing replacement sewers, or the existing sewer lines are being refurbished by the installation of some type of sealant or sleeve inside the existing sewer line, a specific non-discharge permit may not be required. These operations will be deemed permitted as long as: 1) all construction and installation conforms to the design criteria in 15A NCAC 2T .0200 and this Manual; 2) new sources of wastewater flow are not being connected to the rehabilitated sewers; 3) all replacements or newly constructed sewers are located in the same proximity (same general horizontal and vertical alignment) and are the same diameter as the existing sewers, and 4) rehabilitation or replacement of public six (6) inch sewers with eight (8) inch sewers provided that the rehabilitation or replacement is to correct deficiencies and bring the sewer up to current minimum standards . If any of the criteria in this paragraph are not being adhered to, the applicant must apply for a permit. If the project is permitted, once the maintenance or rehabilitation activities are completed, a North Carolina Professional Engineer's certification (form provided by PWC) must be submitted to PWC for the completed work.

## II. REQUIRED PERMITS FOR CONSTRUCTION

PWC is delegated by the North Carolina Environmental Management Commission to issue permits for the construction of all public and private sewer extensions involving pump stations, force mains and gravity sewers. Refer to Chapter 1, Section III "General Requirements" for specific information on when permits are required. The appropriate forms to be completed can be found on the PWC website (www.faypwc.com).

## III. DESIGN CAPACITY AND DESIGN FLOW

### A. GENERAL

1. Sewer capacities and main sizes shall be designed for the estimated ultimate tributary population in the drainage basin. Consideration shall be given to the maximum anticipated capacity of commercial areas, of institutions, industrial parks, inflow/infiltration, etc. in calculating the service requirements within the area of the natural drainage basin. The capability of downstream sewers to accept future flow, made tributary to the collection system, shall be evaluated by the engineer. Where future relief sewers are planned, analysis of alternatives should accompany initial permit applications. Wastewater flow rates shall be determined in accordance with 15A NCAC 2T .0114, or as indicated in Table 1.

2. Unless otherwise permitted by PWC, all gravity trunk mains and outfall sewers shall be designed to serve the entire natural drainage basin and shall be placed on an adequate grade to allow extension to the natural basin ridgeline to collect all tributary flow.

### B. HYDRAULIC DESIGN AND ROUTE SELECTION

The following procedures and criteria are to be used for sizing and hydraulic design of gravity sanitary sewers. Generally, sewer outfalls and trunk mains shall be sized for the future full development of the basin using the following criteria unless more specific data is available. These design and peak flow calculations are <u>not</u> to be used to calculate flows for wastewater permits. Wastewater permits will be issued on the basis of current actual land use and NCDWR guidelines for flow allocation shown in 15A NCAC 2T .0114.

1. Determine Drainage Basin and Population To Be Served

   a. Outline the major basin on topographic maps. Identify and outline all sub basins and identify any other basins or sub basins that will be pumping into the sewer being designed.

   b. Using either a planimeter, or computer calculated area or some other acceptable method, determine the area to be served. Include the basins or sub basins that will be pumped into the sewer. If the area is undeveloped, reduce the area by

20% to account for streets. Further reduce the area by any acreage that is not considered developable (i.e. lakes, wetlands, etc.). If the area is developed, reduce the area as necessary to allow for existing streets.

c. For each basin and sub basin, determine the existing population, land use and zoning. Refer to the appropriate area Land Use Plan to determine trends in land use and zoning and for predictions of population growth rate.

2. Estimate the "Build out" Population to be Served

a. Estimate the "build out" population in the areas to be served when the areas are fully developed according to land use and zoning projections. Table 1 may be used, along with any population projections contained in the Land Use Plan, in estimating this population with supporting hydraulic calculations. Where several pipe diameters are acceptable, i.e. 12 inch and 15 inch, the Design Engineer shall furnish hydraulic calculations for both and a detailed estimate of construction costs for each.

b. Estimate the percentage of the "build out" population that will exist in the areas in the 50th year. This percentage should be based on growth rate projections contained in the Land Use Plan. The sewer line should be sized to serve this population.

Table 1 is intended only as a minimum design standard for the classification listed. The Design Engineer shall be responsible for insuring that the design discharge utilized in sizing sewer collection facilities are adequate for the area, which the extension is to serve.

Table 1. GUIDELINES FOR DETERMINING DAILY DOMESTIC WASTE QUANTITIES

| CLASSIFICATION TYPE | UNITS & MEASUREMENTS | FLOW VALUE |
|---|---|---|
| Rural Residential | 1.2 units/acre @ 270 gal/unit | 324 gal/acre |
| Low Density Residential | 2.5 units/acre @ 270 gal/unit | 625 gal/acre |
| Medium Density Residential | 10 units/acre @ 270 gal/unit | 2700 gal/acre |
| High Density Residential | 15 units/acre @ 270 gal/unit | 4050 gal/acre |
| Commercial | 1000 $ft.^2$/acre developed @ 120 gal/100 $ft.^2$ | 1200 gal/acre |
| Office/Institutional | 60 people/acre @ 25 gal/person | 1500 gal/acre |
| Light Industrial | 8 employees/acre @ 40 gal/employee | 320 gal/acre |
| Heavy Industrial | 4 times light industrial | 1280 gal/acre |

C. FLOW DETERMINATION

1. Determine the average daily flow (design flow) for residential areas.

2. Determine average daily flow (design flow) for industrial or commercial areas. Add additional flow based on research of specific zoning and any known large water users.

3. Determine, peak daily flow by multiplying the average daily flow by the appropriate peaking factor. The minimum peaking factor permitted is 2.5 and this factor should be used in the absence of specific design or flow data supporting a higher peaking factor.

4. Determine the allowable infiltration flow based upon 100 gpd/in. dia./mile (for gravity sewers).

D. SANITARY SEWER MINIMUM SLOPE

1. From topographic maps and any vertical survey control in the area, determine the average slope of the natural drainage in the area to be serviced. Determine whether any sections are significantly flatter than the average.

2. Determine whether there are obstructions (e.g. existing utilities) or natural terrain features that will limit the pipe slopes such as creek crossings, proper cover under railways, etc.

3. Based on (1) and (2), establish the minimum slope for the pipeline. This should be used as the design slope.

4. All public sewers shall be designed and constructed to give mean velocities, when flowing full, of not less than 2.0 feet per second, based on Manning's Formula using an "n" value of 0.013. The following are the minimum slopes, which shall be provided. However, slopes greater than these are recommended, particularly for mains and services serving few residences, to effect flushing solids.

**Table 2. Minimum Slopes**

| Diameter of Pipe (Inches) | Minimum Slope (Feet per 100 feet) |
|---|---|
| 4 (laterals) | 2.00 |
| 6 (laterals) | 1.00 |
| 6 (private) | 0.60 |
| 8 | 0.40 |
| 10 | 0.28 |
| 12 | 0.22 |
| 14 | 0.17 |
| 15 | 0.15 |
| 16 | 0.14 |
| 18 | 0.12 |
| 21 | 0.10 |
| 24 | 0.08 |
| 27 | 0.07 |
| 30 | 0.06 |
| 36 | 0.05 |

E. SANITARY SEWER PIPE SIZING:

1. Use the peak daily flow for design calculations with the pipe flowing full.

2. Sewers shall be designed to flow half full at the average daily flow. However, the smallest acceptable line size for private sanitary sewers is 6 inches. The smallest acceptable line size for public sanitary sewers is 8 inches.

3. Using Manning's Equation or Charts, to determine the pipe size:

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$ Note: all units in feet

Where:
Q = cubic feet per second
n = Coefficient of roughness (typically, n = 0.013)
S = energy grade line in. ft/ft
$R_H$ = hydraulic radius = $\frac{\text{cross sectional area}}{\text{wetted perimeter}}$
A = cross sectional area of pipe in square feet ($A = \pi r^2$)

Solve for A and then r to get the design pipe size.

4. Using Manning's equation, check the velocity of the gravity sewer:

$$V = \frac{1.486}{n} (R^{2/3})(S^{1/2})$$ Note: all units in feet

Where:
V = mean velocity in feet/second
n = coefficient of roughness (typically n = 0.013)
S = Slope of energy grade line, ft/ft
$R_H$ = hydraulic radius, ft
= $\frac{\text{cross-sectional area of flow}}{\text{wetted perimeter}}$ ($ft^2$)

5. Check the pipe size and slope and adjust the pipe size as needed to meet the minimum design slope and velocity as required.

F. PRELIMINARY SANITARY SEWER ROUTE SELECTION

1. Overlay property lines onto topographic map. (Where available, overlay existing structures, utilities, streets, etc.)

2. Make a preliminary layout, minimizing the number of parcels involved, and paralleling property lines where possible. Avoid obvious construction problems where possible such as excessive cuts, wetland impacts, etc.

3. Where wetlands are encountered, delineate in accordance with the guidelines published in the *Corps of Engineers - Wetlands Delineation Manual* if they cannot be avoided.

4. Where Environmental Assessment is required, perform as necessary. Projects involving an Environmental Assessment cannot be permitted by PWC, and must be permitted by NCDWR.

5. If the proposed route crosses or parallels a roadway, have all utilities located or as a minimum obtain utility locations from each affected provider. Consider the NCDOT requirements for encroachments in selecting the route.

6. If the proposed route crosses or parallels a utility, such as an overhead transmission line, consider the requirements for encroachments into the utility right-of-way.

7. If the proposed route crosses a railway, consider the requirements for encroachments into the right-of-way of the particular Railroad Corporation involved.

8. Provide the Public Works Commission with the preliminary route selection.

9. Survey the proposed alignment, setting stakes at each manhole centerline. (Prior to survey, Consultant Engineer shall coordinate with PWC notification to property owners that surveyors/consultants will be working in the area.)

10. Walk the project with PWC staff if required by PWC. Modify preliminary routing as necessary based on field observation of terrain features, environmental considerations, and potential property damage. Maintain sufficient distance from creeks to protect the sewer pipe from washout and comply with minimum separation requirements imposed by NCDWR in 15A NCAC 2T.0200 and this Manual.

## IV. DETAILS OF DESIGN AND CONSTRUCTION OF SANITARY SEWER COLLECTION MAINS

### A. MINIMUM SIZE

1. Public sanitary sewer collection system, conveying wastewater, shall be a minimum of eight (8) inches in diameter. Private sanitary sewer collection systems, conveying wastewater, shall be a minimum of six (6) inches in diameter.

### B. DEPTH

1. A minimum of three (3) feet of cover, as measured from the crown of the pipe to the finished grade, shall be provided for all sewers, unless ductile iron pipe is specified and approved by PWC. Proper bedding shall be provided where sewers are subject to traffic bearing loads to develop design-supporting strength. Additional protection shall be provided for sewers that cannot be placed at a depth sufficient to prevent damage. PWC shall determine the acceptability of such installations.

2. Typically, the depth of gravity sewer mains shall be deep enough to serve adjoining property or the first floor of existing homes if possible. Basement service, or service to low lying lots that require extra depth (greater than 10 feet), will be evaluated by PWC on a case-by-case basis. In isolated cases, the lot will be required to lift sewage

to the gravity main.

3. These minimum requirements do not negate the need for the design engineer to evaluate specific trench conditions in the design of a project. Where unstable soil conditions are known to exist in the pipe zone, structural design shall be based on a careful evaluation of the soil conditions and depth of cover. Special structural designs (e.g. pilings with pipe support cradles, etc.) shall be used where appropriate, and shall be detailed by the Design Engineer. A North Carolina Professional Engineer shall design trench excavation, as indicated in the State of North Carolina minimum design criteria.

4. Special structures such as large concrete vaults, pumping stations and all buildings shall have a specific foundation design. This design shall be based on site conditions and be based on the evaluation of actual subsurface boring and/or other pertinent tests required for the design (soil bearing, soil classification, etc.).

C. SLOPE PROTECTION

1. The pipe diameter and slope shall be selected to obtain the greatest practical velocities to minimize settling problems. Designs must include a minimum scouring velocity of 2 feet per second. Sewers shall not be oversized to justify using flatter slopes. If the minimum scouring velocity cannot be maintained during initial operation prior to the design flow capacities being reached, the lines will be designated as high priority in the permit. High priority lines must be checked once every six months and flushed as necessary (15A NCAC 2T .0403).

2. Maximum grade for sanitary sewers is 9% unless otherwise approved by PWC on a case-by-case basis.

3. Where design velocities are projected to be greater than 15 feet per second, the sewers and manholes shall be protected against displacement by erosion and impact. For velocities greater than 20 feet per second, erosion control measures shall be documented on the “Record Drawings” and in the Engineer’s Certification.

D. STEEP SLOPE PROTECTION

1. If approved by PWC, sewers on 20 percent slopes or greater shall be anchored securely with concrete, or equal, with the anchors spaced as follows:

   a. Not greater than 36 feet center to center on grades 21% to 35%;

   b. Not greater than 24 feet center to center on grades 35% to 50%; and

   c. Not greater than 16 feet center to center on grades 50% and over.

E. CHANGES IN PIPE SIZE

1. Where a smaller pipe joins a larger one, the invert of the larger sewer should be lowered sufficiently to maintain the same energy gradient. Generally, aligning the crowns of the different size pipes is acceptable.

2. Sewer extensions shall be designed for projected flows, even when the diameter of the receiving sewer is less than the diameter of the proposed extension at a manhole, with special consideration of an appropriate flow channel to minimize turbulence when there is a change in sewer size. Justification shall be provided with the certification of completion and the construction plans, indicating that the capacity of the downstream sewer will not be overloaded by the proposed upstream installation. The PWC may require a schedule for construction of future downstream sewer relief.

3. Pipe size and material should remain consistent between manholes, and must not change, unless approved by PWC. At drop manholes, the pipe material shall transition to SDR 26 PVC, in accordance with PWC Standard Details.

## V. SANITARY SEWER LOCATIONS

### A. OUTFALLS/INTERCEPTORS

1. Gravity sewer lines serving drainage basins shall follow the natural drainage pattern of the basin as closely as possible. Specific horizontal alignment should be made with due consideration to property lines, topography, environmental damage, and reasonable property owner requests.

2. Where possible, elevations should be set so that the top of the pipeline is at least four feet below the natural grade and at least three (3) feet below stream or drainage channel beds.

3. Where the natural slope will permit, the Design Engineer shall use the available grade (natural fall of land) to increase slope of the gravity sewer rather than designing for the minimum slope with large invert drops.

### B. COLLECTION MAINS

1. Sewer lines shall be laid on straight lines between manholes and at a constant grade or uniform slope. Sewer collection mains shall be laid on the minimum slope as identified in Table 2. The straight alignment shall be checked by using a laser, lamping and/or mirrors, and a mandrel.

2. All sewer collection mains shall be installed within the street right-of-way or within a dedicated easement, while maintaining separation distances, as stated in Section VII and VIII.

3. When located in the street, the main shall be located as near as possible to the center of the pavement so that manhole covers are not located in vehicle wheel paths.

4. When located in a dedicated easement, the main shall be centered in a permanent easement of adequate width to allow excavation and maintenance of the line while maintaining separation distances. A temporary easement may be required for installation.

5. Mains extended in the street to serve a property must be extended across the entire length of the property to allow for future extension. Mains, which require extension within a drainage basin, must be extended to the upper most point of the property or to any other point, which can provide reasonable service to adjacent property.

6. To accommodate future extensions in unpaved areas, stub out a section of pipe properly plugged and on proper grade. In paved areas, the sewer main shall be extended beyond the pavement and terminate in the next planned manhole.

C. SANITARY SEWER PIPE STRENGTH

1. Sanitary sewer pipe strengths and classes, as shown in Table 3 through Table 7, were designed based upon a minimum weight of 120 cubic feet of soil and an H2O loading condition. Trench width at the top of the pipe and design calculations are based upon not exceeding two (2) feet for 8-inch and 12-inch pipe, three (3) feet for 15-inch and 18-inch pipe, four (4) feet for 24-inch and 30-inch pipe, and six (6) feet for 36-inch through 48-inch pipe. Greater trench widths shall require the Design Engineer to provide individual design to support the additional load up to the transition width. The Design Engineer shall insure that constructed trench dimensions do not exceed those indicated above, otherwise greater trench widths will require either an increase in pipe class, bedding condition and/or pipe material suitable to provide sufficient structural integrity to withstand the increase in load on the pipe.

**Table 3**

**D 0.01 Concrete Pipe & Depth of Cover (feet)**

| **Pipe Dia.** | **Trench Width (ft.)** | **6** | **8** | **10** | **12** | **14** | **16** | **18** | **20** | **22** | **24** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **24"** | 4 | III | III | III | III | III | III | IV | IV | IV | IV |
| **30"** | 4 | III | III | III | III | III | III | III | III | III | III |
| **36"** | 4 | III | III | III | III | IV | IV | IV | IV | IV | IV |
| **42"** | 6 | III | III | III | III | III | III | IV | IV | IV | IV |
| **48"** | 6 | III | III | III | III | III | III | IV | IV | IV | IV |

Note: Reinforced concrete pipe only.

**Table 4**

Greater Depths may be considered, provided individual Design Calculations are submitted

**SDR 26 PVC Sanitary Sewer Pipe Minimum & Maximum Depth of Cover**

| **Bedding Class** | **Minimum Cover** | **Maximum Cover** |
|---|---|---|
| B | 3' | 22' |

| Table 5 | | | | | |
|---|---|---|---|---|---|
| **Extra Strength Clay Pipe Minimum and Maximum Depth of Cover** | | | | | |
| **Maximum Trench Width** | **Pipe Diameter** | **Bedding Class** | **Minimum Cover** | **H2O Maximum Cover** | **H2O @ Transition Width (FIO)** |
| 2 | 8" | B | 3' | 30' | 20' |
| 2 | 12" | B | 3' | 30' | 14' |
| 3 | 15" | B | 3' | 26' | 12' |
| 3 | 18" | B | 3' | 26' | 12' |

Safety Factor Extra Strength Clay Pipe = 1.5
Includes 16,000 lb. Wheel Load.
Includes Impact Load Factor 1.5 (Highways)

| Table 6 | | |
|---|---|---|
| **Ductile Iron Pipe Maximum Depth of Cover (feet) Class "B" Bedding** | | |
| **Pipe Diameter** | **Pressure Class Pipe (Force Mains Only)** | **CL50** |
| 8" | 50 | 50 |
| 12" | 44 | 44 |
| 16" | 34 | 44 |
| 18" | 31 | 38 |
| 20" | 30 | 34 |
| 24" | 29 | 30 |
| 30" | 27 | 24 |

Note: Pressure class 350 is for force mains 4 to 12 inches in diameter.
Pressure class 250 is for force mains greater than 12-inches in diameter.

| Table 7 | | |
|---|---|---|
| **Direct Bury Application CCFRMP (Centrifugally Cast Fiberglass Reinforced Mortar Pipe)** | | |
| **Cover Depth** | **SN Required** [*2] | **Bedding Class** [*1] |
| 0'-10' | 36 | B |
| 10'-15' | 46 | B |
| 15'-20' | 72 | B |

*1 Over 20' depth, improved bedding class required.
*2 SN = Nominal stiffness in PSI
Depth of Cover in Relation to the Specific Pipe Stiffness can increase with improved embedment conditions per manufacturer recommendations.

2. Laying Condition

   Class "B" - Pipe bedded in crushed stone to spring line of pipe, 4-inches minimum under pipe, with an initial backfill to 12-inches above top of pipe.

D. SEWER SERVICE/LATERALS

1. Plans for projects, which propose the creation of lots (subdivision) shall include individual sewer service to each parcel, including any residual parcels reserved for future lots.

2. The sizes and locations of the services shall be based on the anticipated use of the lot, for which, PWC's approval shall be required. The minimum lateral size shall be 4-inch laid on a minimum 2% grade. 6-inch lateral grades shall be a minimum of 1%.

3. Services not terminated at manholes shall be installed at right angles to the gravity sewer main using in-line wyes, or tapping service saddles on existing mains. The wyes, saddles or taps shall be separated horizontally at least five (5) feet, measured along the pipe.

4. The lateral length shall not exceed 75 feet for 4-inch or 100 feet for 6-inch. Up-sizing the lateral size to increase lengths is not acceptable.

5. The service cleanout shall be placed 18-inches inside the right-of-way in the center of the lot unless topography or sanitary sewer main location requires deviation. Cleanouts connecting to terminating manholes may be located 10 feet inside the side property lines.

6. Cleanouts connecting to a sewer main located inside an easement shall be placed at the easement limit or edge of the permanent easement and in no case shall the cleanout be placed within a temporary easement.

7. Lateral service invert elevation and curb elevation, measured at the cleanout stack, shall be shown on the plans to include street centerline station number. Generally, depths (service invert) should provide a minimum of three (3) feet of cover to a maximum depth of six (6) feet. Depth greater than six (6) feet may be approved provided the depth is necessary to gravity serve the lot. The lateral service depth should be designed to provide gravity sanitary sewer services, unless otherwise approved by PWC. The lateral cleanout minimum invert elevation shall be at least 1.4 feet above the invert of the collection main, or as otherwise approved.

8. Services, which convey sewer from car washes and similar facilities, shall include oil and sand separators, designed and installed in accordance with the North Carolina or locally approved plumbing code.

9. Grease interceptors shall be required for food service facilities and dumpster areas containing food debris and in accordance with PWC requirements.

10. PWC sanitary sewer lateral maintenance extends from the sewer main to the cleanout stack located at the edge of a permanently dedicated right of way or permanent easement.

## VI. MANHOLES

### A. LOCATION

1. The maximum distance between manholes, measured horizontally along the centerline of the gravity sewer, shall be 425 feet. On a case by case basis, and with approval from PWC, manholes may be located further than 425 feet apart

2. Manholes shall be installed:

   a. At the end of each main

   b. At all changes in pipe grade

   c. At all changes in nominal pipe size

   d. At all horizontal and vertical changes in pipe alignment

   e. At all intersections, unless otherwise approved by PWC.

3. Manholes shall be located at property lines unless prohibited by topography, ditch stream, etc. in undeveloped areas to facilitate future expansion, or in the lows by natural drainage sub basins.

4. Cleanouts shall be used in lieu of manholes for 4-inch and 6-inch private sewer lines with the maximum distances between cleanouts not to exceed 75 feet for 4-inch and100 feet for 6-inch.

5. Manholes installed in pavement shall have their cover set flush with finished grade, and shall be located outside of designated parking spaces, where possible. Whenever practical, manholes located in streets shall be located in the center of the street.

6. Manholes installed in yards and landscape areas shall have the top elevation set flush with the existing grade. Manhole tops located along outfalls in natural areas shall be set 18-inches above grade, or 24-inches above the 100 year flood elevation, whichever is greater. Manholes should not be located in ditches or roadside swales.

7. The minimum elevation difference between the centerline "invert in" and the centerline "invert out" of manholes shall be 0.05 feet. Exceptions are: 1) when there is a change in flow direction of greater than 90 degrees, the minimum difference shall be 0.2 feet; 2) when pipes of different sizes converge in a manhole, the inside tops of the pipes shall be set at the same elevation; and 3) when grade is critical. Exceptions must be approved by PWC.

B. DIAMETER

1. The minimum inside diameter of manholes shall be 4 feet (48 inches). Larger diameters are required for large (24-inch and greater) diameter sewers. A minimum access diameter of 22 inches shall be provided.

2. The minimum interior diameter for manholes containing drop structures shall be 5 feet (60 inches).

3. Where the deflection angle of the influent verses the effluent sewer mains is 45° or greater, or for larger diameter pipes, the manhole shall be up sized to accommodate the pipes' outside diameter with a minimum of 3-inches of separation between the pipes boot openings, measured along the inside manhole wall.

C. DROP TYPE

1. Vertical elevation drops through manholes should be limited to prevent turbulent conditions. If the vertical elevation difference between the "invert in" and "invert out" is: 1) greater than 12-inches, but less than 2.5 feet, a pipe slide is required to prevent solids deposition; or 2) 2.5 feet and greater, an interior drop structure is required. Invert drops thru manholes shall be accomplished by providing an invert channel of constant slope, which provides a smooth transition from the discharge elevation of the influent pipes to the effluent pipe.

2. Inside Drops: Only inside drops will be permitted for new lines using a 5-foot inside diameter manhole. For existing 4 foot manholes, an inside drop may be permitted, as approved by PWC. Drop manholes shall be constructed with inside drops, secured to the inside of the wall, and shall be positioned, in such a manner, to allow for cleaning.

3. Exterior Drops are not allowed.

4. Sewer lateral taps in manholes:

   a. If a service is proposed in the manhole at a height of 30 inches or greater above the invert, an inside drop shall be required for the service.

   b. The sewer lateral invert shall be a minimum of one (1) inch above the shelf, or sufficiently high enough to allow the installation of a flexible connector and core into existing manholes.

D. FLOW CHANNEL

1. The flow channel straight through a manhole shall be made to conform as closely as possible in shape, and slope to that of the connecting sewers. The channel walls shall be formed or shaped to three quarters (¾) of the height of the crown of the outlet sewer in such a manner so as not to obstruct maintenance, operations, mandrel pulling, inspection or flow in the sewers, etc.

2. When curved flow channels are specified in manholes, including branch inlets, minimum slopes should be increased to maintain acceptable velocities.

E. BENCH/SHELF

1. A bench/shelf shall be provided on each side of any manhole channel, when the pipe diameter(s) are less than the manhole diameter. The bench/shelf shall be sloped not less than 1 inch per foot and not greater than 2 inches per foot. The invert elevation of any lateral sewer, service connection, or drop manhole pipe, shall be above the bench/shelf surface elevation. No invert shall be located directly on the surface of the bench/shelf.

F. WATERTIGHTNESS

1. Manholes shall be pre-cast concrete. Manhole lift holes and grade adjustment rings shall be sealed with non-shrinking mortar or other material approved by PWC.

2. Inlet and outlet pipes shall be joined to the manhole with a gasketed flexible watertight connection (boot) or any watertight connection arrangement that allows differential settlement of the pipe and manhole wall to take place. Connections of new sewers to existing manhole, shall be accomplished by machine coring and the installation of a flexible connector (boot).

3. 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 easement locations or where vandalism may be a potential.

4. Manholes shall be designed for protection from the 100 year flood elevation

   a. Manhole rims shall be 24 inches (2 feet above the 100 year flood elevation or,

   b. Manholes shall be watertight and vented by use of vented covers or external vent structures, only as required for proper pipe ventilation and to insure proper hydraulic performance (e.g. inverted siphon manhole). As a general guideline vents are required at intervals of approximately 1,000 feet or every other manhole, whichever is less. All non-vented manholes shall have solid covers, and all frames and covers subject to flooding or inflow from storm water shall be sealed according to current standard specifications. Manholes with external vents shall have sealed frames and covers with vent outlet a minimum of two (2) feet above the 100-year flood protection elevation.

   c. Manholes that are subject to being pressurized by surcharging or which are likely to be vandalized shall have mechanically restrained covers. Manholes that have restrained watertight covers, which are subject to pressurization by surcharging, shall be designed to withstand the maximum potential surcharge without damage. For design purposes, the maximum potential surcharge shall be that surcharge which would result from a prolonged outage of the nearest downstream pump station.

G. BUOYANCY

1. Buoyancy shall be considered, and flotation of the manholes and/or pipe shall be prevented, with appropriate construction where high groundwater conditions are anticipated.

H. INSPECTION AND TESTING

1. The specifications shall include a requirement for inspection and testing for water tightness or damage prior to placing into service. Refer to PWC Technical Specifications for testing requirements.

I. CORROSION PROTECTION

1. In areas where the potential for release of hydrogen sulfide gas exists, concrete and ductile iron pipe and concrete structures will be protected from hydrogen sulfide induced corrosion. These areas include force main discharges, inside drops, which create turbulence, and areas where septic conditions are likely to occur.

2. Standard concrete pipe and manhole specifications provide for alkalinity control, sacrificial concrete and/or coatings. Wherever significant corrosion potential exists, the interior of concrete pipe and structures shall be fully coated and protected to a minimum distance of 50 feet upstream and downstream of each affected structure.

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

4. For those manholes that have a force main discharging into them, the interior of the manhole shall be fully coated and protected to prevent hydrogen sulfide induced corrosion. In addition, the next four (4) manholes downstream shall also be fully coated and protected against corrosion.

5. Where high flow velocities are anticipated, the manholes shall be protected against displacement by erosion and impact.

## VII. SANITARY SEWERS IN RELATION TO STREAMS AND OTHER WATER BODIES

A. STREAM CROSSINGS

1. Crossings of streams shall be minimized and as nearly perpendicular to the stream as possible. Streams shall be protected in accordance with erosion control plans and specifications and shall be stabilized immediately after construction is completed on the segment of crossing line. Depending on actual cover, stream width, flow conditions and soil conditions, the sewer pipe may require special anchorage to prevent flotation and/or washout. Each crossing must be evaluated individually. Pipe for aerial or submerged stream crossings shall be mechanical joint ductile iron

only.

a. Cover Depth

i. Sewer paralleling streams/creeks shall be designed to be below the streambed elevation, such that lateral connections will be protected as described herein.

ii. 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.

a. One (1) foot of cover where the sewer is located in rock;

b. Three (3) feet of cover in other material unless ductile iron pipe is specified; in which case, a minimum of one (1) foot of cover will be required. In major streams, more than three (3) feet of cover may be required; and

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

b. Horizontal Location

i. Sewers located along streams, lakes or impoundments, shall be located at least 25 feet outside of the stream and/or creek bank (unless subject to Item ii below) or sufficiently removed there from to provide for future possible stream widening and to prevent siltation of the stream during construction.

ii. A distance of 100 feet shall be maintained between sewers and water, classified as WS-I-PWS; and 50 feet shall be maintained for areas classified as WS-II, WS-III, B, SA, ORW, HQW, or SB from normal high water (or tide elevation) and wetlands. If the separation requirements cannot be met, the materials, testing methods, and acceptability standards meeting water main standards, as outlined in 15A NCAC 18C, shall be specified.

iii. All pump station wet wells shall be located a minimum of 50 feet from any wetland.

iv. Sewer systems shall be designed to maintain maximum feasible separations when the 50 foot separation from wetlands cannot be met.

v. Manholes within wetlands shall be in accordance with the following:

a. A water tight ring and cover (with gasket) shall be provided
b. All seams shall be externally sealed
c. A full waterproof interior coating/lining shall be provided
d. Watertight pipe connections shall be provided, consisting of a flexible rubber boot or compression type connector, as approved by PWC
e. All manholes shall be vacuum tested in accordance with PWC requirements

f. The use of “doghouse” manholes are not allowed
g. All manholes not included as part of the United States Army Corps of Engineers 404 Permit or DWQ 401 certification shall be located a minimum of 10 feet from the wetlands.

vi. Sewers shall not be installed under any part of an impoundment and/or earthen dam, without specific PWC approval. Plans may require review, and approval by NCDWR Dam Safety Section, Fayetteville Regional Office.

vii. Sewers crossing streams shall be perpendicular (90°) as practical to the streambed and in no case at an angle less than 75° or greater than 105° to the stream.

viii. Edge of the construction corridor shall not be closer than 10 feet to a stream.

ix. Intermittent or permanent stream crossing shall not have joints connected within the stream channel or within two (2) feet of banks, unless approved by PWC.

x. Construction corridor limited to 40 feet in width in wetlands and across stream channels. Wetland delineation shall be clearly shown on the plans.

c. Structures

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

d. Materials

i. Sewers entering or crossing streams shall be constructed of ductile iron material pipe with mechanical joints, and shall be constructed to remain watertight, free from changes in alignment or grade and tested to 150 psi. Material used to backfill the trench shall be stone, coarse aggregate, washed gravel, or other materials which will not readily erode, cause siltation, damage pipe during placement, or corrode the pipe.

ii. Measures shall be taken to prevent fresh concrete from coming in contact with waters of the state.

iii. Placement of rip-rap is restricted to the stream bottom, banks directly impacted and only below normal high water level.

iv. No fertilizer shall be placed within 10 feet of a stream.

B. AERIAL CROSSINGS

1. Proper joint technology, such as flanged or restrained, adequate supports prevent excessive flexion, or a combination of both, shall be provided for all aerial pipe

crossings. Supports shall be designed to prevent frost heave, overturning, and settlement.

2. Supports shall be designed to withstand the hydrodynamic effects of the stream flow pressure using the following formula:

   $$\mathbf{P = 1.5\ KV^2}$$

   Where:

   1.5 - safety factor against overturning,
   P = pressure, psf
   V = velocity of water, fps
   K = 4/3 for square ends, ½ for angle ends when angle is < 30° or less and 2/3 for circular piers. (Dimensionless)

3. If it is probable that the aerial pipe could be submerged by the stream flow, the effects of the flow pressure on the pipe shall also be taken into account when computing pier-overturning moments. For aerial stream crossings, the impact of flood waters, and debris shall be considered.

4. H-Piles shall be driven to a minimum penetration of 10 feet by an approved hammer developing not less than 7,500 ft-lbs of energy per blow. The load capacity of each pile shall be determined by the following formula:

   $$Ra = 2E/(S+0.3)$$

   Where:

   Ra = Safe load (lbs)
   E = Energy per blow (ft-lbs)
   S = Final penetration per blow (inches); (average of last 6 blows)

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

6. The bottom of the pipe should be placed no lower than the elevation of the 25-year flood. In the event that the 25-year flood elevation cannot be determined, or the proposed gravity sewer must be placed below the 25-year flood elevation, a letter shall be provided by the applicant upon certification stating: "Regular and proper inspection and maintenance of the aerial crossing shall be provided to insure that the creek/stream flow is not impeded and that no damage will be caused to upstream or adjacent properties."

7. Small streams or ditches that can be spanned with a single joint of ductile iron pipe may be anchored with concrete collars provided the collars are below grade.

C. ANTI-SEEPAGE COLLARS

1. In areas where the sewer trench is located in jurisdictional wetlands and has the potential to drain wetlands, anti-seepage collars shall be installed. A water quality and wetlands (401/404) permit shall be required. An anti-seep collar shall be placed at the downstream wetland boundary and every 150 feet until the utility exits the wetland. Wetland crossings that are open cut and less than 150 feet long do not require anti-seep collars unless specifically required by PWC.

## VIII. PROTECTION OF POTABLE WATER SUPPLIES, STORM SEWERS AND OTHER UTILITIES

A. CROSS CONNECTIONS PROHIBITED

1. There shall be no physical connections between a public or private potable water supply system and a sewer, or appurtenances thereto which would permit the passage of any wastewater or polluted water into the potable supply. No water pipe shall pass through, or come in contact with, any part of a sewer manhole.

B. RELATION TO WATER SUPPLY SOURCES

1. A distance of 100 feet shall be maintained between any private or public water supply source, including any WS-1 waters or Class I or Class II impounded reservoirs used as a source of drinking water. If this minimum separation cannot be maintained, ductile iron sewer pipe with joints equivalent to public water supply design standards and pressure tested to 150 psi to assure water tightness shall be used. The minimum separation shall not be less than 25 feet from a private well or 50 feet from a public water supply well.

2. All existing waterworks units, such as basins, wells, or other treatment units, within 200 feet of the proposed sewer, shall be shown on the engineering plans.

C. RELATION TO WATER MAINS AND SEWERS

1. Sewer mains and laterals shall be laid at least 10 feet laterally from existing or proposed water mains as measured edge of pipe to edge of pipe, unless local conditions or barriers prevent a 10-foot lateral separation. In locations where it is not practical to maintain a 10-foot separation, PWC may allow deviation on a case-by-case basis if supported by the Design Engineer provided:

   a. The water main is laid in the same trench as the sewer main and/or lateral with the water main located at one side on a bench of undisturbed earth, and with the elevation of the bottom of the water main at least 18 inches above the top of the sewer main and/or lateral, or

   b. The water main is laid in a separate trench, with the elevation of the bottom of the water mains at least 18 inches above the top of the sewer main and/or lateral, or

c. If it is impossible to obtain prompt horizontal and vertical separation as described above, or anytime the sewer main and/or lateral is over the water main, both the water main and sewer main and/or lateral must be constructed of ductile iron pipe complying with Public Water Supply design standards and pressure tested to 150 psi to assure water tightness before backfilling.

2. If a minimum of 24-inch vertical separation, between storm sewer and sanitary sewer lines cannot be provided, the sanitary sewer must be constructed of ductile iron pipe.

D. CROSSING A WATER MAIN OVER A SEWER

1. Sewer mains and/or laterals crossing water mains shall be laid to provide a minimum vertical distance of 18 inches between the outside of the water main and the outside of the sewer main and/or lateral. The crossing shall be arranged so that the sewer joints will be equidistant and as far as possible from the water main joints.

2. When it is impossible to obtain proper horizontal and vertical separation as stipulated above, one of the following methods must be specified:

a. The sewer main and/or lateral shall be designed and constructed of ferrous pipe and shall be pressure tested at 150 psi to assure water tightness prior to backfilling, or

b. Either the water main or the sewer main and/or lateral may be encased in a watertight carrier pipe that extends 10 feet on both sides of the crossing, measured perpendicular to the water main. The carrier pipe shall be of materials approved by the regulatory agency for use in water main connections.

E. RELATION TO OTHER UTILITIES

1. Underground telephone, cable TV, and conduit banks shall be crossed maintaining a minimum of 12-inch separation or clearance and 18-inches for gas utilities.

2. Where possible, electrical crossings shall be performed while the conductor is de-energized and at all times in the presence of the service provider. Electrical primary conductor crossings shall be as follows:

a. Crossing over a conductor, maintain a minimum of 12 inches of undisturbed soil encasing the conductor.

b. Crossing under a conductor shall be accomplished by boring, maintaining 12 inches of undisturbed soil encasing the conductor.

F. RELATIONSHIP OF SANITARY SEWERS TO STRUCTURES

1. Sanitary sewers shall not be installed within 20 feet of any part of permanent buildings or other structures or within a projected 1½:1 (horizontal and vertical) angle of repose as measured from the pipe centerline at bottom of trench, whichever distance is greater, unless a Geotechnical Engineer determines otherwise. Geotechnical Engineering services are encouraged. The minimum width of a

permanent Sanitary Sewer easement is 20 feet.

2. Should a sewer main be installed between two structures, the sewer main, from manhole to manhole, shall be ductile iron pipe.

G. RELATIONSHIP OF UTILITY TO NCDOT RIGHT OF WAY

1. All collection systems shall be designed, and approved by both PWC and NCDOT in accordance with both PWC "Manual for the Design and Construction of Water and Wastewater System Extensions" and NCDOT Manual "Policies and Procedures for Accommodating Utilities on Highway Rights-of-way", most recent editions.

2. Utilities to be constructed within NCDOT's right-of-way will require a NCDOT encroachment permit.

## IX. PUMP STATIONS AND FORCE MAINS

A. GENERAL

1. Pump stations and force mains design shall be in accordance with the requirements of this manual and 15A NCAC 2T .0200. Where conflicts occur in PWC and State design requirements, the more stringent requirement shall apply. In accordance with NCGS 143-215.1(a), no person shall construct, alter, extend, change, or operate any sewer system without first obtaining a permit from the Environmental Management Commission or PWC.

2. The application of standard design practices, good engineering judgment and/or more stringent or conservative design criteria than presented in this manual is highly encouraged when and where applicable and as deemed necessary.

3. The following types of projects involving pump stations and force mains shall be submitted to Department of Environment and Natural Resources for permitting:

   a. Pump station and force main projects that require an environmental assessment in accordance with 15A NCAC 1C .0100 "State Environmental Protection Act."

   b. Pump station and force main projects that involve a variance from the State's requirements of 15A NCAC 2T .0200.

   c. Pressure sewer systems utilizing septic tank-effluent pumps (STEPs) or grinder pumps (low pressure sewer systems).

   d. Flow reduction requests in accordance with 15A NCAC 2T .0114.

4. The following types of projects involving pump stations and force mains shall be considered private and deemed permitted:

   a. A building sewer, defined in 15A NCAC 2T .0303, and documented by the local

building inspector to be in compliance with the North Carolina State Plumbing Code, that involves a sewage ejector or pump station, which serves a single building with the sole purpose of conveying wastewater from that building into a gravity sewer that runs on or adjacent to the building's property.

b. A pump station documented by the local building inspector to be in compliance with the North Carolina State Plumbing Code, that serves a single building whose force main crosses property lines or runs along right-of-way and has no other pump station connections. The force main, however, shall require a permit as stipulated in 15A NCAC 2T .0303.

c. Operations that involve the routine maintenance, replacement, or rehabilitation of existing pump stations and/or force mains in accordance with 15A NCAC 2T.0303.

B. GRAVITY FLOWS VERSUS PUMP STATIONS

1. PWC's policy is to minimize the need for wastewater pump stations and to limit the construction and use within the collection system. Because pump stations are: (1) inherently less reliable, (2) more expensive to operate, and (3) more likely to cause environmental problems than gravity sewers, pump stations shall be incorporated into the design of a project only as a last alternative. Projects utilizing pump stations or creating a future need for pump stations will not be approved unless documentation satisfactory to PWC is submitted, justifying the installation of a pump station provided the area served by gravity sewers has been maximized. The pump station documentation must include:

   a. A benefit/cost comparison, comparing the cost of constructing and maintaining the station and constructing and maintaining a gravity sewer extension.

   b. The lift station can be eliminated, by a project or combinations of projects, which are, included in PWC's 6-year Capital Improvement Plan.

   c. The proposed lift station is at an appropriate location and has adequate capacity or expansion capacity to serve as a permanent or long term facility and gravity service is cost prohibitive or not possible due to other circumstances.

   d. The construction of the proposed lift station would include elimination of one or more existing lift stations.

   e. The construction of the proposed lift station would facilitate significant progress toward achievement of land use goals and strategies described by current, officially approved planning documents and no other reasonable options are available for service.

   f. In all cases, the receiving system must have available capacity to carry the proposed lift station discharge. Any upgrades required will be the responsibility of the customer requesting the lift station.

2. The Commission may agree to accept ownership and maintenance of pump stations designed and constructed to the standards set forth in this Manual subject to the

following conditions:

a. The Commission determines that acceptance of ownership is in its best interest.

b. Easement, satisfactory to the Commission, is provided for unrestricted access to, and operation and maintenance of the pump station.

3. In situations where no reasonable alternative exists, PWC may approve the installation of a privately owned and maintained pump station and force main.

C. PUMP STATION AND FORCE MAIN ENGINEERING/DESIGN CALCULATIONS & DRAWINGS

1. Engineering calculations must be signed, sealed, and dated by a North Carolina Registered Professional Engineer (PE). Such calculations shall include, at a minimum, the following items:

a. Total dynamic head calculations for all applicable pumping situations.

b. System curve/pump curve analysis used to determine pump selection and operational point.

c. Pump station cycle and pump run times, including an evaluation of any depressed sections of the force main to determine if the pump station is capable of completely flushing the force main section being evaluated in a single pumping cycle.

d. Pump station flotation/buoyancy calculations.

e. Available emergency storage capacities at average and peak wastewater flows for pump stations that have not been connected to multiple power sources.

f. Minimum velocity within the force main.

g. Maximum detention times within the pump station and force main.

2. Downstream sewer evaluation demonstrating that the pump station discharge will not overload the receiving sewer line:

a. In situations where the pump station discharges into a gravity sewer, the downstream gravity sewer shall be evaluated based on peak flow from the proposed project as well as peak flows already tributary to the downstream gravity sewer.

b. In situations where the pump station discharges into another pump station, the downstream pump station shall be evaluated to verify its ability to convey peak flows from the proposed project as well as peak flows already tributary to the downstream pump station.

c. In situations where the pump station discharges into a force main, the downstream force main shall be evaluated on peak flows from the proposed project as well as peak flows already tributary to the downstream force main. The ability of each pump station tributary to the downstream force main to pump against additional head created by greater flows through the force main shall also be evaluated. An evaluation of the discharge point of the downstream force main as described above shall also be performed.

d. TDH of the pumps shall be based on a C-factor of 120 utilizing the Hazen Williams Formula.

3. Construction record drawings that have been signed, sealed, and dated by a North Carolina PE. Such drawings shall include, but shall not be limited to, the following:

a. Plan and profile views of the force main as installed as well as its proximity to other utilities and natural resources. The locations of specific force main materials as well as any valves and other force main appurtenances shall be indicated.

b. Construction record detail drawings of the pump station.

4. Documentation that the required quality assurance/control tests were performed.

5. Proof that operation and maintenance (O&M) manuals have been supplied to the applicant following construction and commissioning of the pump station/force main system.

D. PUMP DESIGN

1. General Requirements

a. Only pumps designed and manufactured for use in conveying raw, unscreened wastewater shall be acceptable.

b. Pump selection shall consider the duty requirements as well as the physical and chemical characteristics of the wastewater being conveyed. Materials used in pump construction shall also be suitable from the physical and chemical characteristics of the wastewater being conveyed.

c. Pump stations conveying residential, commercial, institutional, or industrial domestic wastewater shall be provided with pumps that are suitable for continuous duty in conveying raw unscreened wastewater.

d. Pumps shall be capable of handling a three-inch solid and any trash or stringy material that can pass through a four-inch hose unless a mechanical means of solids reduction is installed at the pump station.

i. Pumps shall be made non-clog either by passing solids, trash, and stringy material through a non-clog or vortex-type impeller or by grinding, chopping,

or cutting them prior to passing them through the impeller. Impellers shall have blades that are generally forward rounded or otherwise configured to avoid catching solids, trash, and stringy material.

ii. Acceptable mechanical means of solids reduction shall include mechanical bar screens, communitors, dimunitors, or other similar devices. The use of a manual bar screen or trash basket at the pump station shall not be sufficient to apply this exception.

e. Pump suction and discharge openings shall be no less than four inches in diameter unless the pump is capable of grinding, chopping, or cutting solids, or a mechanical means of reducing the size of a three-inch solid and any trash or stringy material that can pass through a four-inch hose is installed at the pump station.

f. Pumps shall be designed for continuous duty pumping of raw, unscreened wastewater. Pumps shall be adequately protected from damage due to failure conditions specific to the selected pump type and pump station configuration.

g. The power source, voltage and phasing shall be certified before ordering the pumps.

2. Number and Capacity

a. Multiple pumps shall be used such that the pump station is capable of conveying the peak discharge (a <u>minimum</u> of 2.5 x average design flow) to its desired outfall location with the largest single pump out of service.

i. In duplex pump stations; the pumps shall be of the same capacity. If pumps in series are required, each set of pumps in series shall be viewed as a single pumping unit.

ii. Priming pumps, and other auxiliary system for pump functionality, shall be provided in multiple numbers.

iii. At least one standby pump and motor shall be provided.

b. Pump capacity shall be based on wastewater flow expected to become tributary to the station for the entire project at build out. For regional stations, capacity shall be based on wastewater flow expected from the entire service area over the life of the pump station.

c. Interim sizing of pumps and associated pump stations shall be allowable, although not for economic purposes. A statement of initial service capacity shall be on the drawings for projects that are approved for an interim condition. Additional wastewater flow shall not be made tributary to the station until a request for permit modification is submitted, approved, and the pump station upgraded and certified.

d. The minimum allowable design daily wastewater flow to the station shall be as follows;

   i. In accordance with 15A NCAC 2T .0114

   ii. To serve a developed service area, historical potable water use or wastewater flow generation data may be used in accordance with 15A NCAC 2T .0114. If the resulting design daily wastewater flow is less than that stipulated in 15A NCAC 2T .0114 , NCDWR must approve the flow reduction prior to permit issuance.

   iii. To serve a broad service area when development is not known, design daily wastewater flow may be based on historical data for the area or Table 1 - Guidelines for Determining Domestic Waste Quantities.

e. The peak hourly wastewater flow to the station shall be appropriate for the service area as well as the associated wastewater generation patterns and population being served by the pump station. The minimum peak hourly waste water flow to the station shall be calculated using the design daily wastewater flow in conjunction with a peaking factor determined from the following equation:

$$PF = \frac{Q_{phf}}{Q_{ddf}} = \frac{18 + \sqrt{P}}{4 + \sqrt{P}}$$

Where:

PF = peaking factor
$Q_{phf}$ = peak hourly flow (gallons per day)
$Q_{ddf}$ = design daily flow (gallons per day)
P = service population (thousands)

The above equation yields a peaking factor that is intended to cover normal infiltration and inflow for well-maintained and constructed sewer systems. In no case shall the peaking factor be less than 2.5 for any pump station.

3. Peaking factors for stations conveying industrial or process wastewater shall be based on actual operating conditions, but in no case shall the peaking factor be less than 2.5.

4. Pump capacity shall also be based upon the need to maintain a minimum force main velocity of 2 fps.

5. Selection Methodology

   a. Pump selection shall be based on a hydraulic analysis of the system. The design operating point(s) of the pump(s) shall be determined using a pump curve-system curve analysis for all TDH requirements for the lifetime of the station.

b. A system curve, plotting TDH versus capacity, shall be developed for all operating conditions. TDH for the system shall be calculated by summing the following:

i. Static head requirements for both the suction and discharge sides of the pumps shall be evaluated including intermediate high points in the force main and the discharge elevation.

ii. Friction head requirements for the suction and discharge sides of the pumps shall be evaluated. The friction head shall be calculated using the Hazen-Williams formula:

$$h_f = L\left(\frac{4.73Q^{1.85}}{C^{1.85}D^{4.87}}\right)$$

Where:

$h_f$ = friction head for pipe segment (feet)
L = length of pipe segment evaluated (feet)
Q = pumping rate ($ft^3$ per second)
C = Hazen-Williams coefficient
D = diameter of pipe segment evaluated (feet)

Conditions shall be evaluated including, multiple pump operation within the subject force main, simultaneous pump station operation for common force main situations and the possibility for gravity flow conditions in force main segments with extreme negative slopes that may not flow full.

iii. Head derived from minor losses of valves and other fittings shall be evaluated.

iv. If applicable, the pressure head at the junction of the existing force main shall also be evaluated, considering the effects of simultaneous pump station operation and multiple pump operation in other pump stations.

c. System curves shall be evaluated for present day and conditions that may exist over the expected lifetime of the pump station.

i. The following maximum values shall be allowable for C:

| **Pipe type** | **Initial Service** | **End-of-Service C** |
|---|---|---|
| DI | 125 | 100 |
| PVC | 140 | 120 |
| HDPE | 140 | 120 |

riction head and minor losses shall be evaluated for initial condition and the end-of-service condition.

iii. The design operating point(s) shall be the intersection of the pump curve and the calculated system curve(s)

d. Pumps shall be selected such that all design-operating points are on the pump curve as supplied by the manufacturer. Pumps shall be selected such that the net positive suction head available ($NPSH_A$) shall be greater than the net positive suction head required ($NPSH_R$) at each of the design operating points.

e. Pumps shall be selected such that the pumps will not cavitate. Freewheeling (i.e., operating at pump run-out) or deadheading (i.e., operating at pump shut-off) of pumps shall not be allowed.

f. Pumps shall be selected so operating efficiency is maximized during all hydraulic conditions over the lifetime of the pump station.

i. Consider minimizing motor speeds during the pump selection process.

ii. The horsepower rating of each pump motor shall be at least 1.15 times that required by the pump when operating at all design operating conditions.

iii. The selected pumps and motors shall operate at the most economical efficiency under average daily flow conditions.

6. Cycle and Pump Run Times

a. Constant speed pumps shall be cycled such that the number of starts are minimized and resting times are maximized to avoid overheating and overstressing of the pump motor.

i. Automatic pump alternation shall be provided.

ii. Pumps shall be designed to operate between two and eight times per hour at design daily flow (DDF).

iii. The following equation shall be used to determine the active storage volume (between pump on and pump off elevations).

$$V = TQ_{ddf}\left(1 - \frac{Q_{ddf}}{Q}\right)$$

Where:

V = active volume within the pump station (gallons)
T = allowable cycle time between starts (minutes)
$Q_{ddf}$ = design daily flow to pump station (gallons)
Q = pumping rate of a single pump (gallons per minute)

iv. If less than two cycles per hour will occur at DDF, or if the station is to provide equalization of hydraulic surges, measures to control odor and corrosion shall be employed when detention times cause septic conditions.

b. PWC may allow using variable speed pumps for main pump stations or stations

that discharge into a wastewater treatment facility, only if constant speed pumps are not applicable or practical.

c. Pump run times shall be such that excessive wear of the pumps does not occur.

d. At DDF, adequate time shall be provided to allow a constant speed pump to "ramp up" to full speed before the pumping cycle ends and shall not be less than or greater than those recommended by the pump manufacturer.

E. PUMP STATION DESIGN

1. General Requirements

a. Pump stations shall be designed to contain influent wastewater and minimize I/I.

b. Pump stations shall ordinarily be the above-ground type, although submersible-type lift stations may be used on a case by case basis, with approval from PWC.

2. Location and Access

a. Pump stations shall be located and designed to minimize the development of nuisance conditions (i.e., noise, odor, etc.) in the surrounding area.

b. Pump station sites shall be accessible by an all-weather roadway from a hard surface road. Wherever practicable, the roadway shall be located a minimum of two (2) feet above the 100-year flood elevation, as identified on the most recent FEMA FIRM map and shall accommodate the largest vehicle expected to service the station. The road shall be a minimum width of 12 feet and shall be constructed of 6-inches compacted ABC.

c. A 6-inch compacted ABC turn-around area of located within the site of sufficient size shall be provided to accommodate maintenance vehicles.

d. Surface water shall be directed away from the pump station in all directions.

3. Wet Wells

a. Wet wells shall have the interior walls painted in accordance with Technical Specifications, Division 09800.

b. Buoyancy shall be considered and flotation of wet wells shall be prevented with appropriate construction where high groundwater conditions are anticipated.

c. Surface water shall be directed away from the station pad in all directions.

d. Wet wells, and the access road to the site, shall be located a minimum of two (2) feet above the 100 year base flood elevation.

4. Security

    a. Access to pump station structures/equipment/appurtenances shall be restricted.

        i. All entry into pump station shall be locked.

        ii. Fencing shall be six (6) feet in height and of sufficient material to deter entry. Locked gates, a minimum of 12-feet wide, shall be provided to allow vehicular access.

    b. The pump station shall have outdoor area light with a minimum of 100-watt high pressure sodium bulb mounted a clear height of 15 feet above the ground, and indoor lighting for daylight and non-daylight hours activities for pump station maintenance.

    c. Safety placards, as required by OSHA, shall be provided and be readily visible.

    d. A Pump Station identification sign shall be posted, with the name, emergency number, and instructions to call in the event of an alarm condition or other emergency.

5. Structural Design

    a. Materials of Construction

        i. Pump station shall be in complete compliance with all Federal, State and local codes and OSHA standards.

        ii. Materials for station shall be based on installation and operating factors such as:

            a) Physical, chemical, and biological wastewater characteristics.

            b) Corrosive gas production.

            c) Soil characteristics.

            d) Groundwater presence.

        iii. Pump station structures shall be separated unless made watertight and gas-tight.

        iv. Pump station structures shall be protected from vehicular traffic.

            a) All interior walls located in the wet well or subject to hydrogen sulfide gases shall be protected in accordance with PWC Standard Specifications, Division 09800.

b. Buoyancy Protection

i. Below-ground pump station structures shall be protected from the buoyant forces of groundwater and shall be demonstrated through the use of flotation calculations.

a) Flotation calculations shall assume that the groundwater table is at ground elevation.

b) Calculations shall not add the weight of the pumps, piping, appurtenances, or wastewater in the station, in the downward forces used to counteract buoyancy.

c) Saturated weight of any soil above the extended footing of the pump station structure shall be allowed in the flotation calculations.

d) Flotation calculations shall show pump station structures will be protected from buoyancy with a safety factor greater than 1.0.

c. Flood Resistance

i. Station structures and equipment/appurtenances shall be protected from the 100-year flood.

a) Protection shall ensure that the station shall remain fully functional during a 100-year flood.

b) Protect from floodwaters by elevating structures at least two-feet above the 100-year flood elevation.

ii. The 100-year flood elevation is identified on the most recent FEMA FIRM.

d. Solids Collection

i. Wet wells shall be designed with fillets and sloped floors such that solids are moved toward pump suction piping. No projections within the wet well which would allow deposition of solids under normal operating conditions shall be allowed.

e. Depth

i. Pump Submergence Depth

a) Sufficient submergence of the pump or pump suction piping shall prevent vortexing within the wet well.

b) In no case shall the all pumps-off activation level be less than the minimum level required for successful pump operation, as recommended

by the pump manufacturer. Wet wells shall be provided with the depth required to maintain the active storage volume and the emergency storage volume as defined in PWC Standard Specifications Section 02753.

6. Piping and Valves

a. Suction and Discharge Piping

i. Pumps shall be provided with separate suction and discharge piping systems.

a) Suction and discharge piping shall be no less than four inches in diameter unless the pump is capable of grinding, chopping, or cutting solids.

b) Suction and discharge piping shall have a velocity of between two and eight feet per second with sufficient valves to effect proper operation and maintenance of the pump station during both normal and emergency, conditions.

c) Valves shall be suitable for use with raw, unscreened wastewater, as well as the normal and maximum operating pressures expected at the pump station.

1) A full closing shut-off valve shall be on the discharge piping of each pump and on the suction piping of each drywell pump.

2) A check valve shall be on the discharge piping of each pump, between the pump and shut-off valve. Check valves shall be equipped with counter weights and/or springs to prevent water hammer and back siphoning. Check valves shall be placed horizontal unless of ball check-type.

3) A plug valve shall be provided on the suction piping between the pump and the wet well if a potential exist for the wet well water level to rise above the pimp suction elevation in wet well, dry well applications.

d) All valves shall be readily accessible. Gate valves located greater than six (6) feet above floor elevation shall be furnished as chain operated. If valves are to be installed in a wet well, the shut-off valve shall be provided with an extension handle.

b. Pipe Connections

i. Flexible pipe joints shall be used on pipes between the pump station structures.

ii. Pipe inlets and outlets shall be made watertight.

iii. Core-drill or saw-cut when connections are made through existing the

structure wall, hammer taps are not allowed.

c. Water Service

i. Wherever practicable, water service shall be provided to the station.

ii. Cross-connection control for potable water services shall be provided in accordance with PWC Cross Connection requirements. Cross-connection control for reclaimed water services shall be provided in accordance with the proper regulations.

d. Bypass Pumping

i. Connections shall be provided to allow emergency bypass pumping to occur. The bypass pumping shall have quick connect couplings, as indicated in the standard detail for above-ground lift stations.

7. Appurtenances

a. Consideration shall be given to protecting pump station structures and equipment form physical damage or clogging from solid material normally present in wastewater though the use of screening and other solids reducing equipment.

b. Pump Removal Methods/Equipment

i. Provisions shall be made so that the largest piece of equipment installed at the pump station may be removed, which may include hoisting equipment or designing clearance around the pump station for mobile hoisting equipment access.

ii. Station structures shall have access hatches, doors, skylights, etc. of sufficient size such that the largest piece of equipment may be removed without damaging the integrity of the structural design.

iii. If approved by PWC, stations utilizing submersible pumps in wet wells shall provide for the removal and installation of the pumps without requiring entry into the wet well.

a) Each pump shall be provided with guide rail and a lift-out cable. Rail system and the lift-out cable shall be capable of withstanding the forces required to disengage the pump from the wet well. Rail system and the lift-out cable shall be stainless steel or other corrosion-resistant material approved by PWC, excluding use of steel or galvanized steel.

c. Access Equipment

i. Insure access for operation and maintenance is easy, unobstructed, and safe. Each station structure shall have separate means of access. Under no circumstance shall access to the wet well be provided through a drywell. Steps, ladders, stairs, landings, hatches, and other means of access shall

conform to OSHA standards and local and state building codes.

d. Ventilation Equipment

i. Stations shall be adequately vented in complete compliance with local and state building codes as well as OSHA and NFPA standards. At a minimum, pump station wet wells shall be provided with a gooseneck-type vent. Active ventilation units shall also be acceptable. Vents shall be two (2) above 100-year flood elevation, comprised of sturdy material resistant to ultraviolet light and adequately supported to withstand damage during normal and emergency operation and maintenance. Vents shall be provided with an insect/bird screen of stainless steel, aluminum, and corrosion-resistant material. Under no circumstances shall steel or galvanized steel be used.

ii. Drywells or other enclosed pump station structures into which routine operator entry is required shall either have a positive-pressure ventilation system that meets, at a minimum, the requirements of NFPA 820 "Standard for Fire Protection in Wastewater Treatment and Collection Facilities." Consideration shall be given to installing sensor and alarm systems to detect the accumulation of dangerous levels of hazardous gases.

e. Other Equipment

i. Consider controlling station temperature and humidity to a level appropriate for reliable operation of the electrical and instrumentation/control systems.

ii. Station structures other than the wet well shall be provided with a means to remove accumulated water and wastewater from the structure. All floor and walkway surfaces shall be sloped to an appropriately sized drainage pipe. Drainage pipe shall convey wastewater to the wet well or wastewater collection system and shall be higher than the high-water alarm activation level or the maximum water level expected. The drainage pipe shall be provided with device to prevent backflow of wastewater and gases from the wet well into the structure.

## F. ELECTRICAL DESIGN

1. General Requirements

a. Electrical systems for pump stations shall be designed and installed in strict conformance with NFPA 70 "National Electric Code," ANSI, as well as all applicable federal, state, and local codes. Electrical and instrumentation/control systems and components shall be protected against corrosive conditions.

b. If located in a wet well or other location where explosive or flammable gases may concentrate, electrical and instrumentation/control systems and components shall meet the requirements for a Class I, Group D, Division 1 location.

c. Each pump and motor unit shall be provided with a separate electrical supply, motor starter, alarm sensors, as well as electrical and instrumentation/control

systems and components.

i. Electrical and instrumentation/control systems and components shall be located such that they may be disconnected from outside a wet well.

ii. Cables and conduits shall be provided with seals, which are both watertight and gas-tight, and shall be protected from corrosion, and allow separate strain relief.

d. The main power feed to all pump stations shall be equipped with an above-grade, fused disconnect switch.

2. Enclosures

a. Enclosures for electrical and control components for the pump station shall be located outside of the wet well and in a location such that they are readily accessible, ensure maximum electrical and personnel safety, and are protected from damage due to vehicular traffic and flooding.

b. Enclosures shall have a NEMA-rating that is appropriate for the installation location at the pump station.

i. If not housed, enclosures shall have a minimum NEMA 3R rating. NEMA 4X enclosures shall be used in locations where the potential for flooding and the development and accumulation of corrosive gases exist. However, PWC recommends the use of NEMA 4X enclosures for all outdoor installations.

ii. Enclosures shall be protected by a conduit seal or other appropriate sealing method that meets the requirements of NFPA 70 to protect the wet well atmosphere from gaining access to the enclosure. This seal shall be located such that it will not be disturbed during routine operation and maintenance functions at the wet well for a Class I, Division 2 location.

c. All enclosures as well as all switches and indicator lights, whether mounted on an inner door or face of the enclosure, shall be provided with a label that conforms to UL descriptions and procedures.

i. The applicant's lock-out/tag-out procedures shall be considered in the design of all enclosures to be installed at the pump station.

3. Instrumentation and Controls

a. Wastewater Level Sensing Equipment

i. Pump station cycles shall be controlled by wastewater level sensing equipment in the wet well.

ii. At a minimum, wastewater levels within the wet well shall be detected by sealed mercury-type float switches. In the event that an alternate method of

level detection (i.e., bubble tube, ultrasonic meter, etc.) is used, a float switch at the high-water alarm level shall be installed as a back up.

iii. Wastewater level sensing equipment shall be unaffected by flows, etc., entering the wet well.

b. Components

i. The pump station shall be equipped with sufficient instrumentation/control systems and components to monitor and control key operating conditions.

c. Pump Station Function

i. Each pump installed at the pump station shall be provided with a "Hand-Off-Auto" select or switch.

ii. Each pump installed at the pump station shall have a cumulative pump run timer for each pump.

iii. Sufficient indicator lights shall be used to demonstrate the operational status of the pump station. At a minimum, lights shall indicate a pump on condition and a pump alarm/failure condition.

iv. Weatherproof audible and visual alarms that are external to any structure or enclosure shall be provided at the pump station. In the event of a power loss at the pump station or a failure of the automatically activated stand-by power generation source, the alarm system shall be operated from a battery back-up power source provided with continuous charge. The following minimum conditions shall be monitored, and shall cause activation of the audible and visual alarms:

a) Pump Failure.

b) Wastewater level sensing failure (if applicable).

c) High water in the wet well.

d) High-water level in the drywell sump (if applicable).

e) Loss of telemetry transmission line (if applicable).

f) Loss of power supply.

g) Automatically activated stand-by power generation source failure.

v. It is required that a telemetry system be installed at all pump stations and inspected once a week. The telemetry system shall meet all PWC standards. Stations not connected to a telemetry system (approved PWC variance) shall be inspected everyday including weekends and holidays.

a) The telemetry system shall contact personnel capable of initiating a response to a pump station alarm condition 24 hours per day, 365 days per year.

b) In the event of a power supply loss or a failure of the automatically activated stand-by power generation source, the telemetry system shall be operated from a battery back-up power source with continuous charge.

c) At a minimum, the telemetry system shall be activated for any of the following alarm conditions: high water in the wet well, pump failure, loss of power supply, and automatically activated stand-by power generation source failure.

d. Appurtenances

i. 110-volt electrical receptacles shall be provided for maintenance. Outdoor receptacles shall be ground fault interruptible type protected from the weather.

ii. The pump station shall be provided with an automatically activated standby power generation source. All privately maintained pump stations shall meet the criteria set forth in this design manual and the State regulations.

4. Reliability

a. One of the following reliability options shall be incorporated into the pump station design:

i. The pump station shall be connected to multiple power sources (PWC approved variance).

a) A multiple power source shall be defined as a completely separate power feeder line(s) connected to the pump station from a substation or transformer that is independent from the primary feeder.

b) Each separate substation or transformer and associated transmission lines shall be capable of starting and operating the pump station at its rated capacity.

ii. The pump station shall be connected to an automatically activated stand-by power generation source with automatic reset.

a) The generation unit shall be capable of powering the pump motors' starting current, electrical systems, instrumentation/controls and alarm systems, and other auxiliary equipment as may be necessary to provide for the safe and effective operation of the pump station.

b) The generation unit shall have the appropriate power rating to start and continuously operate under all connected loads.

c) The generation unit shall be provided with special sequencing controls to delay lead and lag pump starts unless the generating unit has the capacity to start all pumps simultaneously while the auxiliary equipment is operating.

d) The generation unit shall be protected from operating conditions that would result in damage.

e) The generation unit shall be capable of shutting down and activating the audible and visual alarms and telemetry (if applicable) if a damaging operating condition develops.

f) The generation unit shall be protected from damage when restoration of the power supply occurs.

g) The generating unit shall be located in a building structure or otherwise protected from the weather elements and shall be adequately ventilated.

h) The generation unit shall be provided with on-site fuel storage. In no case shall the fuel storage be less than that needed to operated the generating unit for 12 continuous hours.

i) Stations that provide reliability through the use of permanent generation units used in conjunction with manual transfer switches shall meet the telemetry system and wet well storage requirements.

b. Demonstrate a history of power reliability for the power supply serving the pump station.

i. This option is available only to those pump stations whose failure would impact surface waters that are classified as C in accordance with 15A NCAC 2B .0100.

ii. Three years worth of data from the power supplier shall be obtained and examined to determine the maximum power outage time at the pump station. Storage shall be provided in the wet well above the high-water alarm level to hold the wastewater expected to become tributary to the pump station over that period of time.

iii. Utilizing this option to demonstrate pump station reliability shall be at the applicant's own risk, and the applicant shall be aware that selection of this option does not relieve the applicant of liability or future enforcement problems should a discharge of wastewater occur at the pump station. It is very strongly recommended that, at a minimum, a telemetry system be installed at the pump station, if this reliability option is selected.

G. FORCE MAIN DESIGN

1. Material

   a. Pipe material and specifications shall be selected based on the installation and operating conditions of the force main following installation. Such factors shall include, but shall not be limited to:

      i. Installation depth and overburden pressure.

      ii. Soil conditions and groundwater presence.

      iii. Corrosion resistance from both external and internal sources.

      iv. Strength required to withstand internal pressures expected during normal operation as well as those resulting from hydraulic surges and water hammer.

   b. Force main materials shall be in accordance with PWC Standard Specifications.

2. Force Main Diameter

   a. A minimum four-inch force main shall be used unless the force main is served by pumps capable of grinding, chopping, or cutting solids, or a mechanical means of reducing the size of a three-inch solid and any trash or stringy material that can pass through a four-inch hose is installed in the pump station.

3. Velocity

   a. Wastewater velocity occurring in a force main shall be calculated using the continuity equation:

$$v = \frac{0.409Q}{D^2}$$

Where:

v = velocity (feet per second)
Q = pumping rate of single pump (gallons per minute)
D = diameter of pipe segment evaluated (inches)

   b. A self-cleansing velocity of at least two feet per second shall be provided.

   c. 90º bends will not be allowed on force mains.

4. Accumulation of Solids

   a. Consider preventing or alleviating the accumulation of solids in the force main by providing one or more of the following:

      i. Velocities of between three and five feet per second. Velocities greater than

eight feet per second are unacceptable.

ii. Drain or blow-off valves provided at all low points in the force main, designed to prevent discharge during operation.

5. Anchorage

a. Force mains shall be adequately anchored with thrust blocks or RJ pipe bends, tees, plugs, and at any other location where a change in flow direction occurs.

6. Surge and Water Hammer

a. Consider analyzing force mains in conjunction with associated pump stations with respect to the development of hydraulic transients.

b. Force main design shall be such that active devices for control of transient hydraulic conditions are minimized to the greatest extent possible. However, if this is not feasible, the following shall be acceptable control strategies:

i. Variable-speed pumps or constant-speed pumps in combination with control valves that open and close slowly.

ii. Providing air-scouring velocities in the force main.

iii. Construction of the force main using a higher-strength pipe.

iv. Vacuum relief valves.

v. Specialized control and/or release valves and other devices designed to prevent transient pressures from reaching levels that could damage the pump station and force main systems.

7. Appurtenances

a. Air Release and Vacuum Relief Valves

i. The route of the force main shall be such that the, number of air release and vacuum relief valves are minimized. An air release valve shall be provided at all high points where the distance between the low point and high point in the force main exceeds 10 vertical feet.

a) Automatic or manual air release valves shall be acceptable.

b) Consider using manual air release valves in lieu of automatic air release valves or providing automatic air release valves with flood protection in areas within the 100-year floodplain or anywhere flooding is anticipated to occur. Automatic air valves shall be of the quick-opening, slow-closing type to prevent the development of hydraulic surge conditions.

c) If possible, force mains should be designed without high points and with

the top of the force main below the hydraulic grade line at the minimum-pumping rate so that air release valves will not be needed. If elimination of high points is not feasible, a manual air-release valve should be installed at each significant high point where air could become trapped. A high point may be considered significant if it is two feet or more above the minimum hydraulic grade line or when pumping is intermittent above the static head line.

d) The maximum interval between air release valves should not exceed 1,500 feet as measured horizontally along the pipe centerline.

e) Where the invert elevation of a force main exceeds the hydraulic grade line, the Engineer shall ensure that the force main pipe is of sufficient strength to withstand the internal vacuum, which will exist in the line during maximum service discharge. Upon request, the Engineer shall supply PWC with documentation demonstrating that the deflection of the pipe due to vacuum will not cause leakage.

f) Air release valves for wastewater force mains shall be installed as shown in the Standard Details.

ii. Consider locating vacuum relief valves at locations along the force main where sub-atmospheric pressures or column separation may occur.

H. MINIMUM SEPARATIONS BETWEEN FORCE MAINS AND STREAM CROSSINGS/PRIVATE PUBLIC WELLS

1. Force mains shall be routed such that the number of stream crossings is minimized. The crossing shall be as nearly perpendicular to the stream flow as possible. Ductile iron pipe with joints equivalent to water main standards shall be used to construct force mains that cross-streams.

2. Ductile iron pipe with flanged joints, with adequate supports, shall be used for aerial stream crossing. Supports shall prevent frost heave, overturning, and settlement, freezing, heaving, and the impact of floodwaters and debris shall be considered during the design of aerial crossings. The bottom of the force main pipes shall be placed no lower than the elevation of the 25-year flood stage of the stream.

3. Force mains shall not be closer than 25 feet from any private water supply well or 50 feet from a public water supply well.

I. QUALITY ASSURANCE AND QUALITY CONTROL

1. Six Operations and Maintenance (O&M) Manuals shall be prepared for each pump station and shall be made available to PWC upon start-up of the pump station/force main system.

2. A copy of the O&M Manual shall be kept at PWC's main office. The O&M Manual shall be kept on file for the life of the pump station and updated as required.

3. At a minimum, O&M Manuals shall contain the following information:

    a. Approved shop drawings, including design data for all installed equipment and each major component and a pump curve/system curve analysis showing the design operating point(s).

    b. Control panel wiring diagrams.

    c. Warranty information for all installed equipment and each major component.

    d. Inventory, functional descriptions, and complete operating instructions for all installed equipment and each major component.

4. Instructions for start-up/shut-down as well as for calibration and adjustment of all installed equipment and each major component.

    a. Recommended maintenance management system, including preventative and predictive maintenance, for all installed equipment and each major component.

    b. Contingency plan and analysis of critical safety issues.

    c. Contact information for local service companies as well as instructions for replacement of all installed equipment and each major component.

    d. Contact information for local contractors capable of performing emergency repairs.

    e. Contact information for regulatory and other agencies.

5. Testing

    a. Refer to Master Specifications for sanitary sewers and manholes, force mains, pump stations and electrical.