City of Tuscaloosa
Manual for the Design of Sanitary Sewers

2010 Edition

OFFICE OF CITY ENGINEER

Prepared By:
Almon Associates, Inc.
Consulting Engineers and Surveyors
2008 12th Street
Tuscaloosa, AL 35403

Revised By:
City of Tuscaloosa
February 2010

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 DEFINITIONS / ABBREVIATIONS 2

3.0 ENGINEERING DESIGN SUBMITTALS 3

3.1 Preliminary Engineering Design and Submittals

3.2 Final Design Submittals

4.0 GENERAL LOCATION CRITERIA 5

5.0 DESIGN GUIDELINES FOR GRAVITY SEWERS. 6

5.1 Population and Land Use Projections

5.2 Wastewater Flow Projections
- 5.2.1 Single Family Residential Wastewater Flows
- 5.2.2 Multi-Family Residential Wastewater Flows
- 5.2.3 Residential Wastewater Flow Peaking Factor
- 5.2.4 Sample Calculation
- 5.2.5 Non-Residential Wastewater Flows
- 5.2.6 Design Flow

5.3 Manhole Design Criteria
- 5.3.1 Manhole Placement, Spacing, and Sizing
- 5.3.2 Location of Manholes
- 5.3.3 Headloss thru Manholes
- 5.3.4 Manhole Linings

5.4 Hydraulic Design of Gravity Sewer System
- 5.4.1 Sizing of Pipe
- 5.4.2 Slopes
- 5.4.3 Minimum Depth of Cover

5.5 Computation Worksheet for Gravity Sewer Design

5.6 Evaluation of Impact to Existing Sewers

5.7 Pipe Materials Selection and Design Criteria for Gravity Sewers
- 5.7.1 Polyvinyl Chloride (PVC)
- 5.7.2 Ductile Iron Pipe (DIP)
  - 5.7.2.1 Ductile Iron Pipe Coatings and Linings
  - 5.7.2.2 Ductile Iron Pipe Polyethylene Encasement

6.0 DESIGN GUIDELINES FOR SERVICE LATERALS 15

6.1 Service Lateral Materials

6.2 Service Lateral Installation

7.0 DESIGN GUIDELINES FOR PRESSURE SEWERS 16

7.1 Pressure Sewer Velocity

7.2 Pressure Sewer Layout

7.3 Pressure Sewer Air and Vacuum Release

7.4 Low Pressure Sewers

7.4.1 Flushing Connections
7.4.2 Polyvinyl Chloride (PVC) for Low Pressure Sewers

7.5 Force Mains

7.5.1 Polyvinyl Chloride (PVC) Force Mains
7.5.2 Ductile Iron Force Mains

7.6 Evaluation of Impact to Existing Sewers

APPENDICES

Appendix A FIGURES

Appendix B TABLES

Appendix C MISCELLANEOUS INFORMATION (CWSRF EID)

Appendix D CITY OF TUSCALOOSA MINIMUM SANITARY SEWER CONSTRUCTION SPECIFICATIONS

Appendix E CITY OF TUSCALOOSA STANDARD DETAILS FOR SEWER CONSTRUCTION

1.0 INTRODUCTION

The purpose of this manual is to provide minimum requirements for the design of gravity sewers, low pressure sewers, and force mains in the City of Tuscaloosa. This manual should be used in conjunction with the attached appendices.

Private sewer lines that connect either directly or indirectly to the City's collection system shall be subject to the requirements stated in this design manual, the Sanitary Sewer Construction Specifications, and the Standard Details for Sewer Construction. Direct or indirect connections to said system by roof drains, yard drains, foundation drains, or other sources of inflow shall be strictly prohibited.

The basic methodology presented in this manual is to establish minimum requirements and should not be accepted as a comprehensive design document. Acceptance of plans by the Office of the City Engineer ("OCE") shall not relieve the owner/developer of any errors or omissions that may result due to a lack of adherence to this manual or due to engineering judgement used for those matters not exclusively addressed by the manual. Furthermore, acceptance by the OCE will not restrict OCE from requiring additional information deemed necessary for a thorough and proper review.

The Owner/Developer shall obtain the services of a Professional Engineer licensed in the State of Alabama. The services provided shall include surveying by a licensed Professional Land Surveyor and engineering design by a Professional Engineer. The Owner/Developer shall also obtain the services of a Professional Engineer to provide resident observation/inspection during the construction of the sanitary sewer project.

Projects funded in part or in whole by the Clean Water State Revolving Fund ("CWSRF") shall satisfy all requirements as set forth in the CWSRF Pre-Application Form and the CWSRF Loan Application. The CWSRF Loan Application requires preparation of an Environmental Information Document ("EID"). The EID provides detailed information regarding the following:

A. Existing Environment,
B. Existing Facilities,
C. Need for Proposed Facilities,
D. Proposed Facilities and Proposed Funding,
E. Alternative Analysis,
F. Physical Data, and
G. Environmental Consequences and Mitigative Measures.

A copy of the EID Outline from the CWSRF Loan Application – Fiscal Year 2006 has been included in Section 10.0 of this manual. Current versions of the CWSRF Pre-Application and CWSRF Loan Application (including the EID) may be downloaded from the ADEM Website (www.adem.state.al.us). The EID shall be submitted as a requirement of the Final Design Submittals reviewed in Section 3.2.

2.0 DEFINITIONS / ABBREVIATIONS

1. ADEM – Alabama Department of Environmental Management

2. Aggressive Soil - a soil deemed corrosive or potentially corrosive to ductile iron pipe according to Appendix A of ANSI/AWWA C105/A21.5. The test methods to determine soil corrosivity outlined in Appendix A evaluate five soil parameters: resistivity, pH, redox potential, sulfide content, and moisture content. A points system is provided for each parameter based on the results of the tests. If the points total 10 or more, the soil is corrosive to ductile iron pipe, and protection against exterior corrosion should be provided. Other parameters listed in the appendix which require consideration include: soil description, potential stray direct currents, and experience with existing installations. See the Appendix A for further details.

3. ANSI – American National Standards Institute

4. ASTM – American Society for Testing and Materials

5. AWWA – American Water Works Association

6. City – the City of Tuscaloosa; as defined in Section 1-2 of the Code of Tuscaloosa, including its duly authorized deputy, agent, or representative.

7. Contractor – the individual, firm, partnership, or corporation licensed by the Alabama Licensing Board for General Contractors who, for a fixed price, commission, fee, or wage undertakes to construct or superintend or engage in the construction, alteration, maintenance, repair, rehabilitation, remediation, reclamation, or demolition of any building, highway, sewer, structure, site work, grading, paving or project or any improvement in the State of Alabama where the cost of the undertaking is fifty thousand dollars or more.

8. DR – Dimension Ratio. Ratio of average outside diameter to minimum wall thickness of pipe.

9. Engineer – A Professional Engineer licensed by the Alabama State Board of Engineers and Land Surveyors and employed by the owner/developer to perform detailed design of the sanitary sewer system. The Engineer shall prepare plans and specifications for review by the ADEM, the City, and any other relevant government agency.

10. Easement – A right to make use of or control the property of another for a limited purpose.

11. Force Main – a pressurized sewer line, with a pipe diameter of four inches or greater, by which wastewater is transported from a sewage pumping station to a point of higher elevation in the collection system from which the wastewater can gravity flow.

12. Lateral – A private sewer generally serving a single user or establishment that generally should have no tributaries to it and which is capable of contributing wastewater into the System by accessing a sanitary sewer or sewer main, line, or inceptor. Laterals do not form part of the City's sanitary sewer system and are not maintained by the City.

13. Private Sewer – A sanitary sewer which is not a sanitary sewer or sewer main, line or interceptor of the system as herein defined and is or was constructed and/or owned by an entity other then the City, not maintained, and/or accepted for maintenance by the City and/or not located within public rights-of-way, easements or interest in land sufficient for that purpose and /or which the City has no pecuniary interest.

14. Low Pressure Sewer – a pressurized sewer line, with a pipe diameter of less than four inches, by which wastewater is transported from a sewage pumping station to a point of higher elevation in the collection system from which the wastewater can gravity flow. Low pressure sewers generally service grinder pumps and septic tank effluent pumps.

15. OCE – Office of the City Engineer; this shall include City Engineer or representative thereof.

16. Owner/Developer – Any person, firm, partnership, corporation or other legal entity or their representative seeking a sanitary sewer permit for the purpose of constructing a developer sanitary sewer or any person, firm partnership, corporation or legal entity that has been issued a sanitary sewer permit. The terms owner and developer shall be used interchangeably.

17. Pressure Sewer – Low pressure sewers and force mains.

18. Sanitary Sewer – A pipe or conduit used for the transport of wastewater and to which storm, surface and groundwater are excluded. These shall include gravity sewers, low pressure sewers, or force mains.

19. Sanitary Sewer System – The POTW and all city sanitary sewers or sanitary sewer mains, lines, collectors, interceptors, lift stations and related facilities of the City for the collection, transportation and treatment of wastewater, not including laterals or private sewers.

20. SDR – Standard Dimension Ratio. Ratio of average outside diameter to minimum wall thickness of pipe.

3.0 ENGINEERING DESIGN SUBMITTALS

3.1 Preliminary Engineering Design and Submittals

After estimating the design flow (as outlined in Section 5 of this manual) for the proposed development or improvement, the owner/developer's engineer shall submit to the OCE the following items three weeks prior to the Preliminary Plat submittal for a subdivision type development and three weeks prior to the Land Development Permit Meeting for a non-subdivision type development (all maps to be of appropriate scale).

1. **Topographic Map** outlining the drainage area.
    a. Maximum scale of 1"= 500' unless otherwise approved by the OCE.
    b. Include any existing developments in addition to the proposed development(s) within the same drainage area.

2. Land Use and Zoning Map for the drainage area.
    a. Provide acreage of each land use/zoning classification.

3. Wastewater Flow Projection (i.e. Q_{DESIGN}) for the proposed development.
    a. Provide flow monitoring data of similar developments or assumed design flowrates and peaking factors.
    b. Provide assumptions regarding total number of housing units and housing density.

4. Preliminary Construction Plans in the following format
    a. Title Page that will include a vicinity map, project name, and project information
    b. Index Page/Plans Legend Page
    c. Typical Section Page
    d. Project Notes Page (This page may be on the same page as Typical Section Page)
    e. Summary of quantities (if applicable)
    f. Standard Plan over Profile Sheets (Profile views that are on a separate sheet from the matching plan view will not be accepted)
        - Proposed Sanitary Sewer Manholes should be labeled in the order of downstream to upstream manholes.
        - Include size and location of existing sewer(s), manholes, and/or pump station where proposed line will connect to the existing system. Each existing City of Tuscaloosa Sanitary Sewer Manhole should be labeled with the City's specific identification number. The identification number can be obtained at http://207.157.9.126/sanitarysewer or from the City of Tuscaloosa Wastewater Engineer.
        - Location and size of any potable water lines should be included on the sanitary sewer plan and profile sheet
    g. Erosion Control Plan Sheet
    h. City of Tuscaloosa Standard Details

5. Adjacent contributing future areas within the same drainage area.

6. Capacity review of existing system to determine adequacy of existing system to accept additional proposed flows (see Sections 5.6 and 7.6). This capacity review shall be taken to the extent determined by the OCE.

The three week review period will provide the OCE with the opportunity to review the contributing design flow projections, review the feasibility of the proposed system, and make recommendations to the proposed system that would facilitate the planning of the City's sewer system. The owner/developer's engineer shall be present at the Land Development Permit Meeting to discuss issues of concern.

3.2 Final Design Submittals

After gaining approval of preliminary engineering design and submittals outlined in Section 3.1, the owner/developer's engineer shall submit final design plans and specifications for the proposed project to the OCE for review. The owner/developer's engineers shall deliver four (4) complete sets of the drawings and specifications along with an electronic CAD file for the project to the OCE prior to beginning construction.

The following items shall be included in the final design submittal:

1. Detailed Plans and Specifications for the proposed project stamped by the Engineer;
2. Soils test results to determine soil corrosivity (if required);
3. CWSRF EID (if required).

4.0 GENERAL LOCATION CRITERIA

Gravity sewers, low pressure sewers, and force mains shall be located using sound engineering practices to determine a cost-effective route that best serves the entire tributary area. The best route will provide service to the greatest number of people within a service area, and be acceptable to the OCE. To determine the "best" route that meets the City's specifications, consideration must be given to several factors in addition to cost. Some of these factors include:

1. rim elevation and all invert elevations of existing sewers, pump stations, and/or treatment plant;
2. sewer depths required to service users (particularly those with basements);
3. impact to environmentally sensitive areas such as streams, wetlands, protected habitats, etc.;
4. impact to areas of archeological significance;
5. existing utilities (overhead and underground), railroads, and highways;
6. existing or proposed high water elevation and/or floodplain;
7. property values, easement requirements, and aesthetic concerns of affected properties;
8. potential development and street extensions within the basin;
9. topographic features such as creek crossings and rock excavation;
10. accessibility by sewer maintenance equipment;
11. adjoining property within the drainage area.

Because of the significant costs that can be associated with easement acquisition, sanitary sewers should be located within existing easements and rights-of-way when practical.

For the City of Tuscaloosa, gravity sewers, low pressure sewers, and force mains shall generally be located in the street rights-of-way. If necessary, sections may require locating in dedicated sewer easements. The minimum easement width shall be 20 feet, or that necessary due to sewer depth to allow for construction and maintenance. Easement widths shall not vary between manholes. If the easement width needs to change, the wider width shall extend a

distance of half (½) the larger easement width past the centerline of the manhole. Sanitary sewer piping shall lay in the centerline of the easement.

Table 4.1 suggests the minimum easement widths required for varying excavation depths.

TABLE 4.1 MINIMUM EASEMENT WIDTHS*

EXCAVATION DEPTH** (FEET)	MINIMUM WIDTH OF PERMANENT EASEMENT (FEET)
0 – 8	20
8 – 12	30
12 – 16	40
16 – 20	50

* For easement widths less than those recommended, or for excavation depths greater than 20 feet, special approval from the OCE will be required.

** Excavation depth measured from flowline of pipe.

One location criterion of particular importance is the separation between sanitary sewers and water mains. In accordance with the *ADEM Design Guidance for Drinking Water Facilities*, separation between sanitary sewers and water mains shall be a minimum of 5 feet horizontally. Where crossing a water main, the top of the sanitary sewer shall be a minimum of 18 inches below the bottom of the water main. Where this minimum separation can not be maintained, the sewer line shall be cased with steel casing pipe, along with the associated casing spacers and casing end seals, such that a minimum five-foot separation exists between each end of the cased pipe and the uncased pipe. Casing installation shall be similar to Standard Detail SD 105 (Appendix E).

Sewers shall not run parallel under concrete curbs or gutters. To allow for maintenance, the minimum distance between the edge of the curb and the centerline of a parallel sanitary sewer shall be 5 feet. Sanitary gravity sewers shall generally be located as close as practical to the street centerlines.

Several of these location criteria / restrictions will be discussed throughout the body of this manual. Standard details have also been developed and adopted by the OCE that address many of these location criteria.

5.0 DESIGN GUIDELINES FOR GRAVITY SEWERS

5.1 Population and Land Use Projections

The preliminary step in performing sewer design requires the estimation of the service area population. Population and land use projections should be performed for the service area for:

1) a 20-year period, and
2) saturation conditions (ultimate tributary conditions).

The development of these projections requires good engineering judgment and consultation with the City's Planning Department. The owner/developer's engineer shall submit the projections to the OCE for review and, if necessary, adjustment.

5.2 Wastewater Flow Projections

Wastewater flows are generally divided into two categories – Residential and Non-Residential. In order to determine the design flow from a service area, average daily flows must be estimated. A peaking factor must then be applied to determine the maximum hourly flow. The maximum hourly flow from a particular service area is the design flow from which hydraulic design of the system may begin. *If available, historical flow monitoring data for similar developments should be used to determine the design flow. In certain instances, specialized land use may require that a separate (site specific) analysis be performed to obtain an accurate wastewater flow estimate.*

5.2.1 Single Family Residential Wastewater Flows

The average daily flow for single family residential areas shall be calculated using the following criteria:
Q_{AVG} = 100 gals / capita-day, and/or 3.5 persons / lot.

This flowrate includes a 25% allowance for inflow and infiltration.

5.2.2 Multi-Family Residential Wastewater Flows

The average daily flow for multi-family residential areas shall be calculated using the following criteria:
Q_{AVG} = 80 gals / capita-day, and/or 2 persons / dwelling unit.

This flowrate similarly includes a 25% allowance for inflow and infiltration.

5.2.3 Residential Wastewater Flow Peaking Factor

The residential wastewater flowrate peaking factor shall be selected from Table 5.2.3.1, or as approved by the OCE. The peaking factor shall not exceed 4.0.

TABLE 5.2.3.1 PEAKING FACTORS FOR RESIDENTIAL FLOWS

POPULATION	PEAKING FACTOR (PF)
100	4.0
500	4.0
1,000	3.8
2,500	3.5
5,000	3.3
10,000	3.0
100,000	2.0

The calculation for the maximum hourly flow (i.e. peak) or design flow is as follows:

$Q_{DESIGN,\,(RES)} = Q_{AVG} * PF.$

5.2.4 Sample Calculation

Determine the design flow (i.e. maximum hourly flow) for a single family residential development with an anticipated population of 500 persons.

Step 1 - Determine average daily flow and convert to cubic feet per second.

$$Q_{AVG} = (500\,person)\times\left(\frac{100\,gal}{capita-day}\right)\times\left(\frac{1\,ft^3}{7.48\,gallons}\right)\times\left(\frac{1\,day}{24\,hr}\right)\times\left(\frac{1\,hr}{3600\,\text{sec}}\right)$$

$$Q_{AVG} = 0.0774\ cfs$$

Step 2 - Determine design flow by applying peaking factor to average daily flow.

$$Q_{DESIGN} = (0.0774 cfs)\times(4.0)$$

$$Q_{DESIGN} = 0.3095\ cfs$$

5.2.5 Non-Residential Wastewater Flows

Non-Residential Wastewater Flows are derived from Industrial, Commercial, Institutional, and Recreational land uses. Because waste water flow rates may vary widely even within similar non-residential developments, extensive effort should be made to obtain an accurate flow estimate. When no specific flow data are available, Tables 5.2.5.1 thru 5.2.5.4 may be used to determine average flow rates. A peaking factor of 2.0 shall be applied to all non-residential average flowrates to obtain maximum hourly flows.

The calculation for the maximum hourly flow or design flow is as follows:

$$Q_{DESIGN, (NON-RES)} = Q_{AVG} * PF.$$

For large tracts of proposed developments, Table 5.2.5.5 below may be used to estimate wastewater flows from commercial and industrial land uses.

Table 5.2.5.5 COMMERCIAL / INDUSTRIAL WASTEWATER FLOWS

COMMERCIAL FLOW				INDUSTRIAL FLOW			
Avg. Daily (gpd/acre)	I/I @ 25%	Total Avg. Daily Flow (gpd/acre)	Peak Flow* (gpd/acre)	Avg. Daily (gpd/acre)	I/I @ 25%	Total Avg. Daily Flow (gpd/acre)	Peak Flow* (gpd/acre)
400	100	500	1,000	1,300	325	1,625	3,250

* Peaking Factor = 2.0

5.2.6 Design Flow

The design flow from which hydraulic design of the system may begin consists of the maximum hourly flows from residential and non-residential developments:

$$Q_{DESIGN} = Q_{DESIGN, (RES)} + Q_{DESIGN, (NON-RES)}.$$

5.3 Manhole Design Criteria

The primary purpose of a manhole is to allow aboveground access to the sewer for inspection and maintenance purposes. The design of the sanitary sewer system shall comply with the requirements listed in this section. All manholes shall be precast concrete unit. Pour-in-place manholes or precast manholes deeper than 20 feet require that special design be submitted to the OCE for approval.

5.3.1 Manhole Placement, Spacing, and Sizing

Manholes shall be placed at the following locations:

- upper reach of each line;
- grade, pipe size, or alignment changes;
- sewer junctions; and
- within maximum spacing requirements.

The maximum manhole spacing shall be limited to 500 feet. Greater spacing may be allowed for large sewers or where site-specific conditions require such. Spacing greater than 500 feet requires approval from the OCE.

Minimum manhole diameter shall be as indicated below.

TABLE 5.3.1.1 MINIMUM MANHOLE DIAMETER*

PIPE SIZE (INCHES)	MINIMUM DIAMETER (INCHES)
8 – 24	48
30	60
≥ 36	As Directed by The City

* See manufacturer's recommendation for deflection angles at manhole greater than 45°.

5.3.2 Location of Manholes

Manholes shall be located outside areas subject to flooding or runoff when possible. Sewers located along drainage channels or structures, or in low-lying areas, shall be designed with the rim elevation 1 foot above the 100-year flood elevation to lessen the possibility of storm water entering the sanitary sewer. In these areas adjustment rings are not allowed for height adjustment and the surrounding ground shall be built up around the manhole so that the rim elevation is no higher than two feet above the ground elevation. The surrounding ground in these cases shall be constructed to provide a minimum of a three feet horizontal area around each manhole. The horizontal area shall be sloped away from each manhole at a ¼ inch per linear foot slope for a minimum of three feet, then sloped at a 3:1 slope to tie to the existing ground. Where raised manholes are not allowed, manholes shall be equipped with watertight frames and covers. Manholes to be located within the 100-year flood elevation shall be equipped with manhole section anchor assemblies. Where required by the OCE, an access road shall be constructed to allow access to all manholes. For manhole installation within a 100-year flood zone, refer to Standard Detail SD 057.

Manholes located in streets shall be placed a minimum of 5 feet from the edge of curb or pavement (within pavement limits); manholes shall be positioned outside the normal tire path of vehicles. For manholes located in swampy areas within the 100-year flood zone or in fill areas, a reinforced concrete spread footing shall be required. The spread footing shall be designed for the total weight of the precast manhole structure, plus the calculated weight of water to within one foot of the top of the manhole. The size of each spread footing shall be designed to equally distribute this total load to the soil without exceeding the allowable soil bearing pressure. Calculations for each manhole spread footing shall be submitted to the OCE for review.

5.3.3 Headloss thru Manholes

The following practices listed in Table 5.3.3.1 shall be adopted to account for entrance and exit losses from flow thru the manholes. Where the difference in invert elevation of two or

more sewers, 18 inches in diameter or smaller, intersecting one manhole is 2 feet or more, a drop manhole shall be constructed. Drop manholes should be avoided if possible. The practice of using a 1.9-foot invert drop across a manhole to lessen excavation depths shall not be acceptable. Pipes shall be laid up to the maximum allowable slopes to avoid drop manholes.

TABLE 5.3.3.1 HEADLOSS THRU STANDARD MANHOLES

FLOW CONDITION THRU MANHOLE	INVERT DROP ACROSS MANHOLE
No change in pipe size	0.1 ft elevation drop in invert of exiting pipe, not to exceed 0.75 ft. Unless approved by the OCE.
No change in pipe size or increase by only one pipe size and alignment changes by 90°.	0.2 ft elevation drop in invert of exiting pipe, not to exceed 0.75 ft. Unless approved by the OCE
Increase in pipe size by 4 inches or more.	Match crown elevations at centerline of manhole.

The maximum deflection angle of sewer alignment at manholes shall be 90 degrees.

These standard headloss requirements are applicable to subcritical flow conditions which are characterized by slow, tranquil flow often seen in gravity systems. However, as slopes become steeper, the pipe flow velocities will approach critical flow. When this becomes a concern, the hydraulic grade line (HGL) shall be calculated and its elevation shown at manholes and transition structures. If the flow velocity entering any of these structures is above critical, the HGL must be computed to ensure that no service connections and/or the exiting pipe are surcharged due to the occurrence of a hydraulic jump. With higher velocities, entrance and exit losses at manholes should be calculated using appropriate loss coefficients and compared to those in Table 5.3.3.1. The HGL should never exceed the pipe crown in a gravity system.

5.3.4 Manholes Linings

When required by the OCE, manholes shall be protected from corrosion by the use of factory applied ceramic epoxy linings. At a minimum, manholes located in the following locations shall be lined:

1. manholes located within 150 feet upstream of a pumping station,
2. manholes directly receiving flow from a force main of 10 inches or greater, and
3. if conditions dictate, at the discretion of the OCE.

5.4 Hydraulic Design of Gravity Sewer System

The hydraulic design of a gravity sewer system shall be based on the Manning Equation which is stated in the form:

$$V = (1.486/n)\, R^{2/3} S^{1/2} \qquad (1)$$

where V = velocity (feet per second),
n = roughness coefficient,
R = hydraulic radius (feet)
= cross-sectional area of flow / wetted perimeter,
S = slope of energy grade line (ft/ft) or, for uniform flow,
= slope of pipe (ft/ft).

Assuming full pipe flow (R = D/4) and substituting Q = VA,

$$V = (0.590/n)\, D^{2/3} S^{1/2} \qquad (2)$$
$$Q = (0.463/n) D^{8/3} S^{1/2} \qquad (3)$$

where Q = flow (cfs)
D = pipe diameter (feet).

The roughness coefficient ("n") for ductile iron, polyvinyl chloride, and concrete shall be 0.013. The basis of the gravity sanitary sewer design requires that a minimum self-cleansing flow velocity of 2 feet per second be maintained at the design flow. Where velocities exceed 15 feet per second at design flow, special design provisions shall be considered (see Sections 5.3.3 and 5.4.2)

5.4.1 Sizing of Pipe

The following criteria shall be used when selecting pipe size:

TABLE 5.4.1.1 PIPE SIZING CRITERIA

PIPE SIZE (INCHES)	SIZING CRITERIA	MINIMUM VELOCITY AT DESIRED DEPTH OF FLOW (FPS)
8 – 15	½ full flow depth at design flow	2.0
> 15	¾ full flow depth at design flow	2.5

The minimum pipe size allowed for the City of Tuscaloosa is 8 inches. It is important to note that, due to the hydraulic properties of circular pipe, the flow velocities at half pipe flow and full pipe flow are equal. This is illustrated in the Hydraulic Element Chart included as Figure 5.5.2. The maximum flow velocity in circular pipe occurs at a flow depth in the range of 80-85% of the full flow depth. Because of this occurrence, it is good engineering practice to establish a minimum velocity of 2.5 feet per second when sizing a pipe for ¾ full flow depth. This allows the minimum velocity to remain at or above 2 feet per second at half pipe flow and full pipe flow.

5.4.2 Slopes

The minimum allowable slopes for various pipe sizes are listed in Table 5.4.2.1. These slopes are derived from Manning's equation at full flow conditions with minimum velocities of 2 feet per second. Slopes that are greater than these minimum allowable slopes are desirable. The maximum allowable slopes are also listed in Table 5.4.2.2. Similarly, these slopes are derived from Manning's equation at full flow conditions with maximum velocities of 15 feet per second. Where site conditions (i.e. steep slopes) require velocities in excess of 15 feet per second, proper design consideration must be given to pipe material, joint restraint, special manholes with energy dissipators, abrasive characteristics of wastewater, turbulence, thrust at changes in direction, and surface erosion. It may also be necessary to provide anchorage or cut-off dams to prevent sewer pipe from creeping downhill, or prevent water from flowing along the pipe resulting in trench washout. Such conditions will require that special design be submitted to the OCE for approval.

5.4.3 Minimum Depth of Cover

All gravity sanitary sewer lines in the City of Tuscaloosa shall have a minimum cover of 36 inches. Collector gravity sewers shall be located at a sufficient depth to allow for service to adjoining lots. Collector gravity sewers shall also extend into the upper reach of the service area such that lateral lengths are kept to a minimum. Special cases where a minimum cover of 36 inches cannot be maintained will require approval from the OCE. At ditches and swales where a minimum cover of 36" cannot be achieved and at actively flowing streams, encasement pipe will be required. For aerial sewer, concrete piers to support the pipe will be required.

5.5 Computation Worksheet for Gravity Sewer Design

A computation worksheet for sanitary sewer design has been included as Table 5.5.1. This worksheet summarizes Section 5.4 of this manual and generally provides for a manhole-to-manhole analysis of a system. Under certain system-specific conditions, the worksheet may require modification. This worksheet assumes uniform flow in all reaches of the system, which is typically assumed in the design of gravity sanitary sewers. This form is not recommended where a detailed analysis of the wastewater surface profile is based on non-uniform flow.

To assist with the performance of these computations, a hydraulic elements chart has been provided as Figure 5.5.2. Column by column instructions have also been included with Table 5.5.1.

5.6 Evaluation of Impact to Existing Sewers

Before design of a proposed upstream sewer system begins, future wastewater quantities (i.e. design flows) shall be calculated to determine if available capacity exist within the existing downstream structures. A similar analysis using the methods outlined above should be performed and applied to an existing system to determine available capacity to the extent as

determined by the OCE. This issue of existing system capacity shall be addressed in the Preliminary Engineering Design discussed in Section 3.1.

5.7 Pipe Materials Selection and Design Criteria for Gravity Sewers

The accepted gravity sewer pipe materials for the City of Tuscaloosa are polyvinyl chloride (PVC) and ductile iron. All gravity piping shall meet the minimum requirements of the City of Tuscaloosa Sanitary Sewer Construction Specifications and be bedded and backfilled according to the City of Tuscaloosa Standard Trench Details. The same pipe material shall extend from manhole to manhole. The minimum design criteria for each pipe material are reviewed in this section. Table 5.7.1 provides a summary of various laying conditions and the corresponding required pipe material.

5.7.1 Polyvinyl Chloride (PVC)

PVC gravity sewer pipe and fittings, 8 to 12 inches in diameter, shall conform to and be tested under ASTM D3034. PVC gravity sewer pipe and fittings shall have a wall thickness equal to or greater SDR 35. Maximum allowable PVC pipe size shall be 12 inches. Table 5.7.1.1 summarizes the allowable PVC pipe materials for gravity and pressure sewer applications.

5.7.2 Ductile Iron Pipe

All ductile iron pipe shall conform to ANSI/AWWA C150/A21.50 and ANSI/AWWA C151/A21.51, latest revision. Pipe pressure classes and wall thicknesses shall be in accordance with bury depths and laying conditions as specified in the above standards. Minimum pressure classes for buried pipe shall be 350 psi for pipes $\leq$ 12 inches, 250 psi for pipes $\leq$ 24 inches, and 150 psi for pipes $\geq$ 30 inches. For depth of cuts greater than 8 feet, pipe wall thickness may be required to be greater than the minimum specified above. The design parameters specified in ANSI/AWWA C151/A21.51, latest revision, shall be followed to determine the minimum pipe wall thickness under these conditions. Thickness design of gravity sanitary sewers shall be based on an internal pressure of 0 psi gage or atmospheric pressure.

5.7.2.1 Ductile Iron Pipe Coatings and Linings

All ductile iron pipe for underground installation shall be provided with an exterior bituminous coating of 1-mil minimum thickness. All ductile iron pipe shall have an interior cement-mortar lining with asphaltic seal coat in accordance with ANSI/AWWA C104/A21.4. Where hydrogen sulfide is a potential problem, ductile iron pipe shall be lined with a 40-mil thickness coating of Protecto 401 ceramic epoxy or approved equal.

Sewer conditions that cause hydrogen sulfide generation are (1) flat grades creating low velocities and long travel times, (2) warm wastewater temperatures, (3) high sulfate ion concentration in the wastewater, (4) high organic content in the wastewater, and (5) sanitary sewer force mains and gravity sewers flowing completely full. Severe corrosion and odor

problems can occur in structures where force mains and full-flowing gravity sewers discharge. The conditions listed above are generally indicative of depleted dissolved oxygen levels (<0.7 ppm) in the wastewater. As dissolved oxygen is depleted and anaerobic bacterial action begins, sulfur-reducing bacteria convert sulfates to hydrogen sulfide. As the hydrogen sulfide is produced, some will diffuse into the air above the flow. If the hydrogen sulfide is absorbed by crown moisture, sulfur bacteria can oxidize the hydrogen sulfide to a dilute form of sulfuric acid. The cement-mortar lining generally specified is vulnerable to corrosive attack by the sulfuric acid, whereas the Protecto 401 ceramic epoxy coating resists attack by the sulfuric acid.

5.7.2.2 Ductile Iron Pipe Polyethylene Encasement

Polyethylene tube or sheet encasement shall be used with ductile iron pipe in project areas where aggressive soils (as defined in Appendix A of ANSI/AWWA C105/A21.5) are encountered or in project areas where other metal pipes exist to protect against corrosion caused by stray currents. For any project areas suspected of having aggressive soils, or at the discretion of the OCE, a soils test shall be conducted by qualified personnel experienced in soil analysis and evaluation of conditions potentially corrosive to ductile iron pipe. Said personnel shall be familiar with Appendix A mentioned above. Certain soil environments, however, can be identified as potentially corrosive to ductile iron pipe, and thus do not require testing to determine the need for corrosion protection. Such environments include, but are not limited to, coal, cinders, muck, peat, mine wastes, and landfill areas high in foreign material. When these environments are encountered, polyethylene encasement shall be used.

Where aggressive soils are encountered or where conditions are such that make corrosion a concern, or at the direction of the OCE, all ductile iron pipe and fittings shall be polyethylene wrapped in accordance with ANSI/AWWA C105/A21.5. Wrappings shall be 8-mil low density or 4-mil high density, cross-laminated (HDCL) polyethylene film.

6.0 DESIGN GUIDELINES FOR SERVICE LATERALS

6.1 Service Lateral Materials

PVC service laterals for PVC sewer mains shall conform to ASTM D3034 and shall have a wall thickness equal to or greater than SDR 26. PVC service laterals for ductile iron force mains shall conform to AWWA C900 and shall have a wall thickness equal to or greater than DR 25.

Ductile iron service laterals shall conform to ANSI/AWWA C150/A21.50 and ANSI/AWWA C151/A21.51, latest revision. Minimum pressure class shall be 350 psi. Coatings, linings, and polyethylene encasement shall be as previously stated in Sections 5.7.2.1 and 5.7.2.2 of this manual.

6.2 Service Lateral Installation

Residential service laterals shall not be less than 4 inch in diameter. Sewer main fittings for service lateral connections shall be factory made inline wye fittings; saddle type fittings shall not be used. Connection between service lateral and sewer main shall be watertight. Service laterals shall be installed for each lot and extend from the sewer main to the user's property line, and, at a minimum, one foot beyond the back of curb. A PVC-coated electronic service marker shall be located six inches above the lateral just beyond the curb. The service lateral shall have a minimum slope of 1/8" per 12" (1%). The minimum depth of cover for service laterals from the top of curb shall be 3 feet. Proposed service laterals connecting to existing sewer mains shall be made with a factory wye connection and in accordance with Standard Detail SD 096 or as approved by the OCE.

7.0 DESIGN GUIDELINES FOR PRESSURE SEWERS

Pressure sewers transport wastewater from pumping stations to points of higher elevation in the collection system. This section will provide design guidelines for the two categories of pressure sewers: low pressure sewers and force mains. Low pressure force mains are generally defined as having a diameter of less than 4 inches and servicing grinder pump installations and septic tank effluent pump installations. Conversely, pumping station force mains have pipe diameters of four inches and larger.

The design approach for pressure sewer piping requires consideration of the three parameters listed below:

1. the required long-term pressure rating of the PVC pipe (with a factor of safety of 2.0) based on the operating pressures of the pump system,
2. the required short-term pressure rating of the PVC pipe (with a factor of safety of 2.0) based on the worst case surge pressure of the pump system,
3. the required DR rating of the PVC pipe based on the pump system's peak pressure due to cyclic pressure surge created at pump start-up and shut-down for a 50-year service life.

These parameters should be reviewed to verify that the minimum pipe requirements specified in Sections 7.4 and 7.5 of this manual are satisfied.

7.1 Pressure Sewer Velocity

The size of a pressure sewer is dependent upon the required flow and the allowable headloss of the pumping system. Accordingly, the size of the force main is determined during the design phase of the pumping station. However, the size of the main shall be selected such that a minimum scouring velocity of 2.5 feet per second is maintained. A minimum velocity of 2.5 feet per second is required to re-suspend the solids that have settled during dormant flow periods.

7.2 Pressure Sewer Layout

Force mains shall be designed in profile on straight grades to generally parallel the ground surface and minimize high or low points. Force main alignment and grade shall generally be straight reaches using manufactured fittings to change direction. The maximum bend angles shall be 45° (no 90° bends allowed).

Deflecting joints to accomplish changes in direction will be allowed, but only within the allowable joint deflections as recommended by the manufacturer. Changes in grade or alignment without fittings shall be performed uniformly with several joints rather than one abrupt change in a single joint.

The minimum cover shall be three (3) feet, or as required by the agencies governing right-of-ways for which permits must be obtained. At ditches, swales, or actively running streams, steel casing pipe with casing spacers and casing end seals or concrete piers to support the pipe shall be required. The conditions required to protect the pipe in these instances shall be at the discretion of the OCE.

7.3 Pressure Sewer Air and Vacuum Release

At a minimum, sewage combination air valves (CAV) shall be installed at all high points along the pressure sewer to prevent air entrapment. Valve types shall be sized per venting capacity requirements for the system operating pressure and manufacturer's recommendation. Additional air release valves (ARV), air/vacuum valves (AVV), and/or combination air valves (CAV) shall be required as directed by the OCE. All air and vacuum release valves shall be located in standard 48" diameter precast concrete doghouse manholes or as approved by the OCE.

7.4 Low Pressure Sewers

7.4.1 Flushing Connections

Flushing connections shall be required at the end of all lines, at junctions with other lines and along straight sections every 600 feet. All flushing connections shall be valved off using Schedule 80 Union Ball Valves. Flushing connections shall be located in a standard 48" diameter precast concrete doghouse manhole or as approved by the OCE.

7.4.2 Polyvinyl Chloride (PVC) for Low Pressure Sewers

The accepted low pressure sewer material for the City of Tuscaloosa is polyvinyl chloride pipe. Low pressure sewer piping shall meet the minimum requirements of the City of Tuscaloosa Sanitary Sewer Construction Specifications and be bedded and backfilled according to the City of Tuscaloosa Standard Trench Details. All low pressure PVC pipe shall be green in color.

PVC low pressure sewer pipe and fittings, less than 4 inches in diameter, shall conform to and be tested under all requirements of ASTM D2241. PVC low pressure sewer pipe and fittings shall have a wall thickness equal to or greater than SDR 21, and shall have a minimum pressure rating of 200 psi.

Alternatively, PVC low pressure sewer pipe and fittings, less than 4 inches in diameter, shall be Schedule 40 made in accordance with ASTM D1785 and ASTM D2665 from a PVC compound conforming to a cell classification of 12454 as defined by ASTM D1784. PVC Schedule 40 pipe and fittings shall have a minimum pressure rating of 260 psi. Pipe shall be solvent-welded.

Table 5.7.1.1 summarizes the allowable PVC pipe materials for gravity and pressure sewer applications.

7.5 Force Mains

The accepted sanitary sewer force main materials for the City of Tuscaloosa are ductile iron pipe and polyvinyl chloride pipe. All force main piping shall meet the minimum requirements of the City of Tuscaloosa Sanitary Sewer Construction Specifications and be bedded and backfilled according to the City of Tuscaloosa Standard Trench Details. The minimum design criteria for each pipe material are reviewed in this section.

7.5.1 Polyvinyl Chloride (PVC) Force Mains

PVC force main pipe, 4 to 12 inches in diameter, shall conform to and be tested under all requirements of ASTM D2241. PVC force main pipe shall have a wall thickness equal to or greater than SDR 21, and shall have a minimum pressure rating of 200 psi. PVC force mains shall be green in color. PVC force main fittings shall be ductile iron, mechanical joint fittings.

7.5.2 Ductile Iron Force Mains

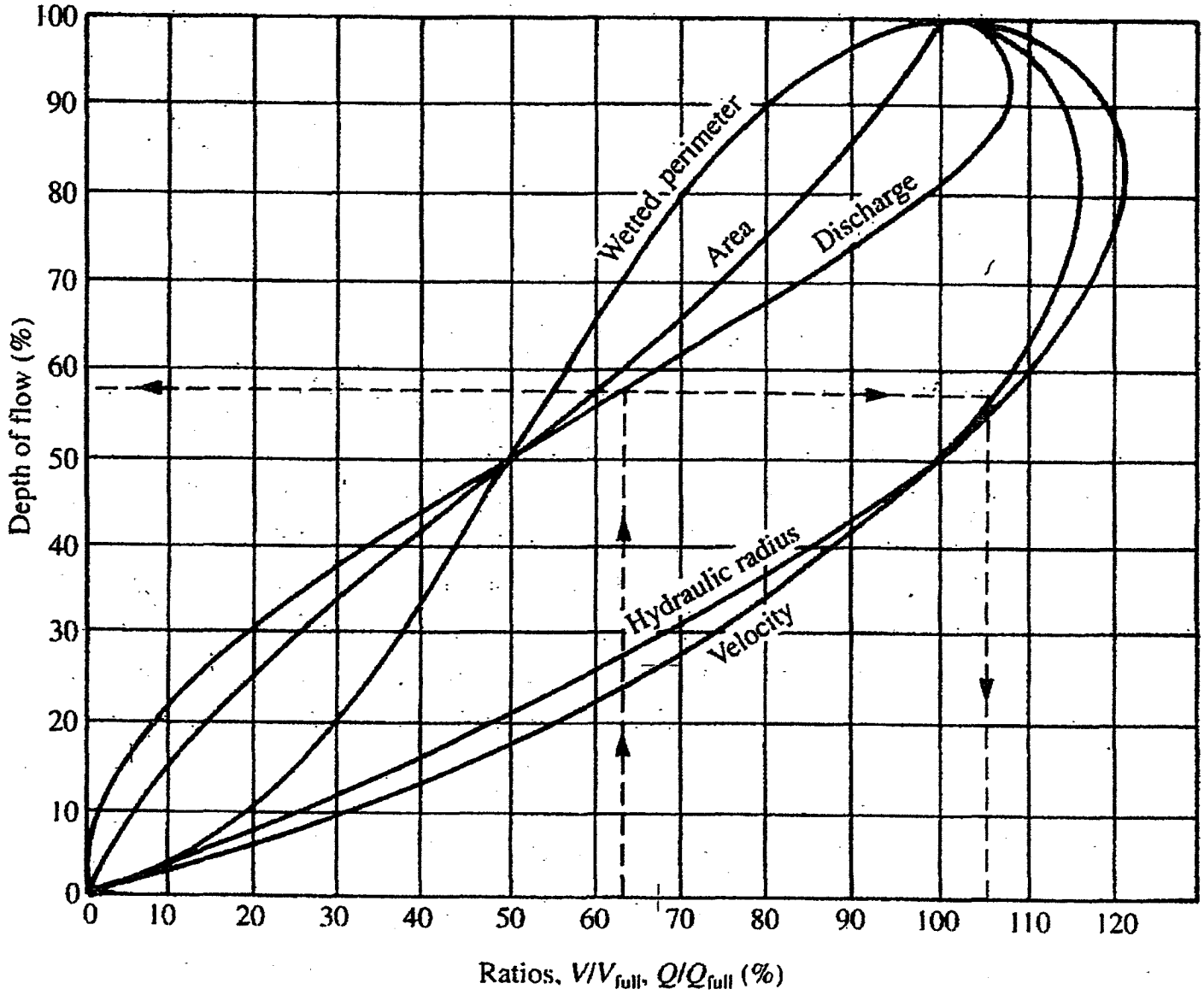
Ductile iron force main pipe and fittings shall conform to Sections 5.7.2 of this manual.

7.6 Evaluation of Impact to Existing Sewers

As with gravity systems (as stated in Section 5.6), before design of a proposed upstream sewer system begins, future wastewater quantities (i.e. design flows) shall be calculated to determine if available capacity exist within the existing downstream structures. A similar analysis using the methods outlined in Section 5 should be performed and applied to an existing system to determine available capacity to the extent as determined by the OCE. This issue of existing system capacity shall be addressed in the Preliminary Engineering Design discussed in Section 3.1

APPENDIX A
FIGURES

FIGURE 5.5.2



A/A_{Full}

$V = \frac{1.486}{n} R^{2/3} S^{1/2}$

$Q = \frac{0.4632}{n} d^{8/3} S^{1/2}$

$Q = VA$

$V = \frac{Q}{A}$

APPENDIX B
TABLES

TABLE 5.2.5.1 TYPICAL WASTEWATER FLOW RATES

GENERATOR	UNIT	FLOW, GALLONS/UNIT/DAY
DWELLINGS		
Dwelling (8 bedrooms or fewer)	Per bedroom	150 (300 min)
9 or more bedrooms to a single system	Per person	75 (min)
ESTABLISHMENTS		
Airports (not including food services)	Per passenger	5
Airport (not including food services)	Per employee	15
Office	Per employee	25
Marinas with bathhouse or showers or toilets	Per boat slip	10
Motels		
No cooking facility	Per bedroom	120
Cooking facility	Per bedroom	175
Movie Theater (no food preparation)	Per seat	4
Restaurants	Per seat	50
Restaurants (interstate or through highway)	Per seat	100-180
Interstate rest areas	Per person	5
Service Station	Per vehicle served	10
Factories and office buildings	Per person per 8-hr shift	
No shower		15
With shower		25
Doctor's office in medical center	Per 100 sq. ft.	500
Laundromats, 9 to 12 machines	Per machine	500
Stores (shopping centers exclusive of food preparation)	Per 1000 sq. ft. of floor space	200
Institutional Establishments		
Churches (no food service)	Per seat	3
Hospitals	Per bed	300
Schools (with or without cafeteria)		
With shower	Per person	16
Without shower	Per person	10
Boarding Schools	Per person	75
Nursing Homes	Per bed	200
Assisted Living	Per bed	100
Community Colleges	Per student and faculty	15
Recreational Establishments		
Theaters, auditorium type	Per seat	5
Picnic Areas	Per person	5
Camps, day no meals served	Per person	5
Camps, resort day and night with limited plumbing	Per space	50
Luxury camps with flush toilets	Per camp site	100
Sanitary Stations	Per camp site	50

Source: Alabama Department of Public Health, *Onsite Sewage Treatment and Disposal*, 2006.

TABLE 5.2.5.2 TYPICAL WASTEWATER FLOW RATES FROM COMMERCIAL SOURCE

FACILITY	UNIT	FLOW, GALLONS/UNIT/DAY	
		RANGE	TYPICAL
Airport	Passenger	2-4	3
Apartment House	Person	40-80	50
Automobile Service Station	Vehicle Served	8-15	12
	Employees	9-15	13
Bar	Customer	1-5	3
	Employees	10-16	13
Boarding House	Person	25-60	40
Department Store	Toilet Room	400-600	500
	Employee	8-15	10
Hotel	Guest	40-60	50
	Employee	8-13	10
Industrial Building (Sanitary waste only)	Employee	7-16	13
Laundry (self-service)	Machine	450-650	550
	Wash	45-55	50
Office	Employee	7-16	13
Public Lavatory	User	3-6	5
Restaurant (with toilet)	Meal	2-4	3
Conventional	Customer	8-10	9
Short Order	Customer	3-8	6
Bar / Cocktail lounge	Customer	2-4	3
Shopping Center	Employee	7-13	10
	Parking Space	1-3	2
Theater	Seat	2-4	3

Source: Crites and Tchobanoglous, *Small and Decentralized Wastewater Management Systems,* McGraw-Hill, Boston, MA, 1998.

TABLE 5.2.5.3 TYPICAL WASTEWATER FLOW RATES FROM INSTITUTIONAL SOURCES

FACILITY	UNIT	FLOW, GALLONS/UNIT/DAY	
		RANGE	TYPICAL
Assembly Hall	Seat	2-4	3
Hospital, medical	Bed	125-240	165
	Employee	5-15	10
Hospital, mental	Bed	75-140	100
	Employee	5-15	10
Prison	Inmate	80-150	120
	Employee	5-15	10
Rest Home	Resident	50-120	90
	Employee	5-15	10
School (day only);			
With cafeteria, gym, showers	Student	15-30	25
With cafeteria only	Student	10-20	15
Without cafeteria, gym, or showers	Student	5-17	11
School, Boarding	Student	50-100	75

Source: Crites and Tchobanoglous, *Small and Decentralized Wastewater Management Systems,* McGraw-Hill, Boston, MA, 1998.

TABLE 5.2.5.4 TYPICAL WASTEWATER FLOW RATES FROM RECREATIONAL FACILITIES

FACILITY	UNIT	FLOW, GALLONS/UNIT/DAY	
		RANGE	TYPICAL
Apartment, resort	Person	50-70	60
Bowling Alley	Alley	150-250	200
Cabin. Resort	Person	8-50	40
Cafeteria	Customer	1-3	2
	Employee	8-12	10
Camps:			
Pioneer Type	Person	15-30	25
Children's, with central toilet/bath	Person	35-50	45
Day, with meals	Person	10-20	15
Day, without meals	Person	10-15	13
Luxury, private bath	Person	75-100	90
Trailer camp	Trailer	75-150	125
Campground - developed	Person	20-40	30
Cocktail Lounge	Seat	12-25	20
Coffee Shop	Customer	4-8	6
	Employee	8-12	10
Country Club	Guests onsite	60-130	100
	Employee	10-15	13
Dining Hall	Meal Served	4-10	7
Dormitory / Bunkhouse	Person	20-50	40
Fairground	Visitor	1-2	2
Hotel, resort	Person	40-60	50
Picnic park, flush toilets	Visitor	5-10	8
Store, resort	Customer	1-4	3
	Employee	8-12	10
Swimming Pool	Customer	5-12	10
	Employee	8-12	10
Theater	Seat	2-4	3
Visitor Center	Visitor	4-8	5

Source: Crites and Tchobanoglous, *Small and Decentralized Wastewater Management Systems,* McGraw-Hill, Boston, MA, 1998.

TABLE 5.4.2.1
Minimum Allowable Slopes for Gravity Pipes (not laterals)

Pipe Diameter (inches)	Slope (ft/ft)	Full Flow Condition (n=0.013)	
		Velocity (fps)	Flow (cfs)
8	0.00400	2.2	0.765
10	0.00280	2.1	1.160
12	0.00220	2.1	1.672
14	0.00170	2.1	2.217
16	0.00150	2.1	2.973
18	0.00120	2.1	3.641
21	0.00100	2.1	5.013
24	0.00080	2.0	6.402
27	0.00067	2.0	8.020
30	0.00058	2.0	9.883
36	0.00046	2.0	14.312
42	0.00037	2.0	19.362
48	0.00030	2.0	24.892

Note: Slopes derived from Manning's equation at full flow condition with minimum velocities of 2 fps.

TABLE 5.4.2.2
Maximum Allowable Slopes for Gravity Pipes

Pipe Diameter (inches)	Velocity (fps)	Full Flow Condition (n=0.013) Slope (ft/ft)
8	15.0	0.18757
10	15.0	0.13930
12	15.0	0.10924
16	15.0	0.07444
18	15.0	0.06362
21	15.0	0.05180
24	15.0	0.04335
27	15.0	0.03705
30	15.0	0.03219
36	15.0	0.02525
42	15.0	0.02056
48	15.0	0.01720

Notes:
1) Slopes derived from Manning's equation at full flow conditions with maximum velocities of 15 fps.
2) Where site conditions require velocities in excess of 15 fps, see Section 5.4.2 for special design considerations.

TABLE 5.5.1 COMPUTATION FORM FOR GRAVITY SEWER DESIGN

1	2	3		4	5	6	7	8	9	10	11	12	13	14	15	16
		Manhole														Invert E
Drainage Area(s) Designation	Sewer Line Designation	From MH#	To MH#	Increment Population	Cumulative Population	$Q_{AVERAGE}$ Residential (gal/day)	$Q_{AVERAGE}$ Residential (cfs)	Residential Peaking Factor	Q_{DESIGN} Residential (cfs)	$Q_{AVERAGE}$ Non-Resid (gal/day)	$Q_{AVERAGE}$ Non-Resid (cfs)	Non-Resid Peaking Factor	Q_{DESIGN} Non-Resid (cfs)	Q_{DESIGN} (cfs)	Length (ft)	Upper End (ft)

Notes:

1. Worksheet is designed for segmental analysis (manhole to manhole). Worksheet does not account for drops across manholes.
2. Worksheet assumes uniform flow in all reaches of the system.

TABLE 5.5.1 COMPUTATION FORM FOR GRAVITY SEWER DESIGN

17	18	19	20	21	22	23	24	25	26	27	28
levation											
Lower End (ft)	Slope (ft/ft)	Pipe Size (inches)	Pipe Size (feet)	Manning's n	Q_{FULL} (cfs)	V_{FULL} (ft/sec)	Q_{DESIGN} / Q_{FULL}	d_{DESIGN} / D_{FULL}	Max. Depth of Flow Ratio	V_{DESIGN} / V_{FULL}	V_{DESIGN} (fps)

Notes:
1. Worksheet is designed for segmental analysis (manhole to manhole). Worksheet does not account for drops across manholes.
2. Worksheet assumes uniform flow in all reaches of the system.

EXPLANATION OF TABLE 5.5.1

Column 1	Drainage Area Designation. If designing an interceptor sewer, this will include multiple areas.
Column 2	Sewer Line Designation.
Column 3	Manhole Designation.
Column 4	Projected 20-year population from an individual drainage area. Column 4 will be used for the design of collector sewers.
Column 5	Total population obtained from all drainage areas contributing to that point. Column 5 will generally be used for the design of interceptor sewers.
Column 6	Average Daily Residential Flow (gal/day).
Column 7	Average Daily Residential Flow (cfs).
Column 8	Residential Peaking Factor See Figure 5.2.3.1 and/or Table 5.2.3.1.
Column 9	Residential Design Flow (cfs). = Column 7 * Column 8
Column 10	Average Daily Non-Residential Flow (gal/day). Use Tables 5.2.5.1 thru Tables 5.2.5.5.
Column 11	Average Daily Non-Residential Flow (cfs).
Column 12	Non-Residential Peaking Factor
Column 13	Non-Residential Design Flow (cfs) = Column 11 * Column 12
Column 14	Design Flow from drainage area(s) = Column 9 + Column 13
Column 15	Length of pipe between manholes measured from centerlines of manholes.
Column 16	Upstream Manhole Invert Elevation
Column 17	Downstream Manhole Invert Elevation
Column 18	Design Slope = (Column 16 - Column 17) / Column 15
Column 19	Pipe Size (inches)
Column 20	Pipe Size (feet) = (Column 19) / 12
Column 21	Manning's n
Column 22	Full Pipe Flow calculated using Manning's Equation = (0.463/Column 21)*((Column 20)^(8/3))*(Column 18 ^ 0.5)
Column 23	Full Pipe Velocity =(Column 22)/(PI*(Column 20 ^2)/4)
Column 24	Ratio of Design Flow to Full Flow = Column 14 / Column 22
Column 25	Depth of Flow Ratio (from Hydraulic Elements Chart or Graph - Figures 5.5.1 and 5.5.2) Use Column 24
Column 26	Maximum Depth of Flow Ratio = 0.5 for pipes ≤ 15 inches, 0.75 for pipes > 15 inches) If Column 25 > Column 26, increase slope or pipe size and recalculate.
Column 27	Ratio of design velocity to full-flow velocity (from Hydraulic Elements Chart) Use Column 25
Column 28	Design Velocity; min 2 ft/sec for d/D=0.5 and min 2.5 ft/sec for d/D=0.75. = Column 23 * Column 27 Check minimum velocity criteria.

Table 5.7.1
Pipe Material Selection Chart for Sanitary Sewers

Criteria	Laying Condition(s)	Required Pipe Material
1	Slopes < 15%	DIP or PVC
2	Slopes ≥ 15%	DIP with restrained joints or PVC with bells anchored into trench.
3	Slope from 20.00% - 34.99%	DIP with anchors spaced at 36-ft centers
4	Slopes from 35.00% - 49.99%	DIP with anchors spaced at 24-ft centers
5	Slopes ≥ 50.00%	DIP with anchors spaced at 16-ft centers
6	Shallow crossing (<3 feet)	DIP with steel casing or concrete pier support
7	Carrier pipes installed in a bore or tunnel	DIP with "Fast-Grip" gaskets
8	Ditch or Stream Crossing	DIP with steel casing or concrete pier support
9	Condition requiring concrete bedding or encasement	DIP
10	Aerial Locations	DIP with concrete pier support at each joint

TABLE 5.7.1.1
Summary of Allowable PVC Materials

Sewer Type	Material Specification	Pipe Size
Gravity Sewer	ASTM D3034 SDR 35	8 - 12 inches
Service Lateral	ASTM D3034 SDR 35	4 inches and greater
Service Lateral	AWWA C900 SDR 35	4 inches and greater
Low Pressure Sewer	ASTM D2241 SDR 21	Less than 4 inches
Low Pressure Sewer	ASTM D1785 SCH 40	Less than 4 inches
Force Main	ASTM D2241 SDR 21 with D.I. Mechanical Joints	4 - 12 inches

APPENDIX C
MISCELLANEOUS INFORMATION (CWSRF EID)

Environmental Information Document Outline:

The Applicant must prepare an **Environmental Information Document (EID)** to support CWSRF funding for the proposed wastewater treatment/transport works. The EID describes and evaluates the environmental impacts of the feasible alternatives of which there should be, as a minimum, **at least four:** the chosen alternative, no action, and two additional alternatives. Furthermore, the alternatives should be substantially different in scope and/or placement and should be thoroughly compared/contrasted within the framework of the following guidelines.

Prior to preparation of the EID, the Applicant should obtain concurrence for the proposed project from the Alabama Historical Commission (AHC), the U. S. Fish and Wildlife Service (rare and endangered species protection), the U. S. Army Corps of Engineers (floodplain management, floodway management, wetlands, Section 404 permits, dredge and fill, structures placed in navigable waterways), the Tennessee Valley Authority (TVA, where applicable), the Alabama Power Company (were applicable), and the Regional Planning Agency (where applicable). Written concurrence from these entities should be attached to the EID. ***COMPLETION OF THE ENVIRONMENTAL REVIEW MAY NOT OCCUR UNTIL SUCH CONCURRENCE LETTERS ARE SUBMITTED.***

Included in the environmental review process is public participation culminating in a public meeting, which presents the proposed project to the public and includes discussion of both environmental and financial impacts. Minutes of the public meeting, with proof(s) of advertising and a sign-in sheet of attendees must be included as a part of the EID. The public meeting should be conducted prior to submission of the CWSRF application.

The EID shall be prepared according to the following outline:

A. Existing Environment.

1. Location of the Project Area(s).
   a. With relation to the City/Town/Service Area.
   b. With relation to the County and State borders.
   c. In relation to the nearest metropolitan statistical area (MSA).
   d. Plotted on the most current USGS Quadrangle Map (with the name, number, scale and revised date of the quadrangle used).

B. Existing Facilities.

1. Name, type and NPDES compliance status of all WWTFs that will be treating wastewater from this project.

2. Existing sewered population, population to be served by this project, and remaining unsewered population.

3. Name and type of industrial users served by public sewer with amount and characteristics of wastewater treated. Discuss any significant impacts due to industrial loading, particularly as a result of this project.

4. Condition of existing collection and interceptor lines.

C. Need for Proposed Facilities.

1. Documentation of public health problems that will be corrected by the proposed project.
   a. From the local public health agency, concerned citizens, ADEM, other governmental agencies, or the Consulting Engineer. (Examples include fish kills, on-site septic system failures, well contamination, Infiltration/Inflow or Sanitary Sewer Overflow occurrences)

2. Lack of treatment capacity.
   a. Include need(s) to increase capacity and a discussion of historical (seasonal) flow data.

3. Lack of treatment capability/quality, to include:
   a. Discussion of NPDES violations to which the City/Town/Board/Authority is a party.
   b. Discussion of any Administrative or Consent Order to which the City/Town/Board/Authority is a party.

D. Proposed Facilities and Proposed Funding.

1. Proposed Facilities
   a. Wastewater Treatment Facilities (WWTFs) to be constructed/upgraded/modified/affected.
      I. Average daily flow for both current and design years.
      II. Expected daily peak and minimum flow for both current and design years.
      III. Expected influent and effluent characteristics (BOD, TSS, DO, etc.) for both the current and design years to include any special considerations (extreme PH, high Ammonia, etc.).
      IV. Identify the receiving stream and watershed.
      V. Identify any land that must be obtained in order to construct/modify facility.
      VI. Identify the method of sludge disposal and any items to satisfactorily carry out the disposal (purchase more land, new permits for landfilling, etc.)
      VII. Identify steps that have been, or will be, taken in order to comply with Part 503, The Standards for the Use or Disposal of Sewage Sludge and other requirements, as necessary.

   b. Include Vicinity Map(s) that
      I. Clearly show(s) the project area(s) in relation to nearby roads and streets.
      II. Include(s) a North Arrow and Graphical Scale.
      III. Clearly show(s) the location of the project area(s) by coordinates (State Plane Coordinates NAD83 (92 Corrections) or Metes and Bounds tied to the Rectangular Grid system of the State of Alabama or UTM Coordinates.

2. Proposed Funding Source(s)
   a. Funding source(s), status and amount(s).

E. Alternative Analysis.

1. Discussion of all feasible alternatives, to include:
   a. Alternative processes and/or locations considered.
   b. Alternative collection systems.
   c. Flow and waste reduction measures.
   d. Inflow and infiltration (I/I) reduction.
   e. Alternative methods of sludge disposal (process options and/or disposal location).
   f. Physical, legal, or institutional constraints.
   g. Regulatory requirements.
   h. Capital and operations and maintenance (O&M) costs.
   i. Significant, irreversible, and/or unavoidable environmental impacts.

2. Choosing an alternative.
   a. Must include the "no action" option and why it was not chosen.
   b. Must clearly indicate the chosen alternative and why it has been chosen.
   c. Must provide an in depth (E 1 a – i) discussion of AT LEAST two other alternatives (in addition to the two alternatives discussed in E 2 a & b).

F. PHYSICAL DATA.

1. Description of the Topography of the City/Town and of the specific site area(s).

2. Description of the Geology of the City/Town and of the specific site area(s). (See link [1]).

3. Hydrology of the City/Town and of the specific site area(s).

4. Climate and Precipitation of the City/Town to include:
   a. Average annual temperature (see link [2]).
   b. Average annual range of temperatures (see link [3]).
   c. Average annual rainfall (see link [4]).

d. Average snowfall (if applicable).
e. Length of the growing season with average date of the first and last freeze (see links [5,6,7]).
f. Direction and Speed of prevailing winds for summer and winter (see links [8,9]).

5. Floodplains, floodways, and wetlands impact(s).
a. The project area(s) must be clearly located on the applicable Flood Insurance Rate Map (FIRM) with Panel Name, Panel Number, Date and graphical scale provided.
b. The project area(s) must be shown in relation to all activities within the project area, including temporary construction easements, and any permanent or man-made features in order to facilitate a clear understanding of the project location.
c. The potential effect of the collection/treatment/sludge on these areas should be examined and discussed in detail.
d. Any chosen alternative that affects a floodplain, floodway and/or wetland must include:
I. A description of alterations to landforms, streams, and natural drainage patterns within the floodplain/floodway/wetland and their effect on local watercourses and the project.
II. A discussion of why the alternative is proposed in the floodway/floodplain/wetland.
III. A discussion of how the alternative will conform to applicable Federal, State, and/or local floodplain/floodway/wetland protection standards.
IV. A discussion of how the alternative is designed to minimize the potential harm to the floodplain/floodway/wetland.
V. Include a map clearly showing the relationship between the floodplain/floodway/wetland and all construction activities with contours of existing and finished grades and flood elevation(s).

6. Description of sewer gravity and/or force main to be constructed/rehabilitated.
a. Size, type and classification of pipe(s).
b. Indicate bore and excavation methods, especially as they relate to existing watercourses, flood plains, floodways, and/or wetlands.
c. Indicate the slope(s) of all sections of sewer line
d. If the plans and/or specifications do not meet the standards from the most current edition of Recommended Standards for Wastewater Facilities (Ten States Standards) then clearly annotate the design methodology and research used. Furthermore, if a design does not meet the Ten States Standards then it must be clearly shown that the project is more cost-effective and/or more environmentally sound.
e. Demonstrate that the receiving facility has capacity to treat additional flow, if any.
f. If rehabilitation of sewer lines will take place clearly indicate the type of repair(s) and the corresponding segment(s) of pipe.
g. Clearly delineate the location and type of construction/rehabilitation on a vicinity map that is of sufficient scale and size to be legible and that clearly relates the work to the surrounding environment (i.e. show all watercourses, structures, roads and utilities that are visible).

G. Environmental Consequences and Mitigative Measures.

1. Historical and Archaeological Features.
a. Include the concurrence/nonconcurrence letter from the Alabama Historical Commission (AHC).
b. Discuss any comments made by AHC and the effect on the proposed project.
c. Include a copy of any archaeological survey(s) performed for the AHC.
d. Insure that all contracts are awarded with the stipulation that "Should previously undetected cultural resources be encountered during project activities, work shall cease and the Alabama Historical Commission shall be contacted immediately."

2. Endangered Species and Critical Habitat.
a. Include the concurrence/nonconcurrence letter from the U. S. Fish and Wildlife Service.
b. Discuss any comments made by the U. S. Fish and Wildlife Service and the effect on the proposed project.
c. Include a copy of any survey(s) performed for the U. S. Fish and Wildlife Service.
d. Insure that all contracts are awarded with required Best Management Practices (BMP) plans, guidelines, and responsible entity.

3. Floodplain, Floodway, and Wetlands.
   a. Include the concurrence/nonconcurrence letter from the U. S. Army, Corps of Engineers.
   b. Discuss any comments made by the U. S. Army, Corps of Engineers and the effect on the proposed project.

4. Tennessee Valley Authority (if applicable).
   a. Include the concurrence/nonconcurrence letter from the Tennessee Valley Authority.
   b. Discuss any comments made by the Tennessee Valley Authority and the effect on the proposed project.

5. Alabama Power Company (if applicable).
   a. Include the concurrence/nonconcurrence letter from the Alabama Power Company.
   b. Discuss any comments made by the Alabama Power Company and the effect on the proposed project.

6. Regional Planning Agency.
   a. Include the concurrence/nonconcurrence letter from the Regional Planning Agency.
   b. Discuss any comments made by the Regional Planning Agency and the effect on the proposed project.

7. Environmental Justice.
   a. Environmental justice is the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations and policies. Fair treatment means that no group of people, including a racial, ethnic, or socioeconomic group should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies.
   b. Discuss the impacts of the project on Environmental Justice areas affected.
   c. Ensure that public participation and/or notification is enhanced if Environmental Justice areas are affected by the project.

8. Pollution from Construction Activities.
   a. Noise causes, intensity, and duration.
   b. Erosion and siltation causes, duration and mitigation plan.
   c. Dust causes, intensity, and duration.
   d. Best Management Practices (BMP) and implementation plan
   e. Impact on Public Parks and/or Prime Agricultural Land.
   f. Impact on 303d listed streams.
   g. Impacts from stream crossings.
   h. If land clearing is involved, discuss the precautionary methods to be taken in order to protect the area environment from the use of herbicides, defoliants, blasting, cutting, and/or burning.
   i. Specify the final disposal method for soil and vegetative spoil.
   j. If facilities are to be abandoned, discuss what will be done with the abandoned structures and/or land.
   k. Indicate the direction from the WWTF to nearby residential and/or business communities and the effect prevailing winds will have on design criteria.

9. Public Participation.
   a. The Public Meeting must be held before May 1st. Please contact the appropriate Project Engineer at ADEM to find out if the project will affect an Environmental Justice area(s) no later than March 15th.
   b. Proof of advertising. Advertisement should run at least once per week for four consecutive weeks in the newspaper that serves the affected area.
   c. If Environmental Justice areas are affected by the project then the advertisement requirement is expanded to ensure that the affected populations are made aware of the project and have every opportunity to respond. Examples of additional advertisements are:
      I. Mailings to each residence affected (provide affidavit of mailing and a copy of the letter used as an addendum to this document).
      II. Running an ad on a radio or television station that serves the affected community (provide an affidavit and transcript of the ad).

III. Advertise in a newspaper or other periodical that serves the affected community (provide a publishers affidavit and a copy of the ad).
IV. The Public Meeting should be held after 6:00 P.M. (local time) and should be in a building that is easily found and highly accessible. A sign-in sheet should be made available to everyone, and should be included as an addendum to this document.

d. Maintain at least one copy of the EID in a public facility (the City/Town Hall, the Board/Authority Office, the local Library, the place of the meeting or the local Post Office) for public review from the first day in which any advertisement is published through the time of the public meeting. The advertisement(s) should inform the public of the existence of this document, the location of this document during business hours, and that this document is for public review.
e. The agenda should follow the following format.
I. The Representative should be introduced and provide an overview of the project.
II. The selection of the funding source(s) should be discussed.
III. The new rate structure (if applicable) and fee structure (if applicable) should be discussed.
IV. A period of question and answer should be allowed after all discussion in complete.
f. Provide a copy of the minutes of the meeting and a list of the questions and answers as an addendum to this document.

10. Internet Links

The following links are provided in order to facilitate the gathering of certain information required in the EID. These links are not the only source for this information. These links are provided solely as a courtesy. Alabama Department of Environmental Management staff has found that the target Web site may contain useful information. Because ADEM has no control over the posting of material to this target Web site, the department cannot take responsibility for the validity of its contents. Please e-mail any comments, or if you encounter an inactive link, to ADEM.

1. http://www.nationalatlas.gov/index.html navigate by clicking appropriate links under title
2. http://www.ncdc.noaa.gov/oa/climateresearch.html
3. http://www.ncdc.noaa.gov/ol/climate/online/ccd/avgwind.html -- Average Windspeed
4. http://www5.ncdc.noaa.gov/cgi-bin/climaps/climaps.pl -- Prevailing Wind Maps, then "Quick Search" (on the left side of the screen), then choose "Wind", then choose "Mean Wind Speed and Prevailing Direction", then choose February and August.
5. http://www.fws/gov/southeast/maps/al.html. U.S. Fish & Wildlife Service
6. http://www.usace.army.mil/ U.S. Army Corps of Engineers
7. http://www.preserveala.org/ Alabama Historical Commission

APPENDIX D
CITY OF TUSCALOOSA SANITARY SEWER CONSTRUCTION SPECIFICATIONS

Section – Trenching, Backfill, and Compaction

Section – Precast Concrete Manholes

Section – Polyvinyl Chloride Gravity Sewer Pipe

Section – Polyvinyl Chloride Pressure Sewer Pipe

Section – Ductile Iron Pipe and Fittings

Section – Sanitary Sewer System

Section – Asphalt Paving and Patching

SECTION - TRENCHING, BACKFILL AND COMPACTION

PART 1 - GENERAL

1.01 Section Includes:

A. This section of specifications covers the requirements for Trenching, Backfill, and Compaction for sanitary sewer lines placed in roadways, lawns or unimproved property or any other area.

1.02 Related Sections:

A. Section – Polyvinyl Chloride Gravity Sewer Pipe
B. Section – Polyvinyl Chloride Pressure Sewer Pipe
C. Section – Ductile Iron Pipe and Fittings
D. Section – Slope Protection and Erosion Control
E. Section – Asphalt Paving and Patching

1.03 References:

A. U.S. Department of Labor, Occupational Safety and Health Administration.

B. State of Alabama Department of Transportation Standard Specifications for Highway Construction.

C. AWWA C600 – Installation of Ductile Iron Water Mains and Their Appurtenances

1.04 Project Conditions:

A. Environmental Requirements:

1. The Contractor shall maintain all drainage ways, gutters, etc., at all times. The Contractor shall remove any eroded or washed material that enters pipes, ditches, or streams.

2. The Contractor shall provide erosion control as required to protect from damage surrounding areas. Erosion control measure shall meet all requirements of the City of Tuscaloosa.

3. All areas damaged as a result of erosion shall be repaired to a condition equal or better than the condition prior to construction, as determined by the Engineer.

4. The Contract shall comply with the City of Tuscaloosa Municipal Code in regards to all environmental best management practices.

PART 2 - PRODUCTS

2.01 Materials:

A. Select Backfill:

1. Select backfill where specified or required shall be crushed limestone. Crushed stone shall meet or exceed the requirements of the Alabama Department of Transportation Standard Specifications for Highway Construction, Section 825, Type "A".

B. Standard Backfill:

1. Standard backfill shall consist of native soils of good earth, sand, and gravel, and shall be free of large rocks, boulders and other deleterious substances.

C. Bedding:

1. Class "1" Bedding shall be Alabama Department of Transportation Standard Specifications for Highway Construction, Section 801, as follows:

Gravity Pipe (ALL materials) - No. 57 crushed limestone
Pressure Pipe (material NOT PLASTIC) - No. 57 crushed limestone
Pressure Pipe (PLASTIC material) – No. 8910 crushed limestone

2. Class "2" Bedding shall be reinforced concrete 3000 psi design mix.

3. Class "3" Bedding shall be native soil.

D. Trench Foundation

1. Trench foundation material shall be Alabama Department of Transportation Standard Specifications for Highway Construction, Section 801, No. 57 crushed limestone. This material shall only be used when approved in advance by the Engineer.

2.02 Source Quality Control:

A. The Contractor shall supply gradation analysis for each type of crushed stone used.

PART 3 - EXECUTION

3.01 Examination of Conditions:

A. The Contractor shall examine the area to be trenched and verify his requirements for

trenching.

3.02 Protection and Removals:

A. Fences:

1. All fences in conflict with the proposed construction shall be removed in a neat and workmanlike manner and then replaced immediately following construction operations. Where materials removed are not suitable for reuse, they shall be replaced with new material of equal or better quality and construction. All fences shall be rebuilt to line, with posts well set, wires fastened with new staples or ties and well stretched. All corner and end posts shall be well braced and set a minimum of 30 inches in the ground.

B. Utility Poles, Guy Wires, Miscellaneous Poles, Etc.:

1. All utility poles, guy wires, sign posts and similar private obstructions which are indicated on the plans or existing on the ground shall be removed and replaced by the Contractor at his own expense. In the event street signposts or signs are damaged or destroyed by the Contractor's operations, they may be replaced by the Owner at the Contractor's expense.

2. When it is necessary to remove or adjust any utilities, representatives of the utilities involved shall be notified to decide the method and nature of work to be done. The Contractor shall make satisfactory arrangements with other utilities for the required removal or adjustments at the Contractor's expense, unless otherwise specified.

3. The Contractor shall be held liable for damage, including negligent or willful damage to any other utility and shall pay for the cost of all necessary repairs and any damages resulting to public or private property resulting therefrom.

4. The Contractor shall take whatever means necessary to support sewer mains to their true line and grade when they are encountered during excavation. The pipe shall be supported so that no leakage will occur and under no circumstances will the Contractor be allowed to bypass raw sewage or allow raw sewage to leak into the trench. If a repair becomes necessary the contractor shall use materials of the same type and class of pipe or PVC pipe and fittings conforming to City of Tuscaloosa Sanitary Sewer Construction Specifications. All couplings to existing pipe shall be manufactured couplings and all metal parts shall be stainless steel.

C. Ornamental Shrubs and Trees in Public Right of Ways:

1. Ornamental shrubs and trees shall not be removed unless directed by the

Engineer. When ornamental shrubs and/or trees are to be removed and replaced, the following steps shall be followed:

a. Remove all trees, shrubs or plants, which interfere with construction intact with root system and protect from drying during construction period.

b. Replace plant to original location as soon as possible, taking care to insure that hole is large enough, and no damage is done to root system.

c. Fill hole with good topsoil and tamp lightly and firmly into place and water plant.

2. Contractor shall replace with like kind and size if any plant, tree, or shrub which is disturbed by construction dies within one (1) year, at no cost to the Owner.

D. Adjacent Property:

1. The Contractor shall confine his operations to the rights-of-ways and/or easements designated. The Contractor at no additional cost to the Owner shall repair any damage to adjacent property.

E. Private Drives and Sidewalks:

1. The Contractor shall keep all private drives and sidewalks open and accessible at all times.

2. All streets and public roads shall be kept open and accessible to emergency vehicles at all times.

F. Existing Underground Utilities:

1. The Contractor shall protect all existing utilities during the trenching operation. The Contractor shall cooperate fully with the utility's requests for temporary and permanent supports during the trenching operation and shall furnish and install supports at no additional cost to the Owner.

2. Storm sewers in conflict with the proposed trench may be carefully dislodged and stockpiled. The pipes shall be cleaned and replaced immediately after new construction is clear. Storm sewers damaged by the Contractor shall be replaced with new pipe at no additional cost to the Owner. All storm sewers removed shall be re-laid to proper grade on a firm bedding so that settlement will not occur.

3.03 Trench Preparation:

A. Clearing and Grubbing:

1. Where clearing or partial clearing of the right-of-way or easements is necessary, such work shall be completed prior to trench excavation. Projecting materials such as trees, logs, brush, hedges, etc., shall be cut as near to the surface of the ground as possible, and all stumps and roots shall be grubbed out unless specifically stated otherwise. All materials so cleared and grubbed shall be removed from the site. In no case shall excavated materials be allowed to cover brush or trees prior to disposal.

2. The Contractor shall bear all costs of disposing of all cleared and grubbed materials. Unless otherwise specified, all merchantable timber cut from the area designated to be cleared shall become the property of the Contractor.

3. Burning will be permitted, provided the Contractor obtains permits and meets the requirements of the proper fire authorities and any other state, county or local ordinances. Burning on private property will not be permitted without written permission of the Owner of the property. The authority to burn shall in no way relieve the Contractor from damages, which may result from his operations.

4. In no case shall any materials from clearing and grubbing operations be left on the project, or be pushed onto abutting private properties, or be buried in embankments or trenches on the project.

5. On public property, existing trees or limbs over 2 inches in diameter shall not be cut unless they are within 7 feet of pipe centerline or specific permission is received from the Engineer. On private easements or in lawns, no trees or brush shall be cleared or cut without prior approval of the Engineer or Inspector. The Contractor shall be required to remove trees, shrubs or plants on private property intact, and to ball the roots, keep watered as required, and replant in their original location upon completion of pipe laying operations, unless written permission is obtained from the Engineer, or unless otherwise specified. The Contractor shall replace, at his own expense, any trees, shrubs, or plants which are damaged as a result of his operations, or which die within 1 year of the time it was disturbed or damaged.

B. Saw Cutting:

1. Prior to beginning the trenching operation in paved areas such as roads, drives, and parking lots, all paving shall be saw cut to a minimum depth of 2 inches. All paving materials shall be removed and disposed of prior to the trenching operation.

2. Prior to beginning the saw cutting, all traffic control devices, barricades, cones and permits required shall be obtained and in place.

C. Verification of Existing Utilities:

1. Prior to the excavation but after the saw cutting in paved areas, the Contractor shall unearth all known utilities and confirm the location and depth of such utility sufficiently far enough in advance to adjust the vertical or horizontal alignment of the pipeline if necessary.

3.04 Trench Construction:

A. General:

1. Trenching or excavation for pipe lines shall consist of the excavation necessary for the installation of sanitary sewers and all appurtenant facilities, including manholes, junction boxes, inlets, outlets, thrust blocks, and pipe protection as called for on the Drawings.

2. Trench excavation shall be made in an open cut unless tunneling or other construction methods are specifically authorized, and shall be true to the lines and grades shown on the plans or established by the Engineer.

3. When vertical banks for trench excavation are not practical to construct or create dangerous conditions to workmen, the banks may be sloped provided that such excavation does not damage adjacent structures. However, when trench banks are sloped, such banks shall be cut to vertical planes as specified above for that part of the ditch below the level of one (1) foot above the top of the pipeline. All side slopes shall conform to the requirements established by OSHA.

4. All streets, sidewalks, crossings, fire hydrants, water valves, fire alarm boxes and other similar public utilities are to be kept open or accessible for their intended use.

5. Every drain, gutter, culvert, or sewer for surface drainage encountered is to be kept open for both temporary and permanent flow, or if necessarily closed, other adequate provision for drainage is to be made.

6. In all cases where materials are deposited along open trenches, they shall be placed so that in the event of rain, no damage will result to the work and/or to adjacent property.

7. Pipe trenches shall not be excavated more than 300 feet in advance of pipe laying and temporary bridges or cross walks shall be constructed where required to maintain vehicular or pedestrian traffic.

8. Trench widths shall be confined to dedicated rights-of-way or construction

easements, unless special written agreements have been made with the affected property owner. Place all excavated materials within easements or rights-of-way, and do not obstruct any public or private roadways or streets.

9. Where select backfill is specified or required, all excavated materials shall be promptly removed and disposed of by the Contractor.

B. Rock Excavation:

1. Rock encountered in trench excavation for pipe lines shall be removed for the overall width of trench and to a depth of 6-inches below the bottom of the barrel of pipe 24-inches in diameter and smaller, and 8-inches below the bottom of pipe 24 to 36 inches in diameter, and 12-inches below pipe larger than 36-inches in diameter, if rock extends to such depths.

2. Where pipelines are constructed on concrete cradles, rock shall be excavated to the bottom of the cradle as shown on the plans. When necessary to provide sufficient working space, rock shall be excavated to additional depth for bell holes.

3. After the Engineer has inspected the completed excavation, the space below the ultimate pipe or structure grade shall be filled with an approved foundation material and compacted to the proper grade.

4. Drilling and blasting methods used in rock excavation shall be optional with the Contractor but shall be conducted with due regard to the safety of persons and property in the vicinity of the work and in strict conformity with all laws, ordinances, or regulations governing blasting and the use of explosives.

5. Rock excavation near existing structures of all types shall be conducted with the utmost care, and every precaution shall be taken to prevent damage to such structures. Any damage or injury of whatever nature to persons or property caused directly or indirectly by blasting operations shall be promptly repaired, replaced, or compensated for by the Contractor at his own expense and to the satisfaction of the persons injured or the owners of the property damaged.

6. Safety During Blasting:

   a. Take all precautions necessary to prevent personal injury, damage to real or personal property, or interference with use and enjoyment of any property resulting from blasting or the vibration or concussions caused by blasting. These precautions shall include, but are not limited to, investigations by the Contractor to establish limits of the size and nature of individual blasts which may be safely accomplished without damage or interference with the use of property.

b. All drilling and blasting operations shall be performed in strict conformity with all laws, ordinances and regulations governing blasting and the use of explosives. The Contractor or blasting subcontractor shall be licensed for this type of blasting and shall take out and maintain, during the term of its contract or subcontract and any extension thereof, insurance equal to that specified for the Contractor in the General Conditions.

c. The Contractor shall notify the fire department at least 48 hours in advance of any blasting.

7. Damage From Use of Explosives:

a. Immediately inform the explosive specialist orally and in writing of all matters concerning complaints and claims between the public, or government, and the Contractor. If the contractor causes damage, injury or interference, as stated herein, the Contractor shall modify his blasting procedure.

b. The Contractor hereby assumes all liability for all personal injury, and damage to real or personal property, or interference with the use or enjoyment of any property by reason of blasting or the resulting vibration or concussion. The Contractor assumes full responsibility for operating all equipment and performing all blasting in conformance with Federal and State laws, and regulations prescribed by any other governmental authority limiting the amount of vibration or concussion.

8. Pre-Blast Survey:

a. The Contractor will conduct a pre-blast survey of the surrounding structures within 500 feet of any blasting operation on either side of the centerline of the blasting right-of-way and document the condition before any blasting or excavation begins. The documentation will include a written description of all defects, digital color photographs of each of these defects, and a complete inspection of all structures on the property. This includes outside structures, walls, sidewalks, etc. No video cameras will be allowed for pre-blast surveys where interior finished surfaces are concerned.

b. In special situations, crack monitors may be located over existing cracks at selected locations to be measured before and after blasting to determine if widening or displacement has taken place.

c. Before carrying out the inspection, the Contractor or his consultant shall notify the Owners of buildings or structures to be inspected and request

permission to carry out the inspection. Should any building Owner refuse permission to carry out this inspection, the Contractor shall notify the Engineers in writing, giving the Owner's reason for refusal.

9. Blasting Program:

   a. The Contractor shall furnish the Engineers the name and qualifications of its blasting consultant for approval.

   b. The Contractor's consultant shall formulate and make recommendations in a written blasting program furnished to the engineer. Criteria for the selection of this program shall be the prevention of damage to existing structures and the prevention of any interruption of their services.

   c. The blasting program shall include, but not be limited to, data on the locations, hole size, depth, overburden, pattern and inclination of the blast holes, the type, strength, amount, distribution, and powder factor for the explosives used, per hole and per blast, the sequence and pattern of delays, maximum amount of explosives in any one period, depth of rock, and depth of overburden, if any, and the description and purpose of special methods to be used. This data shall be accepted by the contractor as the general procedure of blasting on this job.

   d. Explosion and firing devices shall be of a type that is commercially available, suitable for the use intended, in good condition resulting from proper storage and maintenance.

   e. Blasting mats shall be of a size and type to be suitable for the use intended. All blasts should be covered with at least 2 feet of overburden. Fly-rock will not be permitted at any time. If a fly-rock incident does occur, the job will be stopped immediately and a written plan will be submitted by the Contractor to explain how this recurrence of fly-rock will be prevented in the future.

10. Blasting Preparation:

   a. Conduct a pre-blast survey of existing structures as specified herein.

   b. Prepare a written blasting program as specified herein.

11. Trial Blasting:

   a. Conduct a trial blasting program as directed by the Contractor's consultant before general excavation blasting may commence. The maximum explosive charge weight per delay period utilized shall be limited to the

amount submitted in the blasting plan.

b. Trial blasting shall consist of determining the relationship between peak particle velocities and weight of the explosive charges by a planned program of trial blasts. Beginning with small weights of explosive, successively greater explosive weights shall be detonated and the particle velocities measured at several distances from the blast. The trial blasting and field observations are intended to develop a relationship between size of the explosive charge, distance from the explosion, and particle velocity. This data shall be used as a basis for controlling the blasting program.

c. The initial blasts in any blasting area shall be considered test blasts. These test blasts will be monitored, at nearest structures, and modifications of the maximum explosive charge weight per delay may be allowed providing that the vibration effects, at the nearest structure, are maintained below the specified levels. These modifications to the maximum charge weight per delay will only be allowed on the advice of the vibration consultant.

12. General Blasting Procedures:

a. A blast shall be defined as a predetermined number of shots. A period of at least 5 minutes shall elapse between each blast and a minimum delay time of 8 milliseconds shall elapse between each individual shot within a blast. The interval between individual shots may be increased or decreased if requested by the contractor and approved in writing by the Contractor's consultant. The contractor must, however, remain within the vibration limits hereinafter described.

b. Blast Vibration Limits:

1. Blasting vibrations as recorded adjacent to the foundation of the nearest above ground structure shall be limited as follows:

a. A peak particle velocity (on any component of a 3 component particle velocity recording seismograph) of 2.00 inches/seconds shall not be exceeded for the structure closest to the blast site when vibration frequencies are greater than 40 hertz. Frequencies less than 40 hertz will be limited to a peak particle velocity of 0.50 inch/second.

b. Compliance with the Bureau of Mines blast level chart, as noted in RI 8507, will suffice for the previously mentioned limits.

2. When the existing structures are very close to the blasting area, very

slight changes in any blasting variable will result in large changes in vibration intensities. Modifications of the blasting method and reduction of the explosive charge weight per delay shall be used to ensure that one of the above limits is met.

3. At any time the Engineer reserves the right to reduce or increase explosive amounts, change blasting patterns on any blasting, or eliminate blasting in certain areas should conditions warrant.

4. The maximum peak particle velocity may be increased with the written approval of the Contractor's consultant providing that the contractor and his consultant prove that no damage to existing structures will result.

13. Air Blast Limits:

a. Air blast from blasting shall be controlled such that:

1. The maximum allowable air blast at any inhabited structure resulting from blasting operations shall not exceed 128 decibels peak when measured by an instrument having a flat response $\pm$3 decibels) over the range of at least 2 to 200 Hz.

b. Air blast shall be monitored with an approved instrument having the required frequency response and capable of providing a permanent record of the air blast effects. These records, identified by time and recording location shall be made available upon request to the Engineers on a monthly basis or in a tabulated form at other times as required.

14. Documentation of Blasting Program:

a. All recommendations, guidelines, findings, and correspondences for the blasting program will be documented in writing and compiled into a final report.

b. Copies of ground vibration measurements recorded by seismographs will be analyzed and verified by the Consultant and included in the appendix of the final report.

C. Sheeting, Shoring and Bracing:

1. The sides of all trenching excavations shall be sufficiently sheeted, shored, and braced whenever necessary to prevent slides, cave-ins, settlements or movement of the banks and to maintain the excavation clear of obstructions that will, in any way, hinder or delay the progress of the work.

2. Wood or steel sheet piling of ample design and type shall be used when necessary.

3. All sheeting, shoring, and bracing shall have sufficient strength and rigidity to withstand the pressures exerted and to maintain the walls of the excavation properly in place and protect all persons and property from injury or damage.

4. Where excavations are made adjacent to existing buildings or other structures, or in paved streets or alleys, the Contractor shall take particular care to sheet, shore and brace the sides of the excavation adequately so as to prevent any undermining of or settlement beneath such structures or pavement. Underpinning of adjacent structures shall be done when necessary. The Contractor will be liable for any damage to any structure that results from his operations.

5. Sheeting, shoring or bracing materials shall not be left in place unless so shown by the plans or ordered by the Engineer. Such materials shall be removed in such manner as will not endanger or damage the new structure or any existing structures or property, either public or private, in the vicinity, and so as to avoid cave-ins or slides. No trench sheeting and bracing shall be removed until the trench has been backfilled one foot above the top of the pipe.

D. Trenching Through Dikes or Fill Sections:

1. Trenching through existing dikes or fill sections shall be accomplished in accordance with general trenching requirements as specified elsewhere.

2. Trenching for pipe lines or other utilities through dikes or fill sections under construction shall not begin until the new dike or fill section has been constructed, enlarged, or otherwise improved to an elevation 3 feet above the top of the pipe or other utility being installed.

3. Where existing dikes or fill sections are being used for the storage of liquids such as a lagoon, reservoir, pond, lake, canal, or other structure, the Contractor shall take whatever means necessary to preserve the integrity of the structure. No leakage of the stored liquid out of the structure will be allowed without the written approval of the owners of said structure.

E. Minimum Trench Widths:

1. All excavations shall be made to the lines and grades as established by the drawings, and shall be open cut through whatever material encountered. The Engineer may, if requested, make changes in the trench alignment to avoid major obstructions, if such changes can be made within the easement right-of-way

without adversely affecting the intended function of the facility. In areas where soil conditions permit normal excavation of the trench, the sides shall be cut as nearly vertical as possible from the bottom of the trench to a point at least 12 inches above the top of the pipe. The trench width shall conform to Table 2 of the AWWA C600 Specification. For pipes larger than listed in Table 2, the over-all width of trench shall be that determined from the formula 4/3d plus 12 inches, in which "d" is the inside diameter of the pipe in inches.

3.05 Dewatering:

A. The Contractor shall at all times provide and maintain the necessary equipment and means for removal of all water from excavated areas. All excavated areas shall be kept free of water while any work is in progress. Particular precautions shall be taken to prevent the displacement of structures or pipelines as a result of accumulated water.

B. Bedding material or pipe shall not be placed in wet or unstable trenches. Soil that cannot be properly dewatered shall be excavated and dry material tamped in place to such a depth as may be required to provide a firm trench bottom.

C. All water removed or diverted from excavations shall be disposed of in a manner that will prevent damage to adjacent property or any flooding of streets or property. Disposal of trench water through the pipeline under construction shall not be allowed.

D. Water shall be removed and disposed of so as to not damage adjacent property or existing drainage ways.

3.06 Trench Foundation Material:

A. Where unsuitable materials for supporting pipe bedding are encountered, these materials shall be removed and replaced with trench foundation material, as directed by the Engineer.

B. Trench foundation material shall be placed at the specified trench width from the bottom of the excess excavation to the bottom grade line of the pipe bedding.

C. Trench foundation material so placed shall be as shown on the trench detail drawings or specified herein. If not shown on the drawings, trench foundation material shall consist of Alabama Department of Transportation Standard Specifications for Highway Construction, Section 801, No. 57 crushed limestone.

3.07 Bedding and Backfill:

A. General:

1. All areas where bedding is not specifically called for or required by the Engineer, the pipe shall be bedded in native soils. Bell holes shall be excavated so that the entire pipe length rests on firm soil.

2. Areas undercut by the Contractor through negligence, or his convenience, shall be backfilled and tamped with approved materials at the expense of the Contractor. In areas that are to be paved, the backfill material shall be select backfill.

3. Bedding shall meet the requirements of Paragraph 2.01 of these specifications.

4. Backfilling shall not begin before the Engineer or Inspector has inspected the grade and alignment of the pipe.

5. If select backfill is not specified, backfilling to a point 12-inches above the top of the pipe, defined as the pipe zone, shall be done with good earth, sand or gravel and shall be free from large rocks or hard lumpy materials. Large rocks shall be defined as any larger than 2-inches in diameter. No materials of perishable, spongy or otherwise unsuitable nature shall be used in backfilling. It is essential that the completed backfill be done in such a manner as to minimize voids in the backfill.

6. Place trench backfill material at approximately the same rate along both sides of the pipe and compact by tamping in layers not to exceed 8 inches of loose fill up to the horizontal centerline of the pipe. The intent is to cradle the pipe so that the full length is uniformly supported on firm bedding and the weight of the pipe and backfill is borne uniformly by the lower half of the pipe barrel. Special attention should be given to the backfilling and tamping procedures to insure that no voids or un-compacted areas occur beneath the pipe. After this, fill and compact the trench as specified below, depending upon the location of the work and danger from subsequent settlement.

7. All backfilling shall be done in such a manner that will not disturb or injure the pipe or structure over or against which it is being placed. Any pipe or structure injured, damaged, or moved from its proper line or grade during backfilling operations, shall be replaced or repaired and then re-backfilled as herein specified, at the expense of the Contractor.

B. Trench Backfill and Pipe Bedding:

1. Pipe bedding and trench backfill shall be constructed as shown on the drawings for trench details. If no trench details are shown on the drawings, then the Contractor shall install the utilities as described in Paragraphs 3.07 B.3 and 3.07 B.4.

2. Where pipes are installed in unpaved areas, unless specifically shown on the drawings or called out in the Bid Schedule to be unimproved, the areas shall be considered to be ***Improved*** areas and shall be constructed accordingly.

3. Pipe Bedding and Trench Backfill – **GRAVITY** Pipe:

   a. Under Pavement – Asphalt or Concrete and/or Gravel Drives:

   Pipe Material – Ductile Iron.
   Bedding – 6" ALDOT No. 57 crushed limestone.
   Initial Backfill – Select Backfill ALDOT 825 Type "A" from bottom of pipe to springline in maximum 8" loose layers compacted to 95% SPD.
   Final Backfill – Select backfill ALDOT 825 Type "A" to top of trench in maximum 8" loose layers compacted to 95% SPD.

   Pipe Material – PVC.
   Bedding – 6" ALDOT No. 57 crushed limestone.
   Initial Backfill – Select Backfill ALDOT 825 Type "A" from bottom of pipe to 12" above top of pipe in maximum 8" loose layers compacted to 95% SPD.
   Final Backfill – Select backfill ALDOT 825 Type "A" to top of trench in maximum 8" loose layers compacted to 95% SPD.

   b. Improved Areas:

   Pipe Material – Ductile Iron.
   Bedding – 6" ALDOT No. 57 crushed limestone.
   Initial Backfill – ALDOT No. 57 crushed limestone from bottom of pipe to springline in maximum 8" loose layers; consolidated.
   Final Backfill – Standard backfill to top of trench in maximum 8" loose layers compacted to 90% SPD.

   Pipe Material – PVC.
   Bedding – 6" ALDOT No. 57 crushed limestone.
   Initial Backfill – ALDOT No. 57 crushed limestone from bottom of pipe to 12" above top of pipe in maximum 8" loose layers; consolidated.
   Final Backfill – Standard backfill to top of trench in maximum 8" loose layers compacted to 90% SPD.

   c. Unimproved Areas:

Pipe Material – Ductile Iron.
Bedding – 6" ALDOT No. 57 crushed limestone
Initial Backfill – ALDOT No. 57 crushed limestone from bottom of pipe to springline.
Final Backfill – Standard backfill to top of trench, loose.

Pipe Material – PVC
Bedding – 6" ALDOT No. 57 crushed limestone.
Initial Backfill – ALDOT No. 57 crushed limestone from bottom of pipe to 12" above top of pipe in maximum 8" loose layers; consolidated.
Final Backfill – Standard backfill to top of trench, loose.

4. Pipe Bedding and Trench Backfill – **PRESSURE** Pipe:

a. Under Pavement – Asphalt or Concrete and/or Gravel Drives:

Pipe Material – Ductile Iron
Bedding – Class 3 Native Material *
Initial Backfill – Select backfill ALDOT 825 Type "A" from bottom of pipe to springline in maximum 8" loose layers compacted to 95% SPD.
Final Backfill – Select backfill ALDOT 825 Type "A" to top of trench in maximum 8" loose layers compacted to 95% SPD.

Pipe Material – PVC
Bedding – Class 3 Native Material *
Initial Backfill – ALDOT No. 8910 crushed limestone from bottom of pipe to 12" above top of pipe in maximum 8" loose layers compacted to 95% SPD.
Final Backfill – Select backfill ALDOT 825 Type "A" to top of trench in maximum 8" loose layers compacted to 95% SPD.

b. Improved Areas:

Pipe Material – Ductile Iron and/or PVC
Bedding – Class 3 Native Material *
Initial Backfill – Standard backfill from bottom of pipe to springline in maximum 8" loose layers compacted to 90% SPD.
Final Backfill – Standard backfill to top of trench in maximum 8" loose layers compacted to 90% SPD.

c. Unimproved Areas:

Pipe Material –	Ductile Iron and/or PVC
Bedding –	Class 3 Native Material *
Initial Backfill –	Standard backfill from bottom of pipe to springline in maximum 8" loose layers compacted to 90% SPD.
Final Backfill –	Standard backfill, loose to top of trench

* ***Where trench bottom is rock, excavate rock to depth according to Section 3.04 of this specification and provide Class 1 bedding.***

3.08 Cleaning:

A. The Contractor shall thoroughly clean all areas damaged during construction of excess fill, construction debris, etc.

B. All gutters and adjacent curbing shall be swept clean of debris and materials that may hinder storm water flow.

3.09 Protection:

A. The Contractor shall protect the newly constructed pipeline from damage until final acceptance of the work.

END OF SECTION

SECTION – PRECAST CONCRETE MANHOLES

PART 1 - GENERAL

1.1 Section Includes:

A. This section of specifications covers the material and installation requirements for precast concrete manhole sections with tongue-and-groove joints, masonry transition to manhole frame, covers, anchorage and accessories.

B. The testing requirements for materials, in-place, specified under this section shall conform to Section – Sanitary Sewer System.

1.2 Related Sections:

A. Section – Trenching, Backfilling, and Compaction
B. Section – Sanitary Sewer System

1.3 References:

A. ASTM A48 – Standard Specification for Gray Iron Castings.

B. ASTM C443 – Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.

C. ASTM C478 – Standard Specification for Precast Reinforced Concrete Manhole Sections.

D. ASTM C923 - Resilient Connectors Between Reinforced Concrete Manhole Structures and Pipes.

E. International Masonry Industry All-Weather Council (IMIAC): Recommended Practices and Guide Specification for Cold Weather Masonry Construction.

1.4 Qualifications:

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum of five years documented experience.

1.5 Environmental Requirements:

A. Masonry construction shall not be performed when ambient temperatures are 40-degrees F. and falling unless provisions for heating and protecting the work are

approved. Protect new masonry from freezing for 48-hours after completion of the masonry work.

PART 2 - PRODUCTS

2.1 Materials:

A. Precast Manhole Base and Sections:

1. All precast manholes shall be new, unused manholes delivered directly from the manufacturer to the job site. The date of manufacture and the name or trademark of the manufacturer shall be clearly marked on the outside of the barrel.

2. Precast concrete manholes shall be of reinforced concrete manhole sections conforming to the requirements of ASTM C478. The concrete when tested in compression shall not be less than 4000 psi and absorption shall not exceed 9%.

3. Precast manhole base and sections shall be a minimum of 48-inches inside diameter. Precast manhole base shall have a minimum wall thickness of 5 inches and minimum bottom thickness of 6 inches. Minimum wall thickness of the manhole riser sections shall be 5 inches for 48" I.D. sections, 6 inches for 60" I.D. sections, and 7 inches for 72" I.D. sections.

4. Manhole base riser, riser, transition, and cone sections shall have offset tongue and groove joints and shall be made watertight with prelubricated rubber gaskets conforming to ASTM C443 and butyl sealant waterstops. Pre-lubricated gaskets shall be Tylox Superseal as manufactured by Hamilton-Kent or equal; butyl sealant waterstop shall be Conseal CS-231 or equal, in widths as recommended by the manufacturer.

5. Manholes shall be assembled with the fewest number of sections to makeup the required height, thereby reducing the number of joints. The use of more than one riser section of 16 inches or less shall be prohibited. The City Engineer may require that any manhole not composed of the minimum number of sections be replaced.

6. Precast eccentric cone shall be provided at top section of manhole. Eccentric cone shall have the same reinforcing as manhole base and sections. Cone sections shall be made with a minimum 5-inch wall thickness at the bottom and 8-inch wall thickness at the top. Where watertight manhole frame and covers are indicated on the drawings, cone sections shall be supplied with

four (4) stainless steel anchor bolts as shown in the City of Tuscaloosa Standard Detail drawing.

7. Two lift holes shall be cast into each cone or riser section for purposes of handling and placement.

8. Openings for inlet and discharge sewer pipes shall be provided in the manhole base section and in the riser section for drop manholes. Openings shall be at positions and elevations as indicated on the plans, and may be cast into the manhole wall or mechanically cored at the manufacturing facility. Openings shall be sized to accommodate the flexible manhole sleeve.

B. Precast Concrete Adjusting Rings:

1. Provide precast concrete adjusting rings, as required, between top of eccentric cone and finished grade.

2. Precast concrete adjusting rings shall be of same materials of construction as manhole bases and sections, grooved top and bottom.

3. Adjusting rings shall be 3 or 4 inches high by 5 inches thick. Maximum combined height of adjustment rings shall be limited to 8 inches.

C. Flexible Manhole Sleeves:

1. Flexible manhole sleeves suitable for use in precast or cored openings utilizing premolded shapes positioned with expansion rings shall comply with the requirements of ASTM C923 and shall be manufactured by Kor-N-Seal or approved equal. Flexible connectors shall be installed as recommended by the manufacturer.

D. Manhole Steps:

1. Manhole steps shall be Copolymer Polypropylene Plastic Coating over 1/2-inch minimum Grade 60 steel reinforcing, 12-inches wide, with slip resistant surface.

2. Manhole steps shall conform to ASTM C478 as manufactured by M.A. Industries, Model PSI-PF, or equal. Steps shall be centered under the manhole cover opening and be vertically aligned on 16-inch centers.

E. Manhole Frames and Covers:

1. Manhole frames and covers shall be close-grained, cast-iron, smooth, clean, free of blisters, blowholes and other defects and conform to ASTM A48, Class 30B. Plane or grind bearing surfaces to ensure a flat, fine surface. Castings judged to be defective by the Owner or Engineer will be rejected and shall be replaced by the Contractor.

2. Covers and frames shall be "Heavy-Duty" type, rated for a minimum of H-20 loading. Covers and frames shall be made in the United States. All castings shall be clearly marked with the manufacturers name, product catalog No. and made in the U.S.A. in cast letters.

3. Manhole covers shall be cast with two non-penetrating type pick holes. Covers shall not have vent holes.

4. Manhole frames and covers shall be of either Standard Type (non-bolted) or Watertight Type (bolt-down), as indicated on the drawings. If not indicated, manhole covers shall be standard type. In locations where the manhole rim elevation is below the 100-year flood elevation, manhole frame and covers shall be Watertight Type.

5. Manhole frames and covers shall conform to the manufacturer dimensions shown on the City of Tuscaloosa Standard Detail drawings.

6. When watertight frames are required, manhole joints shall be supplied with 3" x 16" x ½" butimastic-coated steel strap anchors and bolts as shown in the City of Tuscaloosa Standard Detail drawings.

F. Non-Shrink Grout

1. Non-shrink grout shall be used to seal openings in the manhole base and riser sections such as lift holes and around flexible sleeve connections as shown on the standard details. Non-shrink grout shall be Thoro WaterPlug or approved equal.

2. Surface preparation, mixing and application shall strictly adhere to manufacturer's recommendations.

PART 3 - EXECUTION

3.1 Excavation and Backfill:

A. Perform excavation to lines and grades established by the Drawings. Construct excavation a minimum of two (2) feet in diameter larger than the outside dimensions of the manhole base and sections.

B. If material in bottom of excavation is unsuitable for supporting manhole, excavate unsuitable material to a depth specified by the Engineer and backfill resulting void with Alabama Department of Transportation No. 57 crushed limestone.

C. Backfill around manholes constructed in paved areas or areas to be paved with Alabama Department of Transportation 825, Type "A". Compact backfill in 8-inch loose lifts to minimum density of 95% Standard Proctor Density with vibratory compaction equipment.

D. Backfill around manholes in unimproved areas and lawns with native materials, compacted in 8-inch loose lifts to minimum density of 95% Standard Proctor Density.

3.2 Granular Base:

A. Remove standing water from excavation. Place 12-inches minimum of Alabama Department of Transportation #57 stone and compact with vibratory compaction equipment.

B. Excavations deeper than 12-inches below required grade of manhole base, not approved by the Engineer, shall be filled with Alabama Department of Transportation No. 57 crushed limestone and compacted by vibratory compaction equipment at no additional cost to the Owner.

3.3 Placing Manhole Base and Sections:

A. Manholes shall be constructed to the sizes, shapes, dimensions, and at the locations shown on the plans and the City of Tuscaloosa Standard Detail drawings.

B. Precast manhole bases shall be set plumb and true to the lines and grades specified by the plans. Manholes out of plumb in excess of 1/4-inch in eight (8) feet shall be reset.

C. Clean ends of manhole sections of foreign materials and inspect ends for damage.

D. Place prelubricated gasket into recess. Place butyl sealant waterstop as shown in the City of Tuscaloosa Standard Details. Follow gasket and waterstop manufacturers' installation instructions. Set manhole section.

E. When new openings are required in existing manholes, openings shall be core drilled.

F. Install flexible manhole sleeves on pipes at the precast or core drilled openings according to manufacturer's recommendations. Grout around flexible sleeve as shown on the City of Tuscaloosa Standard Detail drawing.

G. Seal lifting holes and flexible manhole sleeves in manhole on the interior and exterior with non-shrink grout to divert infiltration.

3.4 Manhole Invert:

A. Manhole inverts shall be constructed of cement mortar and shall have the same cross-section as the invert of the sewers which they connect. The manhole invert shall be carefully formed to the required size and grade by gradual and even changes in sections. Changes in direction of flow through the sewer shall be made to a true curve with as large a radius as the size of the manhole will permit.

B. For pipe diameters less than 48 inches, a bench shall be constructed on each side of the flow channel. The bench shall slope one (1) inch per foot. Bench shall be made of non-shrink grout.

C. Where the difference in the invert elevation of two or more sewers 18-inches in diameter or smaller intersecting in one manhole is 2-feet or more, a drop manhole shall be constructed in the manner shown on the City of Tuscaloosa Standard Detail drawing. They shall be similar in construction to the standard manhole except that a drop connection of pipe and fittings of the proper size and material shall be constructed outside the manhole and supported by 3,000 psi concrete. The manhole and drop connection shall be placed on a 12-inch reinforced concrete foundation base. The drop connection piping assembly shall be bolted to the barrel of the manhole riser. Refer to City of Tuscaloosa Standard Detail SD 080.

D. When manholes are constructed over existing sewers and a full section of pipe is through manhole, break out top section of pipe and cover exposed edges of pipe with grout.

3.5 Manhole Frames and Covers:

A. Install manhole frames and covers with top surface adjoining surrounding grade in improved areas, or 18 inches above grade in unimproved areas. Where manholes are constructed in paved areas, the top surface of the frame and cover shall be tilted so as to conform to the exact slope, crown and grade of the existing pavement adjacent thereto. Set manhole frames at the required elevation in a full bed of grout for provide proper bonding to cone section and/or concrete adjusting rings.

B. Where manhole frame elevation requires adjustment, precast concrete adjusting rings shall be used. A minimum 1/4-inch bed of non-shrinking grout shall be placed

between the manhole cone section and the adjusting ring. Same grout thickness shall be provided in between adjusting rings when multiple rings are necessary. Butyl sealant waterstop shall be placed beneath the frame and in between each concrete adjusting ring as shown on the City of Tuscaloosa Standard Detail drawings. Butyl sealant shall be Conseal CS-231.

C. Manhole frame shall be positioned concentrically above the precast cone section or adjusting rings and set in a full bed of non-shrinking grout. A thick ring of non-shrinking grout extending to the outer edge of the precast cone section or adjusting ring shall be placed all around and on top of the manhole frame. The non-shrinking grout shall be smoothly finished and have a slight slope to shed water away from the frame and cover.

D. Check manhole cover for fit in frame. If a manhole cover is either excessively loose or tight in the frame, or rocks, wobbles, or moves in the frame, the frame and cover shall be removed and replaced by the Contractor.

3.6 Protective Coatings

A. Where shown on the drawings or directed by the City Engineer, manholes shall be protected from corrosion by the use of factory applied ceramic epoxy linings.

B. Epoxy coating shall be an amide cured ceramic epoxy, Permite PCS-9043 Type II or approved equal. The epoxy shall be applied to a 40 mils dry film thickness on the inside of the structure per the manufacturer's recommendations.

END OF SECTION

SECTION - POLYVINYL CHLORIDE GRAVITY SEWER PIPE

PART 1 - GENERAL

1.01 Section Includes:

A. This section of specifications covers the material requirements for polyvinyl chloride (PVC) pipe, fittings, and laterals for use in gravity sewer applications.

B. The installation requirements for pipe specified under this section shall conform to Section – Trenching, Backfill and Compaction.

C. The testing requirements for materials, in-place, specified under this section shall conform to Section – Sanitary Sewer System.

1.02 Related Sections:

A. Section – Trenching, Backfill and Compaction
B. Section – Sanitary Sewer System

1.03 References

A. ASTM D1784, latest revision, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
B. ASTM D3034, latest revision, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
C. ASTM D2412, latest revision, External Properties of Plastic Pipe by Parallel Plate Loading.
D. ASTM D3212, latest revision, Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
E. ASTM F477, latest revision, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
F. ASTM D2321, latest revision, Standard Recommended Practice for Installation of Flexible Thermoplastic Sewer Pipe.
G. AWWA C900 – Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 inches–12 inches, for Water Distribution.

1.04 Quality Control and Assurance:

A. All pipe and fittings shall be inspected at the factory and on the job site. The pipe shall be homogeneous throughout and free from cracks, holes, foreign inclusions, or other defects. The pipe shall be as uniform in color as commercially practical. PVC pipe shall have a ring painted around the spigot ends in such a manner as to allow field checking of setting depth of pipe in the socket.

B. PVC sewer pipe shall be marked with the manufacturer's name, production lot number, ASTM designation, PVC cell classification or material code, dimension ratio or standard dimension ratio, and the nominal diameter. All PVC pipe shall be manufactured in the United States.

C. All PVC pipe shall be new and unused and properly stored at the manufacturer to prevent degradation of the pipe due the exposure to sunlight and excessive heat.

D. Pipe must be delivered to job site by means, which will adequately support it, and not subject it to undue stresses. In particular, the load shall be so supported that the bottom rows of pipe are not damaged by "egging" or crushing. Pipe shall be unloaded carefully and strung or stored as close to the final point of placement as is practical. Pipe shall not be stored outside where subject to sunlight.

E. Pipe which has been stored by the Contractor for three (3) months or longer shall not be acceptable.

PART 2 – MATERIALS

2.01 PVC Gravity Sewer:

A. PVC gravity sewer pipe shall be made from compounds conforming to ASTM D1784. PVC pipe and fittings, 8 to 12 inches in diameter, shall conform to and be tested under all of the requirements of ASTM D3034. This designation specifies minimum requirements and test methods for materials, dimensions, workmanship, flattening resistance, impact resistance, pipe stiffness, extrusion quality, and pipe marking. PVC gravity sewer shall have a wall thickness equal to or greater than SDR 35.

B. Minimum pipe stiffness (F/ ΔY) at 5 percent deflection shall be 115 for all sizes when calculated in accordance with ASTM D2412.

C. PVC sewer pipe shall be supplied in standard lengths of at least 12 feet 6 inches. Longer lengths are permitted. PVC gravity sewer pipe shall be green in color.

D. Fittings for service connections shall be of the factory made inline type conforming to the requirements of ASTM D3034 and shall have a wall thickness equal to or greater than SDR 35. Service connections shall be made with wye fittings. Saddle type fittings shall not be used.

E. All pipe and fittings shall be joined by means of an integral wall bell and spigot with a flexible watertight elastomeric seal. Joint material and testing requirements shall conform to ASTM D3212 and ASTM F477.

2.02 PVC Laterals

A. PVC service laterals for PVC sewer mains shall be of same material described in 2.01A above.

B. PVC service laterals for ductile iron sewer mains shall be AWWA C-900 pipe and shall have a wall thickness equal to or greater than DR 25.

C. Contractor shall provide an easily removable, watertight and airtight, gasketed plug at the end of the service lateral.

PART 3 – EXECUTION

3.01 PVC Gravity Sewer:

A. In addition to the requirements for installation and testing specified in Section – Sanitary Sewer System, installation of PVC gravity sewer pipe shall conform to ASTM D2321 and manufacturer's recommendations unless otherwise amended in these Specifications.

B. Trenching, backfill, and compaction shall conform to Section – Trenching, Backfill and Compaction of these Specifications.

C. The inside of all bells and outside of all spigots shall be wiped to remove all dirt, water, or other foreign matter so that their surfaces are clean and dry when the pipes are joined.

D. Immediately before joining PVC pipe, the joining surfaces shall be completely coated by brushing with the lubricant sealer furnished by the pipe manufacturer. The spigot end shall then be centered to exact line and grade and then sealed by forcing the spigot into the bell in an approved manner.

E. Pipe that has been field cut must be beveled for insertion into the gasketed joint. Bevel can be made with hand or power tool. In either case, the finished bevel should be the same as the factory bevel.

3.02 PVC Laterals

A. In addition to the requirements for installation and testing specified in Section – Sanitary Sewer System, installation of PVC laterals pipe shall conform to ASTM D2321 and manufacturer's recommendations unless otherwise amended in these specifications. Connection between service lateral and sewer main shall be

watertight. PVC service laterals shall be installed for each lot and extend from the collector sewer to user's property line.

B. Trenching, backfill, and compaction shall conform to Section – Trenching, Backfill and Compaction of these Specifications.

C. A PVC-coated electronic service marker shall be located six inches above the top of the lateral just beyond the curb.

END OF SECTION

SECTION - POLYVINYL CHLORIDE PRESSURE SEWER PIPE

PART 1 - GENERAL

1.01 Section Includes:

A. This section of specifications covers the material requirements for polyvinyl chloride (PVC) pipe and fittings for use in pressure sewer applications. These include low pressure sewers and force mains.

B. The installation requirements for pipe specified under this section shall conform to Section – Trenching, Backfill and Compaction.

C. The testing requirements for materials, in-place, specified under this section shall conform to Section – Sanitary Sewer System.

1.02 Related Sections:

A. Section – Trenching, Backfill and Compaction
B. Section – Sanitary Sewer System
C. Section – Ductile Iron Pipe and Fittings

1.03 References

A. ASTM D1784, latest revision, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
B. ASTM D2241, latest revision, Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
C. ASTM D2412, latest revision, External Properties of Plastic Pipe by Parallel Plate Loading.
D. ASTM D3139, latest revision, Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
E. ASTM F477, latest revision, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
F. ASTM D1785, latest revision, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
G. ASTM D2665, latest revision, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
H. ASTM D2672, latest revision, Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement.
I. ASTM D2855, latest revision, Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.

1.04 Quality Control and Assurance:

A. All pipe and fittings shall be inspected at the factory and on the job site. The pipe shall be homogeneous throughout and free from cracks, holes, foreign inclusions, or other defects. The pipe shall be as uniform in color as commercially practical. PVC pipe shall have a ring painted around the spigot ends in such a manner as to allow field checking of setting depth of pipe in the socket.

B. PVC sewer pipe shall be marked with the manufacturer's name, production lot number, ASTM designation, PVC cell classification or material code, dimension ratio or standard dimension ratio, and the nominal diameter. All PVC pipe shall be manufactured in the United States.

C. All PVC pipe shall be new and unused and properly stored at the manufacturer to prevent degradation of the pipe due the exposure to sunlight and excessive heat.

D. Pipe must be delivered to job site by means, which will adequately support it, and not subject it to undue stresses. In particular, the load shall be so supported that the bottom rows of pipe are not damaged by "egging" or crushing. Pipe shall be unloaded carefully and strung or stored as close to the final point of placement as is practical. Pipe shall not be stored outside where subject to sunlight.

E. Pipe which has been stored by the Contractor for three (3) months or longer shall not be acceptable.

PART 2 – MATERIALS

2.01 PVC Force Mains:

A. PVC force mains shall be made from compounds conforming to ASTM D1784. PVC force main piping and fittings, 4 to 12 inches in diameter, shall conform to and be tested under all requirements of ASTM D2241. This designation specifies minimum requirements and test methods for materials, dimensions, workmanship, sustained pressure, burst pressure, flattening, extrusion quality, and pipe markings. PVC force main pipe shall have a wall thickness equal to or greater than SDR 21. Pipe shall have a pressure rating of 200 psi.

B. Minimum pipe stiffness (F/ ΔY) at 5 percent deflection shall be 224 for all sizes when calculated in accordance with ASTM Designation D2412.

C. PVC force main pipe shall be supplied in standard lengths of at least 12 feet 6 inches. Longer lengths are permitted. PVC force main pipe shall be green in color.

D. PVC force main pipe shall be joined by means of an integral wall bell and spigot with a flexible watertight elastomeric seal. Joint material and testing requirements shall conform to ASTM D3139 and ASTM F477.

E. Fittings for PVC force main shall be ductile iron with mechanical joints conforming Section – Ductile Iron Pipe and Fittings. Special transition gaskets shall be used to join SDR 21 PVC pipe to mechanical joint fitting.

2.02 PVC Low Pressure Sewer (SDR 21)

A. PVC low pressure sewer pipe and fittings shall be made from compounds conforming to ASTM D1784. PVC low pressure sewer pipe, less than 4 inches in diameter, shall conform to and be tested under all requirements of ASTM D2241. This designation specifies minimum requirements and test methods for materials, dimensions, workmanship, sustained pressure, burst pressure, flattening, extrusion quality, and pipe markings. PVC low pressure sewer pipe shall have a wall thickness equal to or greater than SDR 21. Pipe shall have a pressure rating of 200 psi.

B. Minimum pipe stiffness (F/ ΔY) at 5 percent deflection shall be 224 for all sizes when calculated in accordance with ASTM Designation D2412.

C. PVC low pressure sewer pipe shall be supplied in standard lengths of at least 12 feet 6 inches. Longer lengths are permitted. PVC low pressure sewer pipe shall be green in color.

D. PVC low pressure sewer pipe shall be joined by means of an integral wall bell and spigot with a flexible watertight elastomeric seal. Joint material and testing requirements shall conform to ASTM D3139 and ASTM F477.

E. Fittings for PVC low pressure sewer pipe shall have a wall thickness equal to or greater than SDR 21.

2.03 PVC Low Pressure Sewer (SCH 40)

A. Alternatively, PVC low pressure sewer pipe and fittings, less than 4 inches in diameter, shall be Schedule 40 made in accordance with ASTM D1785 and ASTM D2665 from a PVC compound conforming to a cell classification of 12454 as defined by ASTM D1784. Belled end of solvent weld pipe shall meet the requirements of ASTM D2672 when installed in accordance with ASTM D2855.

B. PVC SCH 40 pipe and fittings shall have a minimum pressure rating of 260 psi.

PART 3 – EXECUTION

3.01 PVC Pressure Pipe:

A. In addition to the requirements for installation and testing specified in Section – Sanitary Sewer System, installation of PVC pressure sewer pipe shall conform to manufacturer's recommendations unless otherwise amended in these specifications.

B. Trenching, backfill, and compaction shall conform to Section – Trenching, Backfill and Compaction of these Specifications.

C. The inside of all bells and outside of all spigots shall be wiped to remove all dirt, water, or other foreign matter so that their surfaces are clean and dry when the pipes are joined.

D. Immediately before joining PVC gasketed pipe, the joining surfaces shall be completely coated by brushing with the lubricant sealer furnished by the pipe manufacturer. The spigot end shall then be centered to exact line and grade and then sealed by forcing the spigot into the bell in an approved manner.

E. Pipe that has been field cut must be beveled for insertion into the gasketed joint. Bevel can be made with hand or power tool. In either case, the finished bevel should be the same as the factory bevel.

END OF SECTION

SECTION - DUCTILE IRON PIPE AND FITTINGS

PART 1 - GENERAL

1.1 Section Includes:

A. This section of specifications covers the material and installation requirements for ductile iron pipe and fittings used in gravity sewer and force main applications.

B. The testing requirements for materials, in-place, specified under this section shall conform to Section – Sanitary Sewer System.

1.2 Related Sections:

A. Section – Trenching, Backfilling, and Compaction

B. Section – Sanitary Sewer System

1.3 References:

A. ANSI/AWWA C104/A21.4 – American National Standard for Cement-Mortar Lining for Ductile Iron Pipe and Fittings for Water.

B. ANSI/AWWA C105/A21.5 – American National Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.

C. ANSI/AWWA C110/A21.10 – American National Standard for Ductile-Iron and Gray-Iron Fittings, 3-in. through 48-in., for water and other liquids.

D. ANSI/AWWA C111/A21.11 – American National Standards for Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings.

E. ANSI/AWWA C115/A21.15 – American National Standard for Flanged Ductile-Iron Pipe with Ductile-Iron of Gray-Iron Threaded Flanges

F. ANSI/AWWA C150/A21.50 – American National Standard for the Thickness Design of Ductile-Iron Pipe.

G. ANSI/AWWA C151/A21.51 – American National Standard for Ductile-Iron Pipe, Centrifugally Cast for Water and Other Liquids.

H. ANSI/AWWA C153/A21.53 – American National Standard for Ductile-Iron Compact Fittings for Water Service.

I. AWWA C600 – Installation of Ductile Iron Water Mains and Their Appurtenances.

1.4 Quality Assurance:

A. All piping, fittings, and appurtenances installed by the Contractor shall be new and unused and shall be suitable for the intended purposes.

B. Each joint of pipe shall be plainly marked at the site of manufacturer to indicate the class, thickness, and/or strength.

1.5 Delivery, Storage and Handling:

A. All ductile iron pipe and fittings are subject to inspection at delivery and other times as deemed necessary by the Engineer. Any pipe and/or fittings damaged during delivery shall be promptly removed from the job site.

B. Ductile-iron pipe shall be stored off the ground supported by timbers, railings or concrete supports and shall be of sufficient size to avoid contact with the ground or adjacent piping. Supports shall have chocks to prevent movement. Stacking shall be low enough to provide a safe condition, especially in neighborhoods and accessible areas.

C. Pipe and fittings shall be stored to prevent damage to the interior or exterior lining. The interior of all pipe and fittings shall be kept free of dirt and debris. Ductile iron pipe shall not be stacked higher than specified in Table 1 of AWWA C600.

D. Pipe and fittings shall be loaded and unloaded by hoists or skids to avoid sudden impact to the material. In no case shall the pipe or fittings be dropped. Slings, hooks, or pipe tongs shall be padded to avoid damage to the exterior or interior linings.

E. Gaskets for mechanical joint and push-on joint pipe and fittings shall be stored in a cool dry place out of direct sunlight. Contact with petroleum based substances is prohibited.

PART 2 - PRODUCTS

2.1 Approved Manufacturers:

A. American Cast Iron Pipe Company
B. U.S. Pipe
C. Others as approved by the Engineer

2.2 Materials: Ductile iron pipe and fittings shall conform to the following:

A. Pipe and Fittings

1. In general, ductile iron pipe for underground work shall have push-on or mechanical joints; ductile iron pipe for exposed work shall have flanged joints. Where shown on the drawings, grooved-end pipe shall be used to allow removal of valves and fittings.

2. Ductile iron pipe with push-on or mechanical joints shall conform to ANSI/AWWA C150/A21.50 and ANSI/AWWA C151/A21.51, latest revision. Push-on or mechanical joints shall conform to the requirements of ANSI/AWWA C111/A21.11.

3. Pipe pressure classes and wall thicknesses shall be in accordance with bury depths and laying conditions as specified in C150/A21.50 and C151/A21.51. Minimum pressure classes for buried pipe shall be 350 psi for pipes $\leq$12 inches, 250 psi for pipes $\leq$ 24 inches, and 150 psi for pipe $\geq$ 30 inches in diameter.

4. Ductile iron pipe with flanged or grooved joints shall conform to the requirements of ANSI/AWWA C115/A21.15 (including appendix) and shall have a pressure rating of 350 psi for pipes $\leq$ 12 inches, and a pressure rating of 250 psi for pipes $\geq$ 14 inches. Flanges for threading onto ductile iron pipe shall conform to the requirements of ANSI/AWWA C115/A21.15.

5. Fittings for ductile iron pipe with push-on or mechanical joints shall conform to the requirements of ANSI/AWWA C110/A21.10 and shall have a pressure rating of 350 psi for sizes $\leq$ 24 inches, and a pressure rating of 250 psi for sizes $\geq$ 30 inches. Ductile iron fittings for ductile iron pipe with push-on or mechanical joints may be compact fittings conforming to ANSI/AWWA C153/A21.53. Joints shall be mechanical joints conforming to the requirements of ANSI/AWWA C111/A21.11.

6. Fittings for flanged ductile iron pipe shall conform to the requirements of ANSI/AWWA C110/A21.10 (including appendix) and shall have a pressure rating of 250 psi. Fitting flanges shall conform to the requirements of ANSI/AWWA C110/A21.10. Gaskets for flanged joints shall be full face of first quality red rubber, 1/8-inch thick.

B. Coatings and Linings:

1. Exposed piping shall have exterior rust inhibitive primer coating compatible with finished paint.

2. All ductile iron pipe and fittings for underground installation shall receive an exterior bituminous coating of 1-mil minimum thickness.

3. All ductile iron pipe and fittings shall have an interior cement-mortar lining with asphaltic seal coat in accordance with ANSI/AWWA C104/A21.4.

4. Where hydrogen sulfide is a potential problem, ductile iron pipe and fittings shall be lined with a 40-mil thickness coating of Protecto 401 amine cured ceramic epoxy or approved equal.

5. Where shown on the drawings or required by the City Engineer, ductile iron pipe and fittings situated in aggressive soils shall be polyethylene wrapped in accordance with ANSI/AWWA C105/A21.5. Wrappings shall be 8-mil low density or 4-mil high density, cross-laminated (HDCL) polyethylene film.

PART 3 - EXECUTION

3.1 Examination:

A. The contractor shall examine the site, trench and surrounding conditions to assure proper installation of the pipe and associated fittings.

B. The contractor shall examine pipe and fittings for any scratches or abrasions to the coating or linings, or other physical damage prior to its installation.

C. Trenches shall be inspected for proper alignment and grade. Check trench bottom to assure proper clearance from other utilities, pipelines or existing structures.

D. Any bedding required by the drawings or specifications shall be installed prior to pipe placement.

3.2 Installation:

A. Pipe installation shall be according to this section of the specification and the manufacturer's instructions and/or referenced specifications.

B. Every care shall be taken in the handling, cutting, and laying of pipe and fittings to avoid damaging the interior or exterior coating. Damaged or defective areas shall be repaired or replaced to the satisfaction of the Engineer.

C. Any ductile iron fitting showing a crack, any fitting or pipe which has received a severe blow that may have caused an incipient fracture, even though no such fracture can be seen, shall be marked as rejected and removed at once from the job site. In any pipe showing a distinct crack and in which it is believed there is no incipient fracture beyond the limits of the visible crack, the cracked portion, if so approved, may be cut off by and at the expense of the Contractor before the pipe is laid so that the pipe used

may be perfectly sound. The cut shall be made in the sound barrel at a point at least 12 inches from the visible limits of the crack. Except as otherwise approved, all cutting shall be done with a machine having rolling wheel cutters or knives adapted to the purpose. All cut ends shall be beveled and shall be examined for possible cracks caused by cutting. Special care shall be taken to avoid excessive heat during cutting which might damage pipe lining.

D. Each section of ductile iron pipe shall be placed in the prepared trench with the full length of the barrel resting upon the pipe bed and with the pipe bell over a bell hole excavated at the proper location to accommodate the bell. No temporary supports under the pipe such as bricks, rocks, etc., shall be permitted.

E. Any pipe found defective shall be replaced. Cracked pipe may be cut as specified previously in this section if authorized by the Engineer.

F. Pipeline shall be laid with bells in direction of laying, unless it is necessary to do otherwise to make connections to existing pipe. Where pipe is to be laid on a slope, the direction of laying shall be from downstream to upstream.

G. All lumps, blisters, and excess coating shall be removed from the socket and plain ends of each pipe, and the outside of the plain end and the inside of the bell shall be wiped clean and dry and be free from dirt, sand, grit, or any foreign material before the pipe is laid. Foreign material shall be prevented from entering the pipe while it is being placed in the trench. During laying operations, no debris, tools, clothing, or other materials shall be placed in the pipe.

H. As each length of pipe is placed in the trench, the joint shall be assembled and the pipe brought to correct line and grade as shown on the drawings.

I. Assembly of ductile iron push-on joints and mechanical joints shall be in accordance with AWWA Specifications C600, Section 3.4. The contractor shall use particular care in cleaning the socket, plain end and gasket. Mechanical joint bolts shall be tightened to the proper torques shown in Table 4, AWWA Standard C600.

J. Deflections of ductile iron pipe having mechanical joints, if authorized by the Engineer, shall not exceed the deflection limits shown in Table 6, AWWA Standard C600. All bolts and set screws shall be checked immediately before backfilling.

K. Deflections for push-on joint pipe shall conform to Table 5 of AWWA C600.

L. At times when pipe laying is not in progress, the open ends of pipe shall be closed by the use of pipe plugs or other methods approved by the Engineer to keep mud, water, and other debris out of the pipe.

M. Pipe cutting for the insertion of valves and fittings shall follow the manufacturer's recommendations. No torch cutting shall be allowed. Interior and exterior coatings shall be repaired and touched-up per manufacturer's recommendations.

N. Trenches shall be backfilled according to Section - Trenching, Backfill and Compaction.

END OF SECTION

SECTION - SANITARY SEWER SYSTEM

PART 1 - GENERAL

1.1 Section Includes:

A. This section of specifications covers installation requirements of gravity sewer pipe and pressure sewer pipe. Testing requirements for gravity sewers, manholes, and force mains are also provided in this section.

B. All materials used in the construction of sewers shall be new and unused when delivered to the job site and shall be suitable for installation and operation under the conditions for which they are to be used.

1.2 Related Sections:

A. Section – Polyvinyl Chloride Gravity Sewer Pipe
B. Section – Polyvinyl Chloride Pressure Sewer Pipe
C. Section – Ductile Iron Pipe and Fittings
D. Section – Precast Concrete Manholes
E. Section – Trenching, Backfilling and Compaction
F. Section – Slope Protection and Erosion Control

PART 2 – PRODUCTS (NOT USED)

PART 3 – INSTALLATION

3.1 Gravity Sewer Pipe Laying - General:

A. Before sewer pipe is placed in position in the trench, the bottom and sides of the trench shall be carefully prepared and the necessary bracing and sheeting installed.

B. Unless noted otherwise on the drawings, all gravity sewer lines shall be installed with a minimum thirty-six (36) inches of cover.

C. A properly designed and operated laser beam device may be used to align and grade the pipe. Laser beam devices used shall be carefully calibrated at intervals not to exceed 30 calendar days.

D. Air blowers must be used in conjunction with laser beam devices and must be sufficient to provide an air flow through the pipe of 4 to 6 mph.

E. If approved by the Engineer, the batter board method may be used. A mason's line shall then be tightly stretched above ground level, parallel to and directly above the

axis of the pipe to be installed; this line to be supported at intervals not exceeding 50 feet. The exact line and grade for each section of pipe shall be determined by measuring down from this line to the invert of the pipe in place. Each pipe shall be accurately placed to the exact line and grade called for on the plans. The Contractor shall furnish all labor and materials necessary for erecting batter boards.

F. Water shall not be allowed to run or stand in the trench while pipe laying is in progress or before the joints are completed or before the trench has been backfilled. The Contractor shall not open up at any time more trench than his available pumping facilities are able to dewater.

G. Each piece of pipe and special fitting shall be carefully inspected before it is placed and no defective pipe shall be laid in the trench. Pipe laying shall proceed up-grade, starting at the lower end of the grade and with the bells uphill.

H. After pipe laying has begun, it shall continue progressively up-grade. No section of pipe installation will be skipped without a written request for such procedures from the Contractor and approved by the Engineer.

I. Bell holes shall be of sufficient size to allow ample room for properly making the pipe joints. Bell holes shall be cut not more than five joints ahead of pipe laying. The bottom of the trench and the crushed stone cushion between bell holes shall be carefully graded so that the pipe barrel will rest on a solid foundation for its entire length. Each joint shall be laid so that it will form a close concentric joint with adjoining pipe and so as to avoid sudden offsets and inequalities in the flow line.

J. Backfilling of trenches shall be started immediately after the pipe is in place and the joints completed and inspected by the Developer's Engineer.

K. A metallic tape and wire shall be installed in the same trench with all non-metallic pipe (PVC) in order that the pipe may be located with electronic metal detection equipment. Wire shall be T.W. 12-gauge solid copper conforming to specifications for annealed copper, ASTM B-3 and Underwriters Laboratories Thermoplastic Insulated Wire Standard No. 83, latest revision. Wire shall be Simplex BW3001, or equal. Pipe detector tape shall be two (2) inch wide minimum metalized tape. Tape shall be Griffolyn Company, Inc., Terratape 2" D., or equal. Wire and/or Tape shall be secured to pipe at intervals of 20 feet.

L. Manholes shall be installed according to Section – Precast Concrete Manholes.

3.2 Laterals Installation:

A. Wye shall be installed in sanitary sewer lines at all points shown on the plans or specified herein. If such branches are not to be used immediately, they shall be closed with gasketed plugs specifically designed for such purpose.

B. If the work consists of the construction of a sewer that is to replace an existing sewer, all of the existing service lines shall be connected to the new line.

C. Wyes shall be installed in sanitary sewers so as to properly serve each existing house and each vacant lot facing or abutting on the street or alley in which the sewer is being laid, and at such other locations as may be designated by the Engineer. The exact location of each connection shall be determined by the Engineer before backfilling.

D. Should ductile pipe lining be scratched, chipped, or otherwise damaged during the tapping process, it shall be properly repaired or recoated by the Contractor.

E. Laterals shall be bedded and backfilled according to Section – Trenching, Backfill, and Compaction.

F. Where the depth of cut is over 8 feet or where the grade of a sanitary sewer is lower than necessary to drain abutting property, and when designated by the City Engineer, connecting risers shall be installed to serve each existing house and each vacant lot facing or abutting on the street in which the sewer is being laid.

G. Connecting risers shall be either 4 or 6 inches in diameter installed from a wye connection to the elevation designated by the Engineer. Open ends of connecting risers shall be closed, as herein before specified for wye branches. Backfilling shall be carefully done around these risers.

3.3 Pressure Sewer Pipe Laying – General

A. Before sewer pipe is placed in position in the trench, the bottom and sides of the trench shall be carefully prepared and the necessary bracing and sheeting installed.

B. Unless noted otherwise on the drawings, all pressure sewers shall be installed with a minimum of thirty-six (36) inches of cover.

C. Water shall not be allowed to run or stand in the trench while pipe laying is in progress or before the joints are completed or before the trench has been backfilled. The Contractor shall not open up at any time more trench than his available pumping facilities are able to dewater.

D. Each piece of pipe and special fitting shall be carefully inspected before it is placed and no defective pipe shall be laid in the trench. No section of pipe installation will be

skipped without a written request for such procedures from the Contractor and approved by the Engineer.

E. All pressure pipe 4 inches and over in diameter shall be provided with adequate thrust restraints. Thrust restraints, consisting of concrete thrust blocks and/or mechanical restraining rod attachment shall be furnished at all fittings, plugs, and all pipe bends as shown on the Standard Detail Drawing.

F. Air release valves, Air/Vacuum release valves, and Combination air valves shall be installed at the locations shown on the drawings.

G. A metallic tape and wire shall be installed in the same trench with all non-metallic pipe (PVC) in order that the pipe may be located with electronic metal detection equipment. The tape or wire shall be attached to the top of the pipe. Wire shall be T.W. 12-gauge solid copper conforming to specifications for annealed copper, ASTM B-3 and underwriters Laboratories Thermoplastic Insulated Wire Standard No. 83, latest revision. Wire shall be Simplex BW3001, or equal. Pipe detector tape shall be two (2) inches wide minimum metalized tape. Tape shall be Griffolyn Company, Inc., Terratape 2" D or equal. Wire and/or Tape shall be secured to pipe at intervals of 20 feet.

3.4 Pipe Protection:

A. Sewer pipe which, when completed, will have less than three (3) feet of cover, shall be provided with concrete protection and shall be constructed of ductile iron pipe.

B. Where foundation conditions are not satisfactory, as determined by the Engineer, sewer pipe shall be either laid on a concrete cradle, sand backfill, foundation material, and/or constructed of ductile iron pipe as shown on the plans or as directed by the Engineer.

3.5 Testing of Gravity Sewers and Manholes:

A. General:

1. The approval and acceptance of gravity sewer lines and manholes shall be based on final testing. The Contractor must provide a 72-hour notice prior to final testing to the City Engineer. A representative from the Engineer and/or Owner must be present to witness final testing procedures. Tests performed in the absence of the Engineer's and/or Owner's representatives shall be considered invalid and shall be repeated by the Contractor.

2. Final testing of gravity lines shall only be performed after all work adjacent to and over the pipeline has been completed. Trench backfilling, grading, roadway

sub-grade, concrete work, other utility installation, and any other superimposed loads shall be completed and in place prior to final testing.

3. Prior to any testing and final inspection, all gravity lines shall be cleaned of debris and flushed clean with water as necessary by the Contractor. Debris and flush water shall be contained at a lower manhole and removed from the line. Debris and flush water shall not be allowed to enter live existing sanitary sewers. Contractor shall be responsible for collection and proper disposal of debris and flush water.

4. All apparatus and equipment required for testing shall be furnished by the Contractor.

5. Contractor shall provide the City Engineer and Owner with copies of all field notes and documentation obtained during final testing.

B. Scope:

1. All gravity sewers shall be tested by one or more of the following methods as directed by the City Engineer:

   a. Direct Visual Inspection by the Engineer

   b. Exfiltration of water

   c. Infiltration of water

   d. Exfiltration of air under pressure (Low Pressure Air Testing)

   e. Video Inspection.

2. In addition to the above testing requirements, all PVC gravity sewers shall pass mandrel testing to verify roundness and proper installation.

3. All manholes shall be vacuum tested.

C. Direct Visual Inspection by the Engineer

1. The Engineer and/or his Representative shall visually inspect all gravity sewer pipe installed to verify alignment and ensure the pipe is free from obstructions and debris. Each segment of sewer shall be "flashed" using sunlight and mirrors. When the full diameter of the pipe is visible between adjacent manholes, the segment of pipe is deemed properly aligned and free of sags and debris.

2. If segment of pipe fails visual inspection, the pipe shall be cleaned and/or replaced and re-tested by the Contractor.

D. Exfiltration of Water

1. The section of sewer to be tested shall be sealed by inserting inflatable rubber bags or plugs in the pipes or by other means approved by the Engineer. Water shall then be introduced into a manhole until the pipeline section is completely filled. The Contractor shall fill the pipe to the required test level prior to the time of exfiltration testing to permit normal absorption into the pipe walls if concrete or concrete lined ductile iron pipe is being tested. Throughout the test period of two (2) hours minimum, the water level in the upper manhole shall be maintained at least 18-inches above the crown of the upper end of the pipe or at least 18-inches above the groundwater table, whichever is greater. The length of pipe tested shall be limited such that the pressure on the centerline of the lower pipe end tested does not exceed six (6) feet water column.

2. Exfiltration of water shall not exceed 100-gallons per mile of sewer per inch of inside diameter per 24-hours in any section of the completed work. In no case shall the exfiltration of water exceed 2500 gallons per mile per 24 hours. All observed leaks shall be corrected by the Contractor even though exfiltration is within the allowable limits.

3. The City Engineer may direct the Contractor to test selected sections of the sewer in the following manner: after the selected sections of the sewer are laid in the trench and the joints completed but before any backfill is placed, the Contractor shall install suitable bulkheads or stoppers in each end of the sewer and fill the sewer with water. The sewer shall be filled through one length of sewer pipe installed vertically at a wye or at the end of the pipe being tested. Water shall be maintained in the line approximately to the top of the fill pipe until the Engineer can inspect the section of sewer being tested. Any leaks in the sewer system being tested shall be repaired by the Contractor. The total amount of sewer thus tested shall not exceed five percent (5%) of the total length of sewer constructed. Should the results of any of these tests indicate leakage, the City Engineer may direct the Contractor to change the methods of construction to reduce the leakage on the remaining part of the work.

E. Infiltration of Water:

1. The section of sewer to be tested shall have been trench backfilled and the test conducted by inducing infiltration conditions by jetting the sewer trench for a sufficient length of time to insure that the water level in the trench is a minimum of eighteen(18) inches over the crown of the sewer pipe. The test must be

performed before existing sewers are connected and before sewage load is allowed in the sewers.

2. Infiltration of ground water or other leakage into the sewer (including manholes) shall not exceed 100 gallons per mile of sewer per inch of inside diameter of the sewer per 24 hours in any section of the completed work, and in no case shall it exceed 2500 gallons per mile per 24 hours.

3. Infiltration flow shall be measured in wet weather by a 90-degree "V-notch" weir with free discharge or other means acceptable to the Engineer. These weirs shall be furnished, installed, and removed by the Contractor.

4. Any leaks into the sewer that can be located shall be repaired or corrected by the Contractor as directed by the Engineer regardless of infiltration test results.

F. Exfiltration of Air Under Pressure (Low Pressure Air Testing):

1. Scope

a. This recommended practice defines the proper procedures for acceptance testing of installed gravity sewer pipe, using low-pressure air, to provide assurance that the pipe, as installed, is free from significant leaks. Included are requirements for equipment accuracy, safety precautions, line preparation, test method, and minimum holding times. This recommended practice does not cover the testing of manholes. All new pipe shall be low-pressure air tested to insure the integrity of the pipe and joints

b. Only lines tested after backfilling to final grade will be considered for acceptability. However, this test may also be used by the installer as a presumptive test to determine the condition of the line prior to backfilling. At no time will more than four manhole to manhole reaches of pipe be installed before air testing is performed.

c. Low Pressure Air Testing shall be conducted in accordance with ASTM C828, C924, F1417 and UBPPA UNI-B-6.

2. Responsibilities:

a. Responsibility of the Contractor: Unless otherwise specified, the Contractor shall furnish all the necessary equipment and be responsible for conducting all low-pressure air tests. In addition, the Contractor is responsible for any necessary repair work on sections that do not pass the test. No sealant shall be used in any newly installed sewer without the

prior approval of the City Engineer. Proper structural repair work will be required by the Engineer or the Owner.

b. Responsibility of the Engineer: The Engineer and/or a qualified inspector shall witness all low-pressure air tests and verify the accuracy and acceptability of the equipment utilized. The engineer should inform the Contractor regarding acceptable methods of repair in the event one or more sections fail to pass the low-pressure air test. The Engineer should also report to the Owner regarding the acceptability of the Contractor's work.

c. Responsibility of the Owner: The Owner shall make a final decision as to the acceptability of the Contractor's work based upon the Engineer's recommendation.

d. Regulatory Agencies: Regulatory Agencies in the State, Federal, and/or local level may be legally entitled to witness any air testing and/or review the results. The Owner or his Engineer should check to see that the low-pressure air test specified for his installation is at least as stringent as those which may be required by such regulatory bodies.

3. Equipment

a. Air testing shall be performed by the Contractor using equipment manufactured by Cherne Industries, Inc., or approved equal. Equipment used shall meet the following minimum requirements.

b. Pneumatic plugs shall resist internal testing pressures without requiring external bracing or blocking. However, the Contractor should internally restrain or externally brace the plugs to the manhole wall as an added safety precaution throughout the test. No one shall be allowed in the manhole adjoining a line being tested so long as pressure is maintained in the line.

c. Pneumatic plugs shall have a sealing length equal to or greater than the diameter of the pipe to be inspected.

d. To facilitate test verification by inspecting Engineer, all air used shall pass through a single, aboveground control panel.

e. The aboveground air control equipment shall include a shut-off valve, pressure regulating valve, pressure relief valve, input pressure gauge, and a continuous monitoring pressure gauge having a pressure range from 0 to at least 10 psi.

f. Three individual hoses shall be used for the following connections:

1. from control panel to pneumatic plugs for inflation.
2. from control panel to sealed line for introducing the low pressure air.
3. from sealed line to control panel for continually monitoring the air pressure rise in the sealed line.

4. Line Preparation

a. During sewer construction, all service laterals, stubs, and fittings into the sewer test section shall be properly capped or plugged so as not to allow for air loss that could cause an erroneous air test result.

b. A wetted interior pipe surface is desirable and will produce more consistent test results. Where practical, clean the line with cleaning balls, manufactured by Cherne Industries Incorporated or equal, prior to testing, to wet the pipe surface and eliminate debris.

5. Test Procedure

a. All pneumatic plugs shall be seal tested before being used in the actual test installation. One length of pipe shall be laid on the ground and sealed at both ends with the pneumatic plugs to be checked. Air shall be introduced into the plugs to the manufacturer's recommended inflation pressure. The sealed pipe shall be pressurized to 9 PSIG. The plugs shall hold against this pressure without bracing and without movement of the plugs out of the pipe.

b. After a manhole to manhole reach of the pipe has been backfilled and cleaned, and the pneumatic plugs are checked by the above procedure, the plugs shall be placed in the line at each manhole and inflated to manufacturer's recommended inflation pressure. When plugs are being placed, the pipe adjacent to the manhole shall be visually inspected to detect any evidence of shear in the pipe due to differential settlement between the pipe and the manhole.

c. Low pressure air shall be slowly introduced into this sealed line until the internal air pressure reaches 4.0 PSIG greater than the average back pressure of any groundwater above the pipe, but not greater then 9.0 PSIG. If groundwater is present, refer to the following Paragraph 6. Determination of Groundwater Elevation and Air Pressure Adjustment, of Section 3.5.F in this Specification.

d. After a constant pressure of 4.0 PSIG (greater than the average groundwater back pressure) is reached, the air supply shall be throttled to maintain the internal pressure for at least 2 minutes.

e. When the pressure has stabilized at 4.0 PSIG, the air hose from the control panel to air supply shall be shut off or disconnected. The continuous monitoring pressure gauge shall then be observed while the pressure is decreased to no less than 3.5 PSIG. At a reading of 3.5 PSIG, or any convenient observed pressure reading between 3.5 PSIG and 4.0 PSIG, timing for the test may begin.

f. The portion of line being tested shall be termed "Acceptable" if the allocated line pressure decreases less than one PSI in the time shown for the given diameters and lengths in the following table. Consult the City Engineer for test lengths greater than those provided.

MINIMUM SPECIFIED TIME REQUIRED FOR A 1.0 PSIG PRESSURE DROP

Pipe Dia (inches)	Specification time for Length Shown (min:sec)							
	100 FT	150 FT	200 FT	250 FT	300 FT	350 FT	400 FT	450 FT
8	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
21	19:50	26:10	34:54	43:37	52:21	61:00	69:48	78:31
24	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33

g. If there has been no leakage (0 PSIG drop) after one hour of testing, the test section shall be accepted and the test complete. If there is any pressure drop, the complete test shall be run to determine whether or not the test section is acceptable.

h. If the pressure drops 1.0 PSIG before the appropriate time shown in the table has elapsed, the air loss rate shall be considered excessive and the section of pipe has failed the test.

i. If the section fails to meet these requirements, the Contractor shall determine the source(s) of leakage, and he shall repair or replace all defective materials and/or workmanship to the satisfaction of the Engineer. The extent and type of repair which may be allowed, as well as results, shall be subject to the approval of the Engineer. The completed pipe installation shall then be retested and required to meet the requirements of this test.

6. Determination of Groundwater Elevation and Air Pressure Adjustment

a. In areas where ground water is known to exist, the Contractor shall install a ½-inch diameter capped pipe nipple, approximately 10 inches long, through the manhole wall directly on top of one of the sewer lines entering the manhole. A permanent, watertight seal shall be provided around the pipe nipple at the manhole wall. This shall be done at the time the sewer line is installed.

b. Immediately prior to the performance of the air testing, the ground water shall be determined by removing the pipe cap, blowing air through the pipe nipple into the ground so as to clear it, and then connecting a clear plastic tube to the nipple. The plastic tube shall be held vertically and a measurement of the height in feet of water over the invert of the pipe shall be taken after the water has stopped rising in this plastic tube. The height in feet shall be divided by 2.31 to establish the pounds of pressure that will be added to all readings. (For example, if the height of water is 11-1/2 feet, then the added pressure will be 5 psig. This will increase the 3.5 psig (mentioned in item e above) to 8.5 psig, and the 2.5 psig to 7.5 psig.)

c. The allowable pressure drop of 1.0 PSIG and the timing in the previous table are not affected and shall remain the same.

d. In no case shall the starting test pressure exceed 9.0 PSIG. If the average vertical height of groundwater above the pipe invert is more than 12.7 feet, the section so submerged may be tested using 9.0 PSIG as the starting test pressure.

e. After determining the air pressure adjustment, the test shall resume according to Item 5 - Test Procedures stated above.

f. After determining groundwater height, each pipe nipple shall be recapped and sealed to prevent future infiltration.

G. Video Inspection:

1. Prior to final acceptance, the sewer installation shall be video inspected by City forces. Said inspection shall verify locations of service connections, and locations of possible defects/infiltration. Any defects found shall be repaired by the Contractor in a manner acceptable to the City Engineer.

H. Mandrel Testing:

1. Mandrel test (deflection test) shall be performed by the Contractor in order to verify the roundness and proper installation of the PVC gravity sewer line.

2. Equipment systems used to perform mandrel tests shall be specifically designed for the pipe material being tested. Mandrels that do not specifically state the size and type of piping for which it is applicable shall not be allowed.

3. Deflection Test:

   a. The deflection test shall consist of testing PVC gravity sewer pipe for proper installation by the method outlined (see ASTM D3034). The testing shall be accomplished prior to final acceptance, but at least 30 days after the pipe has been backfilled completely to permit stabilization of the soil-pipe envelope.

   b. After the pipeline has been installed and backfill materials have been compacted to their required standard densities, the mandrel shall be pulled by hand through the pipeline with a suitable rope or cable that is connected to an eyebolt at one end of the gauge. A similar rope or cable shall be attached to the eyebolt at the opposite end of the mandrel and tension shall be applied to it. This will insure that the mandrel maintains its correct position during testing and also to remove the mandrel if it should become lodged in an excessively deflected pipeline. Winching or other mechanical means of forcing the mandrel through the pipeline is unacceptable. Pipeline deflection testing shall have a deflection not exceeding 5% of the base inside pipe diameter as established by ASTM Standards D3034 and F679.

   c. Permanent record of all testing with locations where excessive pipeline deflections occur shall be kept by the Contractor and forwarded to the Engineer after completion of testing on each line.

   d. The Contractor shall immediately correct or replace all sections of pipe which deflect more than 5%.

   e. All material and labor required for testing and/or replacement of pipelines shall be furnished by the Contractor.

   f. Pipelines requiring correction and/or replacement shall be retested after an additional 30 day backfill stabilization period.

I. Manhole Vacuum Testing:

1. Vacuum tests shall be conducted on newly constructed manholes. Preliminary manhole testing shall take place following construction after all connections are made, and before backfilling. Test results derived from this test will allow time for necessary repairs to be completed before further construction proceeds and hinders such repairs. Final tests must be performed after the manhole has been backfilled.

2. Equipment:

   a. Manhole vacuum tester assembly and vacuum pumps shall be manufactured by Cherne Industries, Inc., or approved equal.

   b. Pneumatic plugs shall be manufactured by Cherne Industries, Inc. or approved equal. These plugs shall have a sealing length equal to or greater than the diameter of the connecting pipe to be sealed.

3. Procedures:

   a. Plug all manhole entrances and exits other than the manhole top access using suitably sized pneumatic or mechanical pipeline plugs and follow all manufacturer's recommendations and warnings for proper and safe installation of such plugs. Plugs should be inserted a minimum of 6" beyond manhole wall. Make sure such plugs are properly rated for the pressures required for the test. The standard test of 10" Hg. (mercury) is equivalent to approximately 5 PSIG (0.3 bar) backpressure. Unless such plugs are mechanically restrained, it is recommended that the plugs are used with a minimum of two times (2x) safety factor or a minimum of 10 PSIG (0.7 bar) backpressure usage rating.

      CAUTION: BRACE INVERTS IF LINES ENTERING THE MANHOLE HAVE NOT BEEN BACKFILLED TO PREVENT PIPE FROM BEING DISLODGED AND PULLED INTO THE MANHOLE.

   b. Any other openings such as lifting holes shall be sealed with an approved non-shrink grout.

   c. Install the vacuum tester head assembly at the top of the manhole. Adjust the cross brace to insure that the inflatable sealing element inflates and seals against the straight top section of the manhole or the ring assembly, if possible. (If using a "plate" style manhole tester, position the plate on the manhole ring assembly).

d. Attach the vacuum pump assembly to the proper connection on the test head assembly. Make sure the vacuum inlet/outlet valve is in the closed position.

e. Following safety precautions and manufacturer's instructions, inflate sealing element to the recommended maximum inflation pressure. CAUTION: DO NOT OVER INFLATE.

f. Start the vacuum pump and allow pre-set RPM to stabilize.

g. Open the inlet/outlet ball valve and evacuate the manhole to 10" Hg. (approximately negative 5 PSIG, 0.3 bar).

CAUTION: DO NOT PRESSURIZE MANHOLE! THIS MAY RESULT IN MANHOLE DAMAGE AND/OR RESULT IN MANHOLE TEST HEAD DISLODGING FROM MANHOLE INLET!

h. Close vacuum inlet/outlet ball valve and monitor vacuum for specified test period (see table). If vacuum does not drop in excess of 1" Hg., manhole is considered acceptable and the manhole passes the test. If manhole fails the test, Contractor shall complete necessary repairs and repeat test procedures until satisfactory results are obtained.

Minimum Test Times for Various Manhole Diameters

DEPTH – FEET	MANHOLE DIAMETER – INCHES			
	48	60	72	96
8	20 sec	26 sec	33 sec	38
10	25 sec	33 sec	41 sec	48
12	30 sec	39 sec	49 sec	57
14	35 sec	46 sec	57 sec	67
16	40 sec	52 sec	67 sec	76
18	45 sec	59 sec	73 sec	86
20	50 sec	65 sec	81 sec	95
+ 2 ft incr.	+5 sec	+6.5 sec	+8.0 sec	+9.5 sec

(The values listed above are based upon ASTM Specification C1244 "Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test".)

4. Repeat the above test procedure after backfilling manhole for final acceptance test.

5. All manholes that fail the test or have visible leaks, even if they pass the test, shall be repaired or replaced by the Contractor until the manholes pass the

test, to the complete satisfaction of the City Engineer. Manholes that have any visible leaks will not be accepted.

3.6 Testing of Force Mains

A. General:

1. This Section shall cover testing of sanitary sewer force mains for pipe sizes of four inches (4") in diameter and larger for flushing, hydrostatic pressure and leakage. Testing shall be accomplished so that all portions of the system are flushed and tested according to these requirements. These requirements are for both Ductile Iron and Polyvinyl Chloride (PVC) Pipe. The Contractor shall furnish test equipment, labor, materials, and water for all tests. All test equipment shall be approved by, and meet the requirements of, the City Engineer for the City of Tuscaloosa.

2. The Contractor must provide a 24-hour notice prior to final testing to the City Engineer.

3. All apparatus and equipment required for testing shall be furnished by the Contractor.

4. Contractor shall provide City Engineer and Owner with copies of all field notes, documentation, and recording charts obtained during final testing.

B. Flushing:

1. Prior to beginning the pressure test, the line shall be flushed to remove all dirt and debris trapped in the line.

2. All valves shall be partially opened and closed during the flushing process.

3. All lines shall be flushed with a velocity of at least two and one-half feet per second (2.5 fps).

4. The Contractor is responsible for the proper disposal of all flushed water.

C. Testing:

1. Before applying the specified test pressure, all entrained air shall be expelled completely from the section pipe under test. Air shall be bled from the highest elevations in the line. If permanent air vents are not located at the high points in the test section, corporation cocks meeting the approval of the City Engineer shall be installed at such points so that air may be expelled as the line is filled

with water. At the conclusion of the pressure test, the corporation cocks shall be removed and tightly plugged, or left in place at the direction of the City Engineer.

2. All exposed pipe, fittings, and joints shall be examined carefully during the test. Any damaged or defective pipe or fittings or any visible or audible leaks, discovered during or following the pressure test shall be repaired or replaced, regardless of the pressure test results, with sound material by the Contractor. The test shall be repeated until the results are satisfactory to the City Engineer.

3. The Test Pressure shall be the Working Pressure of the line as defined below, but in no case less than one hundred pounds per square inch (100 psi).

   a. The Working Pressure shall be defined as one and on-half (1.5) times the shut-off head of the system pump or as defined by the City Engineer.

4. Leakage shall be defined as the quantity of water that must be supplied into the section of pipe being tested to maintain pressure within ± 5 psi of the specified test pressure after the pipe has been filled with water and the air has been expelled. Leakage **shall not** be measured by a drop in pressure in a test section over a period of time.

5. Upon complete removal of all air entrapped in the line, the line shall again be filled with water and pressurized to the required test pressure. The line shall be allowed to stabilize at the test pressure for a minimum of four (4) hours before conducting the pressure test.

6. Duration of the test shall be two (2) hours for uncovered pipe and six (6) hours for covered pipe. The test pressure shall not vary by more that plus or minus five pounds per square inch (± 5 psi) during the duration of the test. The specified test pressure shall be applied by means of a pump connected to the pipe.

7. A recording pressure gauge approved by the City Engineer shall be installed and pressure fluctuations recorded for the duration of the test. For each test, copies of all test charts and records shall be furnished to the City Engineer.

D. Acceptance:

1. Acceptance shall be determined on the basis of allowable leakage. If any test of pipe laid discloses leakage greater than that specified, the failure shall be located and repaired using approved materials an acceptable construction practices until the leakage is within specified allowance. All visible leaks are to be repaired

regardless of the amount of leakage.

2. Maximum allowable leakage in a test period shall not exceed:

$$L = \frac{SD(P^{1/2})}{133{,}200}$$

where: L = allowable leakage in gallons per hour
S = length of pipe tested in feet
D = nominal diameter of pipe in inches
P = average test pressure during the leakage test in pounds per square inch, gauge (psig)

3.7 Clean-Up and Grassing:

A. After the ditch lines have been sufficiently compacted, all excess material shall be removed from the job site by the Contractor.

B. Any trees or undergrowth shall also be removed by the Contractor.

C. All disturbed areas shall have topsoil replaced equal to that before construction began. If necessary, the Contractor shall provide topsoil.

END OF SECTION

SECTION - ASPHALT PAVING AND PATCHING

PART 1 - GENERAL

1.01 Section Includes:

A. This Section of Specifications covers the material and installation requirements for asphalt patching over excavated trenches in roads, parking lots and driveways.

B. This Section of Specifications covers material and installation requirements for an asphalt overlay across the entire paving width if required in the proposal.

1.02 Related Sections:

A. Section - Trenching, Backfill and Compaction

1.03 References:

A. State of Alabama Department of Transportation Standard Specifications for Highway Construction, Latest Edition.

1.04 Quality Assurance:

A. The work of asphalt paving shall be accomplished by skilled workmen experienced in the laying of asphalt.

B. All equipment shall be of a design and size to successfully accomplish the work.

1.05 Project Conditions:

A. The Contractor shall comply with all environmental laws and requirements pertaining to the work.

B. The Contractor shall take adequate measures to control dust in the work area.

C. The Contractor shall thoroughly inspect the backfilled trench and assure himself that proper laying conditions exist.

D. The Contractor shall provide and maintain adequate and safe traffic control.

PART 2 - PRODUCTS

2.01 Materials:

A. Prime Coat:

1. Prime Coat shall be emulsified asphalt, Type AE-P, or cutback asphalt Types MC 250, RC 70, and RC 250 as defined in Section 401 and Section 804 of the Alabama Department of Transportation Standard Specifications.

2. Prime Coat shall be applied at the rate of 0.22 to 0.25 gallons per square yard over the entire area to be treated with asphalt.

B. Tack Coat:

1. Tack coat shall be as per City of Tuscaloosa Standards provided by the OCE.

C. Asphalt Patch:

1. Asphalt paving used in patching shall be as per City of Tuscaloosa Standards provided by the OCE.

D. Asphalt Overlay:

1. Asphalt used as the overlay of an existing street shall be Bituminous Concrete Wearing Surface, Mix "A" and all materials used shall conform to Article 429.02 of the State of Alabama Department of Transportation Specifications. Bituminous Concrete Wearing Surface shall be ALDOT Item 429A-243.

2. The Contractor shall refer to the Standard Detail Drawings for the quantity of material to be applied per square yard.

E. Traffic striping and control markings shall conform to Sections 701 and 703 of the State of Alabama Department of Transportation Standard Specifications for Highway Construction. All striping, delineations, markers, etc., damaged or destroyed during the construction shall be replaced by the Contractor at his expense.

F. Before overlaying the street, the Contractor shall raise or lower all valve boxes, manholes and other embedded items, including items that have previously been paved over. No extra payment will be made for these adjustments.

2.02 Equipment:

A. Equipment used in asphalt patching and/or asphalt paving shall meet the requirements of Article 410.03a of the State of Alabama Department of Transportation Specifications.

B. Equipment used in the application of Prime Coat and Tack Coat shall comply with Article 401.03a of the above mentioned Specifications.

2.03 Temperature and Weather Requirements:

A. Prime and Tack Coat:

1. Bituminous materials shall not be placed on wet surfaces or when the air temperature is below 60-degrees F.

2. Bituminous materials shall not be placed when the temperature is expected to fall below freezing during the night regardless of the daytime temperature.

B. Asphalt Patching and Overlay:

1. The asphalt mixture shall be placed only upon an approved underlying course that is dry.

2. Asphalt layers of 200-pounds per square yard or less shall not be placed when the air temperature is below 40-degrees F. The air temperature must be 40-degrees F. and rising before the spreading operation is started and the spreading operation shall be stopped when the air temperature is 45-degrees F. and falling.

3. For asphalt layers over 200-pounds per square yard, the above temperatures shall be lowered by 5-degrees.

PART 3 - EXECUTION

3.01 Execution:

A. Prime and Tack Coat:

1. All loose material, dust and foreign material shall be removed from the surface. Cleaning shall be continued until all caked and loose dirt and dust are removed.

B. Asphalt Patching:

1. All designated areas to be patched shall be trimmed to neat vertical lines to the depth of patch specified. All loose material shall be removed. A prime or tack coat shall be applied as specified above. The asphalt shall be placed and compacted to a degree that further consolidation of the patch is not anticipated.

2. Any patched areas that do consolidate shall be replaced or additional material brought in to bring the patch up to the surrounding level.

3. All asphalt or concrete streets, parking areas and drives shall be patched the same day they are cut. Temporary or cold patch material may be used until the permanent patch can be placed.

3.02 Application:

A. Prime and Tack Coat:

1. Prime and Tack Coat shall be uniformly applied at the rate specified by pressurized distributors.

2. All areas to be treated with an asphalt surface treatment shall be primed and/or tacked.

B. Asphalt Patch and Overlay:

1. Asphalt Patching may be applied with spreaders, by hand, or with motor graders. All areas inaccessible to large equipment shall be spread by hand.

2. Asphalt patching shall be thoroughly compacted through the use of steel wheeled rollers and/or rubber tired rollers. Density shall be as specified in the State of Alabama Department of Transportation Standard Specifications.

3. Asphalt Overlay shall be applied with spreaders; except in inaccessible areas spreading may be done by hand, uniformly placing the desired rate per square yard over the underlying surface.

4. As soon as the mixture has set sufficiently to prevent cracking, the mixture shall be rolled with steel wheel and rubber-tired rollers to compact the mixture. Density shall be as specified in the State of Alabama Department of Transportation Standard Specifications.

3.03 Testing and Surface Requirements:

A. Testing of the asphalt mixtures shall be performed at the discretion of the Engineer. Testing shall include but not be limited to density tests and extraction tests.

B. The finished surface of asphalt overlays shall be checked with string, level and/or straightedge. The finished surface shall not vary more than 1/4" from the required sections as measured at right angles to the roadway centerline. The finished surface shall not vary more than 3/8" in any 25-foot section measured parallel to the centerline

at the following locations: one foot inside of the edges of pavement, at the centerline and at other points as designated.

3.04 Maintenance:

A. The contractor shall maintain and protect the newly laid asphalt until final acceptance of the work.

END OF SECTION