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SECTION 4 – SANITARY SEWER DESIGN & CONSTRUCTION STANDARDS

4.1 ENGINEERING

4.1.1 Introduction

This chapter outlines design and construction requirements for all public sanitary sewers. The provisions and technical specifications herein set forth the requirements of the City of Independence for constructing sanitary sewer improvements. Interpretations of such provisions and their application in specific circumstances shall be made by the Public Works Department authorized representative. Refer to Section 1 of the “Public Works Standards” for general provisions and requirements.

A map may be required that shows the drainage basin in which the project is located. The map shall show the major basin that is consistent with the City’s current Wastewater System Master Plan and any applicable amendments and updates to it.

4.1.2 General Provisions

Along with the provisions established in Chapter 1 Subsection “Control of Public Works Projects,” all sanitary sewers shall be designed and constructed so as to conform to the requirements of the Oregon state plumbing laws and rules of the Oregon DEQ. Except as otherwise provided, the extension of the public sewerage facilities to serve any parcel or tract of land shall be done by, and at the expense of, the property owner, although the City reserves the right to perform the work or cause it to be performed and bill the owner for the cost of the work or to pursue special assessment proceedings. Public sewer extensions shall extend to the most distant parcel boundary, to facilitate future extension, unless otherwise approved by the Public Works Department authorized representative.

4.1.3 Extension of Public Sanitary Sewer

The extension or upsizing of the public sanitary systems to serve any parcel or tract of land shall be done by and at the expense of the property owner or permit applicant. The Public Works Department authorized representative may require a sewer pipeline that serves or may serve more than one property to be a public system.

4.1.4 Sanitary Plans

A. It is the design engineer’s responsibility to ensure that engineering plans are sufficiently clear and concise to construct the project in proper sequence, using specified methods and materials, with sufficient dimensions to fulfill the intent of the design guidelines contained in these standards.
B. All elevation on design plans and record drawings shall be based on the applicable NAVD datum specified in Chapter 1 Subsection “Surveying and Land Monuments.”
C. All engineering sanitary plans shall be stamped by a Professional Engineer registered in the State of Oregon. The sanitary plan shall contain the following:
    1. At least one sheet shall show a plan view of the entire project site. If the project site is sufficiently large that detailed sanitary plans on any given sheet do not encompass the entire project site, then a sheet showing the plan view of the entire site must serve as an index to subsequent detailed plan sheets.
    2. A topographic map showing existing conditions for the site, including the following:
        a) Existing topography for the site.
        b) Adjacent streets, including street names.

c) Existing utilities, including franchised utilities located above or below ground. Existing drainage pipes, culverts, and channels shall include the invert or flow line elevations.
d) Existing environmentally sensitive areas (e.g., ravines, swales, steep slopes, wells, springs, wetlands, creeks, lakes). For natural drainage features, show direction of flow, drainage hazard areas, and 100-year floodplain boundary (if applicable).

3. Plans for proposed sanitary improvements shall include the following:
   a) Finished grades, showing the extent of cut and fill by existing and proposed contours, profiles, or other designations.
   b) Proposed structures, including roads and road improvements, parking surfaces, building footprints, walkways, landscape areas, etc.
   c) Proposed utilities, showing exact line and grade of all proposed utilities at crossings with the proposed sanitary system.
   d) Applicable detail drawings.
   e) Existing and proposed easements.
   f) Setbacks from environmentally sensitive areas and protected natural resource areas.
   g) Proposed sanitary structures.
   h) Maintenance access, as applicable (see Chapter 3 Subsection "Access Road Design").
   i) Plan and profile of sanitary systems, including the following information: pipe sizes, pipe types and materials, lengths, slopes, type of structure, location of structures, invert elevations in/out of structures, and top elevations of structures. Notes shall be included for referencing details, cross-sections, profiles, etc.
   j) Any proposed phasing of construction.

4.1.5 Surveying

A. The design engineer shall be responsible for establishing the location of the sewer by means of reference stakes offset along the sewer. No construction shall be allowed to begin before construction staking. All staking shall be performed by or under the direction of a Professional Land Surveyor registered in the State of Oregon.

B. Stakes shall locate all public tees, cleanouts, manholes, water line crossings, and pump stations. Maximum spacing for reference stakes is 50 feet. Stakes shall reference cuts or fills to all invert elevations and rim grades. The design engineer shall also be responsible for identifying easements during construction.

4.1.6 Population Density

Population density figures shall be obtained from the most recent information available for use by the Planning Department of the City of Independence. If those figures vary from those of the applicable master plan estimates, the difference must be noted in the design calculation.

4.1.7 Sewage Flow Determination

A. **Design Basis**

1. Sewers shall be designed to carry the peak domestic, commercial, and industrial contributions, plus infiltration/inflow from the individual gravity service laterals, sewer mains and manholes. Where more detailed information is not available, new sewer systems within the City may be designed on the basis of the following flows.
   a) Residential domesticated flows: 90 gal/capita/day (gpcd)
   b) Schools, non-residential students & staff: 25 gpcd
   c) Commercial, non-residential customers
      1) Restaurant/Café: 40 gal/day/seat
      2) Tavern/Bar: 50 gal/day/seat

d) Laundries, self-service: 500 gal/day/machine
e) Infiltration/Inflow (I/I)
    1) New facilities: 0 gal/acre/day
    2) Existing facilities 1,600 gal/acre/day or as measured.

B. **<u>Sewer Capacity</u>:** Sewers should be designed to carry when flowing full but not surcharged, not less than the following plus existing or planned flows from upstream properties.
1. Lateral and Mainline Sewers:
    a) For new installations serving new areas, minimum peak design flow shall not be less than 4 times the design sanitary flow plus I/I allowance.
    b) For new installations serving existing sewered areas, minimum peak design shall not be less than 4 times the design sanitary flow plus an additional plus I/I allowance based on existing conditions.
2. Trunk Sewers:
    a) New installations serving new areas, minimum peak design flow shall not be less than 3 times the design sanitary plus I/I allowance based on existing conditions.
    b) New installations serving existing served areas, minimum peak design flow shall not be less than 4 times the design sanitary flow plus an additional I/I allowance based on existing conditions.
3. Roughness Coefficient:
    a) A minimum "n" value of 0.013 shall be used in Manning's formula for the design of all sewer facilities regardless of pipe material. The use of higher "n" values for existing pipe may be required by the City Engineer.
    b) In theory, new PVC sewers have manufacturer's "n" value of 0.009. However, sand and grit as well as slime build up on the pipe walls over time tend to render a true "n" value of 0.013. Hence, a value of less than 0.013 will not be considered for approval,
4. It is recommended that design calculations include estimates of average, maximum and minimum daily flows. The submission of design calculations will not ordinarily be required, but engineers should be prepared to substantiate pipe sizes, layout, population estimates, land uses or other assumptions as may be requested.

4.1.8 Interceptor Required

Grease, oil, and sand interceptors shall be required when, in the opinion of the Public Works Department authorized representative or Building Official, they are necessary for the proper handling of wastewater containing fats, wax, grease, sand, or oils, whether emulsified or not, and containing any products or substances that may solidify or become viscous at temperatures of between 32° and 150°F (0° to 65°C). Any discharger of such wastewater shall be required to install, use, maintain, and keep in good working condition an interceptor. See definitions in Chapter 1.

4.1.9 Interference with City Sewer System Prohibited

No person shall block, obstruct, or interfere with any portion of the City sanitary sewer system without a plan being submitted and permit approved by the Public Works Department authorized representative. This prohibition includes, but is not limited to, the obstruction of the flow of sewage from, and to any point within, the City sewer system.

4.2 SANITARY MANHOLE AND PIPE DESIGN STANDARDS

4.2.1 Manhole Design

A. Manholes shall be provided at least every 400 feet, unless otherwise approved by the Public Works Department authorized representative. Manholes shall be located at every grade change, change in pipe size, and change in alignment. Manhole lids shall be centered in the roadway as indicated in the street detail drawings of these standards unless an exception is approved by the Public Works Department authorized representative.

B. When a manhole is 5 feet or less deep, a flat-top or shallow manhole shall be used. Flat-top manholes shall be designed to be installed at an elevation to permit construction of the full street section, allowing for the design gradients.
C. All manholes shall be a minimum of 48 inches in diameter for pipe sized up to 18-inches diameter, minimum 60-inch diameter manhole for 18-inch to 30-inch pipe diameter, and minimum 72-inch manhole for 30-inch and larger pipe diameter.
D. Suburban style manholes frames shall not be used in PCC streets.
E. There shall be a maximum of 4 pipes entering/exiting a manhole unless otherwise approved by Public Works Department authorized representative.
F. Detail(s) shall be submitted with the plans where pipes into or out of a manhole are larger than 24 inches or where more than four mainline connections are made. The manufacturer or design engineer shall provide the Public Works Department authorized representative with supporting calculations, stamped by a Professional Engineer registered in the State of Oregon, documenting the structural integrity of the manhole.
G. Connections to an existing manhole, elevation of the existing ledge, location of steps, and elevations of existing inlets and outlets shall be submitted with the plans.
H. All precast manhole bases shall have smooth, clean openings at the design inlets and outlet points. Openings shall not be sawcut or broken out.
I. All manhole bases shall be properly channelized. No more than three side laterals are allowed to be connected to a manhole, unless an exception is approved by the Public Works Department authorized representative. There shall be a minimum of 8 inches separating connections, measured from the outside diameter of the core holes.
J. All manholes shall have inlets at a minimum 90-degree angle in relation to the outlet, as measured from the center of the manhole base.
K. Manholes shall have a minimum freefall of 0.10 feet and a maximum freefall of 1.5 feet.
L. Drop manholes: The maximum inside drop in a manhole shall be 8 feet.

4.2.2 Sanitary Pipe Design

A. Pipe size: No public sanitary sewer shall be less than 8 inches in diameter, unless otherwise specified by the Public Works Department authorized representative. Side sewers shall be either 6-inch or 4-inch inside diameter, as required by the City. All side sewer pipes shall be polyvinyl chloride (PVC) and shall conform to ASTM D-3034.
B. Location: Sanitary sewers, wherever possible, shall be installed near the centerline of the public right-of-way. Sanitary pipe shall be located not closer than 12 feet to face of curb unless an exception is approved by the Public Works Department authorized representative. In any event, all sewer locations shall be approved by the Public Works Department authorized representative.
C. Easements: When it is not possible or practical to install the sewer line in a dedicated public street, a minimum 15-foot public pipeline easement shall be provided. Sewer lines shall be located in the center of the easement unless an exception is approved by the Public Works Department authorized representative. The centerline of the pipe shall be at least 7½ feet from an easement side line.
D. Alignment: Public sanitary pipe shall be laid on a straight alignment and at uniform grade unless an exception is approved by the Public Works Department authorized representative.
E. Connections: Lateral connections on new construction work shall be done using manufactured tees installed at surveyed locations. Lateral connections to existing sanitary lines may be done using either saddle tees or by using Inserta Tee® as per Chapter 3 Subsection "Stormwater Pipe and Fittings". Laterals shall be of same material as main. The

lateral shall be no larger than 50% the diameter of the main line, unless otherwise approved by the Public Works Department authorized representative. Any laterals greater than 50% of the diameter of the main line shall connect with a manhole.

F. Laterals: Sanitary laterals shall be provided with a cleanout installed at the public right-of-way or easement. Cleanouts shall not be installed in the driveway or sidewalk, unless approved by the Public Works Department authorized representative.

G. Curb Marking: Newly constructed curbs or replaced curbs shall be stamped with the capitol letter "S" at the location of each sanitary lateral crossing. Letters shall be 3 inches in height and embossed a minimum of ⅛-inch deep.

H. Locating Wire and Tape: Sanitary mains and laterals shall have tracer wire (10-gauge solid core with green THNN insulation) installed beside the pipe. Surface locating wire at right-of-way cleanouts; tape shall be tied off to the 2 x 4 marker.

I. Grade: All sanitary sewers shall be laid on a grade that will produce a mean velocity of at least 2 feet per second when flowing full or half-full. The minimum grades for various sizes of pipe are listed in **Table 4.1**.

Table 4.1. MINIMUM GRADIENT FOR SANITARY SEWERS

Inside Pipe Diameter (inches)	Grade (%) (feet per 100 feet)
Sanitary Laterals	
4	1.00
6	0.60
Sanitary Mains	
8	0.40
10	0.28
12	0.22
15	0.15
18	0.12
21	0.10
24	0.08
27	0.07
30	0.06

J. Steep Slopes: Sewers pipes on slopes in excess of 20% gradient shall be secured with approved concrete anchor walls. Spacing for anchors shall be as shown in **Table 4.2**.

Table 4.2. SECURING SEWERS ON SLOPES

Minimum Anchor Spacing Sewer Gradient >20%	
Grade (%)	**Center to Center (feet)**
<35	35
35-50	25
>50	15 (or concrete encasement)

K. Pipe Cover: All sanitary sewers shall have a minimum of 5 feet of cover over the top of the sewer pipe to finish grade. If such minimum cover is not possible, pipe cover shall meet the requirements in **Table 4.3**.

Table 4.3. MINIMUM PIPE COVER

Type of Pipe	Cover (inches)
Other Pipe Materials	30
Nonreinforced	30
RCP Class III	30
RCP Class IV	24
RCP Class V	12
AWWA C-900, C-905	12
ADS SaniTite HP	12
Ductile Iron	12

L. Sewer in Vicinity of Water Supplies: No existing or proposed pressured sanitary sewer shall be permitted within 100 feet of any well, spring, or other source of domestic water supply. No existing or proposed gravity sewer line shall be permitted within 50 feet of any well, spring, or other source of domestic water supply.

M. Water and Sewer Lines:

1. Sanitary sewers and domestic water lines shall not be laid in the same trench. Parallel water and sewer lines shall be at least 10 feet apart horizontally and meet Oregon DEQ separation requirements.
2. When there is less than 18 inches of vertical clearance between water and sewer, and when physical conditions render that spacing impossible or impractical, then class 50 ductile iron pipe with watertight joints, C-900 PVC pipe, concrete encasement, or pipe approved by the Public Works Department authorized representative shall be required.
3. Wherever it is necessary for sewer and water lines to cross each other, the crossing shall be at an angle of approximately 90 degrees. The sewer line shall be located 18 inches or more below the water line or shall be constructed of pipe material approved by the Public Works Department authorized representative for a distance of 10 feet on both sides of the water line.

N. Bedding Materials:

1. Granular backfill shall be ¾”-0 conforming to OSSC (ODOT/APWA) 02630.10 (Dense Graded Base Aggregate), with no more than 10% passing the #40 sieve and no more than 5% passing the #200 sieve.

4.2.3 Access

Access roads are for maintenance and inspection purposes. All-weather access shall be provided to every manhole. Access roads shall be constructed as per Chapter 3 Subsection “Access Road Design.”

4.3 PUMP STATION DESIGN

4.3.1 General Provisions

A. Applicability: These standards are applicable to the construction, installation, or modification of any wastewater pump station system requiring a City of Independence Public Works Permit.

B. Scope: In order to accomplish the orderly and desirable development of land within the corporate limits of the City and to limit the costs associated with the operation and maintenance of wastewater pump stations borne by the City, the Public Works Director deems it reasonable and necessary to restrict the installation of wastewater pump stations. Therefore, wastewater pump stations will not be allowed in areas: where gravity sewer service is programmed for construction in an applicable capital improvement plan, where improvements are recommended in the City of Independence Wastewater Collection System Master Plan, or where sewers are available within three thousand (3,000) feet. Temporary pump stations will be allowed in areas where future development will require extension of gravity sewers, and the Public Works Department authorized representative determines that the temporary station is economically justified. Design life must be less than ten (10) years, as determined in the preliminary engineering report, and have a capacity of less than four hundred (400) gallons per minute (GPM).
Permanent pump stations will be allowed in areas where future development does not require extending gravity sewers, as determined in the preliminary engineering report and the applicable, if any, master plan for the area.

C. Variance: When engineering justification satisfactory to the Public Works Department authorized representative is provided substantially demonstrating that variation from the design standards or siting criteria will result in either: at least equivalent effectiveness while significantly reducing costs, or improved effectiveness, such a variation from design standards or siting criteria may be accepted by the Public Works Department authorized representative.

D. Reviewing Authority: The Oregon Department of Environmental Quality is the final reviewing authority. All plans and specifications for a wastewater pump station shall be reviewed and approved by the Oregon Department of Environmental Quality (DEQ). The basis for review by DEQ review engineers is Oregon Administrative Rule 340 Division 52 (OAR 340-52), Review of Plans and Specifications. To that extent, all plans and specifications shall follow the guidelines and criteria set forth in the current version of the Oregon Standards for Design and Construction of Wastewater Pump Stations. The standards in this Wastewater Pump Station Design Standards chapter of the Public Works Standards are developed as supplemental standards to address local needs, preferences, and existing equipment. Conflicts between the City’s established standards and DEQ guidelines shall be resolved by first following that standard or guideline which is more stringent and/or specific; second, by determination of the Public Works Department authorized representative as to which standard or guideline is in the best interests of the City.

4.3.2 General Requirements

A. Administration: The design engineer in charge must be registered in the State of Oregon and have had previous experience designing similar facilities, including mechanical, electrical, telemetry, and control systems. The engineer's qualifications shall be submitted prior to initiation of study and shall be acceptable to the Public Works Department authorized representative. An authorized representative of the City will be available for construction observation during construction of the project. The design engineer of the pump station shall provide startup services. Provisions for maintenance of temporary pump stations may be required.

B. Flood Protection: The station's electrical and mechanical equipment, which would be permanently damaged by flooding, shall be located at an elevation that is not subject to a 100-year flood or shall otherwise be adequately protected against damage from the 100-year flood. The station shall be designed to remain operational and accessible during the 25-year flood. In the absence of official records to establish 100-year and 25-year flood elevations, the best available local information shall be used.

C. Siting: Pump stations shall be located as far as practical from present or proposed built-up residential areas and off the traffic way of streets and alleys. Noise control, odor control, station architectural design and other aesthetic items shall be taken into consideration and reviewed by the Public Works Director. Sites for stations shall be of sufficient size for future expansion or addition, if applicable.

D. Safety: It is the design engineer's responsibility to ensure that the OSHA, the National Electrical Code, and all other applicable building and construction codes and requirements are met during construction. Adequate provision shall be made to protect construction and, subsequently, maintenance and operation personnel from hazards. Equipment and training for confined space entry in accordance with OSHA and regulatory agency requirements shall be provided for all wastewater pumping stations.

4.3.3 Preliminary Engineering Report

A preliminary engineering report prepared by the design engineer as a basis for design for all wastewater pumping stations shall be submitted to the Public Works Department authorized representative for review and approval. The preliminary engineering report shall include, but is not limited to, the following information:

A. Service Area Study
   1. Population: Present and future population and/or industrial/commercial usage projections. Present, design and ultimate flows of all areas that could be served.
   2. Land Use: Type of land use, zoning, and comprehensive plan designations.

B. Design Characteristics
   1. Average and peak flow calculations, unit flows and peaking factors and infiltration/inflow allowances for present and future design conditions.
   2. Wet well configuration and size.
   3. Number, type, capacity, motor horsepower and Net Positive Suction Head (NPSH) requirements of proposed pumping units. Motor shall be protected from over-current, over-temperature and voltage imbalance. Pumping units shall be duplex.
   4. System head curve and head computations for design conditions of pumping system. (Future pumping capacity requirements shall be considered in sizing pumping equipment.)
   5. System head calculations shall include the size and length of force main static head, all dynamic losses and assumed "c" (friction) factor. Force main shall be a minimum of four (4) inch diameter.
   6. Calculations showing flotation potential and ballasting, if necessary.

7. Description of primary and back-up power sources. All wastewater pump stations shall be supplied with a back-up or alternate power source.
8. Other hydraulic computations shall include, but not limited to, pump cycling time, wet well capacity, flushing velocity and surge analysis.

C. Preliminary Plans

Plans shall be in conformance with Subsection "Sanitary Plans" and, in addition, shall show the following:

1. A contour map of the proposed site, service area, and force main.
2. Proposed pump station, including structure, site layout, landscaping street connection, and provisions for future pumps, if necessary.
3. Existing pump station, if applicable.
4. The 100-year flood plain elevation at the site.
5. Maximum elevation of wastewater in the collection system and wet well in the event of a power failure for the estimated duration of the power outage.
6. Worst-case overflow drainage pattern and receiving stream.
7. Process and Instrumentation diagrams for electrical and control systems.
8. Force main with both plan and profile views to the connection at the receiving location.

4.3.4 Design Criteria

A. General

1. The pump station shall be designed to maintain the liquid level of a wet well by automatically starting and stopping pumping operation as required by wet well conditions.
2. The pump station shall have a firm capacity to pump the peak hourly and peak instantaneous flows associated with the 5-year, 24-hour storm intensity (see Chapter 3 Table 3.2. Rainfall Distribution) of its service area, without overflows from the station or its collection system.
3. Design shall be consistent with EPA Class I reliability standards for mechanical and electrical components and alarms.
4. Pumping systems shall be duplex with pump sequencing and each pump sized in excess of the expected maximum flow.
5. Above ground pump stations shall be required unless otherwise approved.
6. The wet well shall have sufficient volume to provide a holding period of 10 minutes between pump operating cycles at maximum design pump station flow. The floor shall be sloped for proper installation and function of the pumps inlets. Influent flow shall enter the wet well above the pump operating level.
7. All-weather access for vehicles shall be provided. The site shall be fenced, and the fence shall be six feet high. Landscaping shall be provided that adequately obscure the site from view.
8. A remote telemetry unit shall be installed and integrated with the city's programmable logic controller/SCADA system. Local control shall be provided in case of telemetry failure. All appropriate alarms shall be wired and tested for accuracy before they are accepted.
9. The pump station shall be provided with potable water for wet well wash down. Water shall be metered, at or above finish grade and provided with a reduced pressure (RP) backflow device (If outside, a heated enclosure for the RP shall be supplied.)
10. Sufficient back up power to operate the station in case of power outage shall be supplied.
11. Exterior and interior lighting and convenience outlets shall be provided.

12. Adequate piping, valves, and appurtenances for isolation and removal of equipment shall be provided. Capability for bypass pumping shall be provided.
13. Pumps shall be sized to pass a minimum of a three-inch sphere. Pump suction, discharge, and force mains shall be at least four inches diameter.
14. Suitable shutoff and check valves shall be placed on the discharge line of each pump. The check valve shall be located between the pump and the shutoff valve. Check valves shall be suitable for the material being handled and shall be placed on the discharge line in a horizontal position. All shutoff and check valves shall be operable and accessible from floor level. Swing check valves shall have outside levers.
15. Federal and State OSHA regulations and guidelines, and any other relevant state, federal and local safety regulations and guidelines shall be followed and adhered to.

B. Above Ground Pump Station
   1. The above ground pumping station shall be an enclosure housing a duplex, skid mounted, auto-start station utilizing two electric-motor driven, self-priming centrifugal pumps, motor control panel, system piping, two level control systems and a natural gas standby engine (in addition to back-up electric power.). The pump station shall be a Gorman-Rupp base mounted package pump station.
   2. A load-test-certified electric hoist and trolley, or approved equal, shall be provided in the pump room. Overhead crane hoist and other installed equipment shall have adequate horizontal and vertical clearance to allow for lifting and moving motors and pump equipment to the station doors using the monorail.
   3. The level control system shall consist of a duplex pump air bubbler wastewater level sensing system with a backup submersible pressure transducer or ultrasonic level sensor. Provision shall be made to automatically/manually alternate the bubbler air pumps. The level control system shall be capable of sensing and activating controls at four wet well levels.
   4. The pump station enclosure shall be supplied with adequate ventilation and a thermostatically controlled electric heater. The heater shall be sufficient to prevent the freezing of the pumps and piping within the pump station enclosure at an outside temperature of minus twenty (20) degrees F.
   5. The pump equipment compartment shall be above grade or offset and effectively isolated from the wet well to prevent humid and corrosive wastewater gases from entering the equipment compartment.
   6. Wet well access shall not be through the equipment compartment.
   7. Valving shall not be located in the wet well.

C. Submersible Pumps
   1. Submersible pumps and motors shall be designed specifically for wastewater use, including totally submerged operation during a portion of the pump cycle.
   2. Submersible pumps shall be readily removable and replaceable without de-watering the wet well or disconnecting any piping in the wet well.
   3. Valves for submersible pumps shall be located in a separate valve chamber. Accumulated water shall drain to the wet well. Wastewater and gases from the wet well shall be prevented from entering the valve chamber.
   4. Electrical supply, power, control, alarm circuits, and lines shall be designed to provide strain relief and to allow for disconnection and de-energizing outside the wet well. Terminals and connectors shall be protected from corrosion by location outside the wet well. All penetrations of the wet well shall be watertight. All conduits shall be sealed to prevent gases from entering outside cabinets and equipment from the wet well.
   5. The motor control center shall be located outside of the wet well and protected by conduit seals to prevent wet well gases from entering the control cabinet.

6. A stainless-steel rail and mounted hoist shall be provided for access to and servicing of the pumps and backup-generator or motor.

4.3.5 Operation and Maintenance Manual

Three copies of an operation and maintenance manual shall be provided and shall contain the following information:

A. Component description, with both simplified and detailed system schematics.
B. Operation information, including startup, normal, and emergency operation and instructions on common problems.
C. Maintenance information, including records, lubrication, and scheduling requirements and information on local representatives.
D. Safety.
E. Manufacturers' manuals.

4.4 MATERIAL AND TECHNICAL SPECIFICATIONS

4.4.1 Manholes and Structures

A. General
Manholes shall be constructed at locations shown on the plans, or as required by the Public Works Department authorized representative. The maximum distance between manholes shall be 400 feet, unless otherwise approved by the Public Works Department authorized representative. All manholes shall be a minimum of 48 inches in diameter. When a manhole is less than 5 feet deep, a shallow or flat-top manhole shall be used. Flat-top manholes shall be installed at an elevation to permit for construction of the full street section, allowing for the design gradients.

B. Materials
   1. Aggregate and Cement: Aggregate shall meet the standards set forth in ODOT SSC Section 02690, "PCC Aggregates"; Portland cement shall meet the standards set forth in ODOT SSC Section 020, "Portland Cement."
   2. Concrete: PCC for poured in place manholes and structures shall conform to ODOT Class 3000 – 1½, Commercial Grade Concrete. Slump shall be between 2 and 4 inches.
   3. Manhole Frames and Covers:
      a) Casting shall be of new material, tough, close-grained gray iron conforming to ASTM A-48, Class 30, and shall be smooth and clean, free of blisters, blowholes, and all defects. Bearing surfaces shall be planed or ground to ensure flat, true surfaces. Covers shall be true and set within rings at all points.
      b) Rings shall be grouted in place and made watertight with a high-strength, non-shrink grout meeting ODOT SSC Section 02440.50(b), "Non-Shrink Grout," such as Alcrete Twenty Minute Fast Setting Grout® or approved equal. Unused grout shall be disposed of after 20 minutes and shall not be used. Rings shall not be brought to grade with lumber.
      c) Frames and covers shall be standard or suburban, depending on the manhole location and as approved by the Public Works Department authorized representative. Suburban style manhole frames shall not be installed in PCC streets.
      d) Manholes installed outside of paved street or sidewalk areas shall be installed with a tamperproof frame and cover.
   4. Manhole Types: Manholes shall be one of the following types or equal.
      a) Precast 48-Inch-Diameter Manholes: Materials shall conform to the requirements of ASTM C-478. Minimum wall thickness shall be 5 inches. Cones shall be eccentric. Before precast manhole sections of any size are delivered to the job site, the sections shall meet the permeability test requirements of ASTM C-14.

b) Precast Large-Diameter (60-inch or larger) Manholes: Materials shall conform to the requirements of ASTM C-478.
c) Cast-in-Place Large-Diameter Manholes: Aggregate shall meet the standards set forth in ODOT SSC Section 02690, “PCC Aggregates”; Portland cement shall meet the standards set forth in ODOT SSC Section 020, “Portland Cement.”
d) Precast Bases: Precast base sections or manhole bases shall be used, except over existing pipe, where poured-in-place bases shall be used. Precast manhole bases shall be inspected and approved by the Public Works Department authorized representative prior to installation. Where precast bases are not channelized, the contractor shall construct smooth channels to connect the flow from inlet pipe(s) to outlet pipe.
e) Concrete Bases (Poured-in-Place): Poured-in-place bases shall be used over existing pipelines. The contractor shall remove water from the excavated area, provide a minimum 8-inch-thick layer of compacted ¾”-0” crushed aggregate for a base, and construct the concrete base so that the first precast manhole section has a uniform bearing throughout the full circumference. There shall be a minimum of 8 inches of concrete between the compacted gravel and the lowest invert of the manhole. The contractor shall deposit sufficient concrete on the base to assure a watertight seal between base and manhole wall. Twenty-four hours shall be allowed to elapse before the remaining manhole sections are placed on the base, unless otherwise approved by the Public Works Department authorized representative.

5. Pipe Stub-outs for Future Sewer Connections: Pipe stub-outs shall be the same type as approved for use in the lateral, main, or trunk sewer construction. Strength classifications shall be the same class as in adjacent trenches. Where two different classes of pipe exist at a manhole, the higher-strength pipe shall govern strength classification. Connect stub-outs to manholes as specified in Subsection “Connection to Existing Manholes.” Rubber-gasketed, watertight plugs shall be furnished with each stub-out and shall be adequately braced against air test pressures.
6. Gaskets: Manhole sections shall be installed with either preformed rubber gaskets or plastic gaskets. Rubber gaskets shall conform to ASTM C-443. Plastic gaskets shall be Kent-seal No. 2 or Ram Neck, or approved equal, and shall meet all requirements of ASTM C-990.
7. Manhole Steps: Steps shall be required and shall be constructed as specified in these standards, unless otherwise approved by the Public Works Department authorized representative. When pipe is 24 inches in diameter or smaller, steps shall be located as indicated in these standards. For pipes larger than 24 inches in diameter, steps shall be located over a bench as coordinated with the Public Works Department authorized representative. Maximum drop from rim to first step shall be 27 inches.
8. All sanitary sewer manholes shall be internally sealed with Strong-seal or approved equal (including both new manholes and existing manholes worked on for taps, repairs, etc.). Installation shall be by methods and by a contractor approved by the Public Works Department authorized representative.

C. Workmanship

1. Foundation Stabilization: If, in the opinion of the geotechnical engineer or the Public Works Department authorized representative, unstable subgrade material exists that will not support the manhole or other structure, the contractor shall excavate below grade and backfill with foundation-stabilization material approved by the Public Works Department authorized representative.
2. Pipe Connections: All rigid pipes entering or leaving the manhole shall be provided with flexible joints within 1 foot of the manhole structure and shall be placed on firmly

compacted bedding. Special care shall be taken to see that the openings through which pipes enter the structure are completely watertight. All flexible pipes shall be connected to manholes according to the manufacturers' recommendations.

3. Flexible Joints: Where the last joint of the line laid up to the manhole is more than 1 foot from the manhole base, a 6-inch concrete encasement shall be constructed around the entire pipe, from the manhole base to within 1 foot of the pipe joint, at the discretion of the Public Works Department authorized representative. The pipe encasement shall be constructed integrally with the manhole base. Pipes laid out of the manhole shall be shortened to ensure that the first flexible joint is no more than 1 foot from the manhole base.
4. Manhole Connections: The contractor shall connect sewer pipe to manholes as specified in Subsection "Types of Connections."
5. Drop Manholes
   a) The maximum inside drop in a manhole shall be 18 inches. See "Shallow Inside Drop Manhole," for construction of this connection.
   b) When more than 18 inches of drop exists, an outside drop manhole shall be used. Outside drop manholes shall use ductile iron pipe.
6. Placing Manhole Section: The contractor shall clean the end of each section of foreign material. Manholes shall be installed with either watertight rubber O-rings or preformed plastic gaskets in conformance with the manufacturers' recommendations. If plastic gaskets are used, the inside seams shall be grouted with a high-strength, non-shrink grout meeting ODOT SSC Section 02440.50(b), "Non-Shrink Grout," such as Alcrete Twenty Minute Fast Setting Grout® or approved equal. Unused grout shall be discarded after 20 minutes and shall not be used. Manholes will be visually inspected for water leakage by the Public Works Department authorized representative. Any leakage observed shall be repaired at the contractor's expense, and the manhole re-inspected.
7. Manhole Inverts: The contractor shall construct manhole inverts in conformance with these standards. Inverts shall have smooth transitions to ensure an unobstructed flow through the manhole. The contractor shall remove all sharp edges or rough sections that tend to obstruct flow.
8. Manhole Stub-outs: The contractor shall install stub-outs from manholes for sewer extensions, as shown in these standards or as required by the Public Works Department authorized representative. A watertight flexible connection shall be used for pipe sizes 6 inches through 18 inches in all new manholes. The contractor shall construct invert channels in accordance with these standards. The minimum length of stub-outs in existing manholes shall be 12 inches outside the manhole wall. Pipes shall be grouted in precast walls or the manhole base to create a watertight seal around the pipes. The contractor shall install compacted base rock, as specified in these standards, to undisturbed earth under all stub-outs.
9. Manhole Extensions, Rings, and Covers: The contractor shall install rings and covers on top of manholes to positively prevent all infiltration of surface water or groundwater into manholes. Rings shall be set in a bed of high-strength, non-shrink grout meeting ODOT SSC Section 02440.50(b), "Non-Shrink Grout," such as Alcrete Twenty Minute Fast Setting Grout®, or approved equal, with the grout carried over the flange of the ring, and shall be set so that tops of covers are flush with the surface of the adjoining pavement, or 1 foot above the natural ground, unless otherwise directed by the Public Works Department authorized representative. Unused grout shall be discarded after 20 minutes and shall not be used. Total thickness of grade rings shall not exceed 12 inches; rings shall be grouted watertight. Drop from rim to first manhole step shall not exceed

27 inches. In designated floodplain areas, all manholes shall be at an elevation of at least 2 feet greater than the 100-year storm event.

D. Types of Connections

1. Connection to Existing Manholes: The contractor shall connect sewers to existing manholes at the locations shown on the plans. Contractor shall submit a plan for diversion control and receive written approval from the Public Works Department authorized representative before proceeding with construction. The contractor shall provide all diversion facilities and shall perform all work necessary to maintain sewage flow in existing sewers while connections are being made to the manholes. Connections to existing manholes shall be core-drilled, and the bases shall be grouted as necessary to allow a smooth flow into and through the existing manholes.
2. Manholes over Existing Sewers: The contractor shall construct manholes over existing operating sewer lines at the locations shown on the plans. The contractor shall construct a poured-in-place base under the existing sewer and the precast sections as specified. The contractor shall not cut into any existing lines until the new manhole(s) are grouted and pressure tested, the new lines are balled, flushed, deflection tested, and pressure tested, and all portions of the sewer have been approved and accepted by the Public Works Department authorized representative. After acceptance, the contractor shall sawcut into the existing line; cut edges of concrete pipe shall be covered with grout and troweled smooth; with ductile iron or plastic pipe, grout shall be applied up to cutout and troweled smooth.
3. Shallow Inside Drop Manhole: Where the invert of the connecting pipe is above the manhole shelf and less than 18 inches above the outlet, an inside drop shall be constructed utilizing Portland cement concrete. The sewage entering the manhole shall follow a smooth concrete channel transitioning evenly from the invert of the inlet pipe into the main channel. Sewage shall not be allowed to fall freely to the manhole base.

4.4.2 Gravity Sewer Pipe and Fittings

A. General

Sanitary sewer pipes shall have flexible gasket joints. Joints on all fittings shall be the same as the joints used on the pipe. Caps or plugs shall be furnished with each fitting, outlet, or stub, as required, and shall have the same type of gasket or joint as the pipe.

B. Materials

Materials shall be the following types or approved equal:

1. Ductile Iron Pipe (D.I.)
   a) Ductile iron pipe shall conform to the requirements of AWWA C-151/ ANSI A21.51, cement lined push-on joint. The minimum thickness class shall be Class 50 (up to 12-inch diameter pipe) and Class 51 (for 14-inch diameter and larger pipe).
   b) Fittings shall be mechanical or push-on. Mechanical joint ductile iron fittings shall conform to AWWA C-110. Push-on joint fittings shall be gray iron, with body thickness and radii of curvature conforming to ANSI A-21.10. Rubber gasket joints shall conform to AWWA C-111/ ANSI A-21.11.
2. Plastic Pipe
   a) Plastic pipes shall have a minimum stiffness of 46 psi as determined by ASTM D-2412.
   b) Polyvinyl Chloride Pipe (PVC) pipe shall conform to the applicable portions of the following specifications: ASTM D-3034 (SDR 35 or lower), ASTM D-1784, ASTM D-1785, ASTM F-679, ASTM F-794, AWWA C-900, AWWA C-905, and AWWA C-906.
   c) PVC fittings shall conform to the applicable portions of the following specifications: ASTM D-3034, ASTM D-1785, ASTM D-2466, and ASTM D-2467. Fitting joints shall be

the same as pipe joints. Threaded connections shall conform to the requirements of ASTM D-2464 for schedule 80 pipe.

3. Fittings
   a) General
      1) Manufactured tee fittings shall be provided in the sewer main for side sewers. Fittings shall be of sufficient strength to withstand all handling and load stresses encountered.
      2) Fittings shall be of the same materials as the pipe. Material joining the fittings shall be of the same material as the pipe.
      3) Material joining the fittings to the pipe shall be free from cracks and shall adhere tightly to each joining surface.
      4) All fittings shall be capped or plugged and shall be gasketed with the same gasket material as the pipe joint, fitted with an approved mechanical stopper, or have an integrally cast knockout lug. The plug shall be able to withstand all test pressures without leaking. When later removed, the plug shall permit continuation of piping with jointing similar to joints in the installed line.
      5) Mechanical Couplings: Mechanical couplings shall be wrought steel. Installation procedures must meet the manufacturers' recommendations.
4. Line Tap Saddle
   a) PVC Tee Saddle: manufactured in accordance with ASTM D-3034 with minimum cell classification of 12454B-C or 12364-C as defined in ASTM D-1784. Elastomeric seals shall meet ASTM F-477 specifications; locate seals at both the lead and skirt ends of the saddle. Saddles shall be banded to pipe with #316 Stainless Steel bands, 9/16-inch wide. This saddle is allowed on PVC, clay, IPS, concrete, asbestos cement, and PE pipe.
   b) Romac Style "CB" Saddle shall be made of casting of ductile iron, which meets ASTM A-536, grade 65-45-12. Rubber gaskets shall conform to AWWA C-111/ANSI A21.11. The band shall be stainless steel with Teflon coated nuts and bolts. This saddle is not allowed on plastic pipe except C-900.
   c) Inserta Tee® or approved equal: hub adaptor shall be manufactured in accordance with ASTM D-3034; elastomeric seals shall meet ASTM F-477 specifications. This connection is allowed only on thick wall pipe material, e.g., concrete, ductile iron, rib type plastic. Connection point shall be core drilled. Hole diameter shall be cut to manufacturer's specifications. Hub adaptor shall be connected to rubber sleeve with #316 Stainless Steel band (9/16-inch wide), screw, and housing. Inserta Tee® connection shall have a gasketed bell for use with sanitary sewers.

C. Proof Tests

The intent of this requirement is to prequalify a joint system, components of which meet the joint requirements, as to the water tightness capability of the joint system. The proof test shall be understood to apply to sanitary sewers that are to be tested for water tightness before acceptance. Material and test equipment for proof-testing shall be provided by the manufacturer. When approved, internal hydrostatic pressure may be applied by a suitable joint tester. Each pipe material and joint assembly shall be subject to the following three proof tests, at the discretion of the Public Works Department authorized representative:

1. Pipe in Straight Alignment: No less than three or more than five pipes selected from stock by the Public Works Department authorized representative shall be assembled according to the manufacturers' installation instructions, with the ends suitably plugged and restrained against internal pressure. The pipe shall be subjected to 10-psi hydrostatic pressure for 10 minutes. Free movement of water through the pipe joint wall shall be grounds for rejecting the pipe.

2. Pipe in Maximum Deflected Position: A test section is described below for each pipe material. The pipe shall be subjected to 10-psi hydrostatic pressure for 10 minutes. Free movement of water through the pipe joint or pipe wall shall be grounds for rejecting the pipe.
3. Joints under Differential Load: The test section shall be supported on blocks or otherwise, as described below for each pipe material. There shall be no visible leakage when the stressed joint is subjected to 10-psi internal hydrostatic pressure for 10 minutes.
   a) Ductile Iron Pipe: For the deflected position, a position ½ inch wider than the fully compressed section shall be created on one side of the outside perimeter. For a differential load, one of the pipes shall be supported so that it is suspended freely between the adjacent pipe and bearing only on the joints. A force shall be applied along a longitudinal distance of 12 inches beside one of the joints, as specified in **Table 4.4**.

Table 4.4. TEST LOADS FOR DUCTILE IRON PIPES UNDER DIFFERENTIAL LOAD

Pipe Size (inches)	Load (pounds)	Pipe Size (inches)	Load (pounds)
4	600	15	3,700
6	900	18	4,400
8	1,200	21	5,000
10	1,500	24 and over	5,500
12	1,800	--	--

   b) PVC Pipe: For the deflected position, two 12½-foot lengths shall be joined, then deflected along an arc of 720-foot radius (0.11 feet offset at the end of each length from a tangent at the joint). For a differential load, two lengths shall be joined and uniformly supported for at least 2 feet on both sides of the joint and the adjacent pipe to 95 percent of its vertical diameter.

D. Workmanship
1. Line and Grade
   a) Survey control hubs for both line and grade shall be provided by the design engineer in a manner consistent with accepted practices. The contractor shall establish line and grade for pipe by the use of lasers or by transferring the cut from the offset stakes to the trench at a maximum of 50-foot intervals, to maintain the line and grade.
   b) Variance from the established line and grade shall not be greater than ¼ inch for grade and ½ inch for line, provided that such variation does not result in a level or reverse-sloping invert.
   c) The contractor shall check line and grade, as necessary. If the limits prescribed in these standards are not met, the work shall be immediately stopped, the Public Works Department authorized representative notified, and the cause remedied before proceeding with the work.
   d) Variation in the invert elevation between adjoining ends of pipe, due to non-concentricity of joining surface and pipe interior surfaces, shall not exceed 1/64 per inch of pipe diameter, or ½ inch maximum.

e) Tee stations shall be staked as specified in Subsection “Surveying” to enable the contractor to install services at the correct property location.

2. Pipe Handling
   a) The contractor shall unload pipe only by approved means. Pipe shall not be unloaded by dropping it to the ground and shall not be dropped or dumped into trenches.
   b) The contractor shall inspect all pipe and fittings before lowering them into trenches to ensure that no cracked, broken, or otherwise defective materials are used.
   c) The contractor shall clean the ends of pipe thoroughly, remove foreign matter and dirt from inside the pipe, and keep it clean during laying and joining.
   d) The contractor shall lower the pipe into the trench in such a manner as to avoid any physical damage to the pipe.
   e) The contractor shall remove all damaged pipes from the job site.
3. Tying In
   a) The contractor shall not break into an existing sewer line until just before the project is finalized and the manhole has been tested and approved by the Public Works Department authorized representative.
   b) When a contractor ties into a “live” line, the contractor shall keep the new line plugged at the downstream end of the construction to prevent groundwater from entering the City’s sewage system.
4. Foreign Material
   a) The contractor shall take all necessary precautions to prevent excavated or other foreign material from entering into the pipe during the laying operation.
   b) At all times, when laying operations are not in progress, the contractor shall use a mechanical plug at the open end of the last laid section of pipe, to prevent entry of foreign material or creep of the gasketed joints.
5. Pipe Laying
   a) Pipe laying shall proceed upgrade, with the spigot ends pointing in the direction of flow.
   b) After a section of pipe is lowered into the prepared trench, the contractor shall clean the end of the pipe to be joined, the inside of the joint, and the rubber ring (if required) immediately before joining the pipe.
   c) At the location of each joint, dig bell (joint) holes of ample dimensions in the bottom of the trench and at the sides, where necessary, to permit the joint to be made properly.
   d) The joint shall be assembled according to the recommendations of the manufacturer. The contractor shall provide all special tools and appliances required for the jointing assembly. After the joint is made, the pipe shall be checked for alignment and grade.
   e) The trench bottom shall form a continuous and uniform bearing and support for the pipe at every point between joints.
   f) Do not lay pipe in water or when, in the opinion of the Public Works Department authorized representative, trench conditions are unsuitable.
6. Movable Shield: When pipe is laid in a movable trench shield, the contractor shall take all necessary precautions to prevent the pipe joints from pulling apart when the shield is moved ahead. The bottom of the shield shall not extend below the spring line of the pipe without recompacting the pipe zone.
7. Cutting Pipe: When cutting or machining the pipe is necessary, the contractor shall use only the tools and methods recommended by the pipe manufacturer and approved by the Public Works Department authorized representative. The contractor shall cut ductile

iron pipe using a method approved by the Public Works Department authorized representative; all burrs or rough edges shall be removed before joining pipe. The contractor shall not flame-cut the pipe.

8. Transition Fittings: When joining different types of pipes, the contractor shall use approved ridged fittings. Flexible fittings such as Fernco, Caulder, or approved equal may be considered upon approval of the Public Works Department authorized representative; flexible fittings may require additional support under the coupling. Bell type couplings are considered flexible.
   a) Shear ring/ridge transition couplings meeting the ASTM C-564 or equal shall be used.
   b) PVC couplers or adapters shall meet the specifications for ASTM D-3034, SDR 35 pipe fittings.
   c) Ductile iron transition couplings shall be manufactured from ductile iron conforming to ASTM A-536, grade 65-45-12, for center and end rings. Rubber gaskets, bolts, and nuts shall conform to AWWA C-111/ANSI A21.11.
9. Concrete Closure Collars
   a) The contractor shall pour closure collars against undisturbed earth, remove all water from the excavation, and construct suitable forms to create shapes that will provide full bearing surfaces against undisturbed earth.
   b) Closure collars shall be used only when approved by the Public Works Department authorized representative, and then only to make connections between dissimilar pipe or where standard rubber-gasketed joints are impractical.
   c) Before the closure collars are installed, the contractor shall wash the pipe to remove all loose material and soil from the surface where they will be placed.
10. Pipe Zone Material: The contractor shall install pipe zone material uniformly on both sides of the pipe, up to the spring line of the pipe. Material shall be placed in lifts not exceeding 6 inches. Material shall be well worked with hand tools to ensure proper support in the haunching area.
11. Line Taps
   a) Line taps shall be core drilled unless approved otherwise by the Public Works Department authorized representative. Core drilled holes shall be done using a cylinder-style hole saw for only plastic pipe material or a diamond core bit for concrete and D.I. pipes.
   b) Line tap connections to existing sanitary lines may be done using either saddle tees or by using Inserta Tee® saddle tees or by using Inserta Tee® as per Chapter 3 Subsection “Stormwater Pipe and Fittings”.
   c) Line taps shall be centered on the spring line of the pipe being tapped.
   d) The area around the saddle installation site shall be cleaned and free of all rough edges before installing the saddle.
   e) While installing the saddle, no rock, dirt, or debris shall be allowed to enter the main sewer line from the core hole.
   f) The contractor shall install ¾”-0” crushed aggregate in the pipe zone around the line tap, from 6 inches below the pipe to 12 inches above the pipe.
   g) Laterals shall have tracer wire (10-gauge solid core with green THNN insulation) installed beside the pipe.

4.4.3 Pressure Mains

A. General Provisions

These specifications, together with all other applicable requirements of federal, state, and local law, shall govern the character and quality of material, equipment, installation, and construction procedures for pressurized sanitary sewer work.

B. Materials
   1. Ductile Iron Pipe: Ductile iron pipe shall be lined with cement mortar and seal-coated and shall conform to applicable portions of the following specifications: ASTM A-536, AWWA C-104/ANSI A21.4, AWWA C-111/ANSI A21.11, and AWWA C-151/ANSI A21.51.
   2. PVC Pipe: PVC pipe with diameters of 4 inches through 12 inches shall conform to the requirements of AWWA C-900. Joints shall be elastomeric gasketed and shall conform to the requirements of ASTM D-3139.
   3. High Density Polyethylene Pipe (HDPE): HDPE pipe with diameters of 4 inches through 63 inches shall conform to the requirements of AWWA C-906. Joints shall be joined by thermal heat fusion and shall conform to the requirements of ASTM D-2683 for socket-type fittings, ASTM D-3261 for butt-type fittings, or ASTM F-1055 for electrofusion-type fittings.

C. Workmanship and Pipe Installation
   1. All pipe shall be laid to the specified lines and grades. The minimum depth of the pipe cover shall be as specified in Subsection “Sanitary Pipe Design.” Pipes shall not be deflected either horizontally or vertically beyond the limits established and recommended by the pipe manufacturer.
   2. Pipeline shall be laid to a grade that results in the minimum number of high points, based on terrain and economic considerations. Abrupt transitions and sharp peaks shall be avoided.
   3. All tees, elbows, or other fittings shall be produced by the pipe manufacturer and shall be properly braced, anchored, or blocked.
   4. Automatic air and vacuum release valves with a bleed-off port shall be installed at all high points or locations in the pipeline where air pockets would be expected to accumulate. Valves shall be installed in a vault so as to provide accessibility for service and repair. Sumps shall be required for holding excess liquid discharged from the bleed-off port.

4.5 CONSTRUCTION SPECIFICATIONS

4.5.1 General Provision

The specifications detailed here, together with the standards established by the Oregon DEQ, the U.S. Environmental Protection Agency, and any other applicable requirements of the City, shall govern the character and quality of material, equipment, installation, and construction procedures for mainline sanitary sewer work of gravity-flow systems.

4.5.2 Scheduling

The contractor shall plan their construction work in conformance with Chapter 1 Subsection “Scheduling.”

4.5.3 Environmental Protection, Erosion Prevention, and Sediment Control

The contractor shall take all appropriate measures and precautions to minimize the work’s impact on the environment and shall control erosion, as outlined in Chapter 1 Subsection “Environmental Protection, Erosion Prevention, and Sediment Control.”

4.5.4 Interferences and Obstructions

Various obstructions may be encountered during the course of the work. The contractor shall follow the guidelines established in Chapter 1 Subsection “Interferences, Obstructions, and Abandoned Utilities.”

4.5.5 Contaminated Soil or Hazardous Material

If during construction contaminated soil or with hazardous materials or chemicals are encountered, the Contractor shall follow the procedures specified in Chapter 1 Subsection “Contaminated Soils or Hazardous Materials.”

4.5.6 Trench Excavation, Preparation, and Backfill

Trench excavation, preparation, and backfill shall conform to the requirements of Section 6, “Trench Excavation and Backfill Standards.”

4.5.7 Preservation, Restoration, and Cleanup

Cleanup of all construction debris, excess excavation, and excess materials and complete restoration of all fences, mailboxes, ditches, culverts, signposts, and similar items shall be completed according to Chapter 1 Subsection “Preservation, Restoration, and Cleanup.”

4.5.8 Bores

Bores shall conform to the requirements of Chapter 3 Subsection “Bores.”

4.6 TESTING PROCEDURES

4.6.1 General

A. Testing Order: Sanitary systems and appurtenances shall pass a deflection test and an air test before acceptance and shall be free of visible leakage. Information about air testing may be obtained from the Public Works Department authorized representative. Individual joints on pipe 54 inches in diameter or larger may be tested by an approved joint-testing device. All details of testing procedure shall be subject to approval of the Public Works Department authorized representative. Testing of sanitary systems shall be conducted in the following order.
   1. Deflection testing of pipelines.
   2. Air pressure testing of pipelines.
   3. Video-inspection of pipelines.
   4. Vacuum testing of manholes
B. If repair work is required on a section of the system, that portion of the system shall be retested in the testing order given above.
C. Deflection testing, air pressure testing, and video-inspection shall be done only after backfill has passed the required compaction test(s) based on AASHTO T-180 and roadway base rock has been placed, compacted, and approved.
D. The sanitary system must pass deflection testing, air pressure testing, and video-inspection before paving of overlying roadways will be permitted.
E. Vacuum testing of manholes shall be performed only after paving is completed and approved.

4.6.2 Line Cleaning

Before testing and City inspection of the system, the contractor shall ball and flush and clean all parts of the system. The contractor shall remove all accumulated construction debris, rocks, gravel, sand, silt, and other foreign material from the system at or near the closest downstream manhole. If necessary, the contractor shall use mechanical rodding, bucketing or vactor equipment. When the City's authorized representative inspects the system, any foreign matter still present shall be flushed and removed from the system. Contractor shall provide screening; no material shall be flushed into the downstream city sewer system.

4.6.3 Deflection Testing for Flexible Pipe

Storm systems constructed of flexible pipe shall be deflection-tested by pulling an approved mandrel through the completed pipeline. The diameter of the mandrel shall be 95% of the nominal pipe diameter, unless otherwise specified by the City's authorized representative. The mandrel shall be a rigid, nonadjustable, odd-numbered-leg (9 legs minimum) mandrel having an effective length of not less than its nominal diameter. Testing shall be done manhole-to-manhole and after the line is completely balled and flushed with water, and after compaction tests of backfill are completed and accepted. The contractor shall be required to locate and repair any sections that fail the test and to retest those sections. All repairs shall follow and be in compliance with the manufacturer's recommendations.

4.6.4 Video Inspection of Gravity Systems

All sanitary sewer systems shall be video-inspected and approved prior to City acceptance. Video inspection shall take place after trench backfill and compaction has been completed and accepted, and channels have been poured in manholes. All pipes shall be thoroughly flushed immediately prior to the video inspection; only that water remaining from flushing shall be present in the system. The camera shall have the ability to tilt up to 90 degrees and rotate 360 degrees on the axis of travel. An inspection of all lateral connections shall be conducted using the tilt capabilities of the camera. A 1.0-inch target ball shall be placed in front of the camera. Observed sags must be less than 0.5 inch.

The City's authorized representative shall be notified and shall be present during video-inspection of the system, unless otherwise approved by the City's authorized representative. A copy of the video and a written video inspection report, on a City-approved form, shall be supplied to the City's authorized representative. The video shall be recorded in color and in DVD format on a thumb drive and shall include a visual footage meter recording. Problems revealed during the inspection shall be noted on the video and in the written report. After repairs have been made, the line shall be re-inspected and re-tested. If excessive foreign material, in the opinion of the City's authorized representative, is encountered during video inspection, the line shall be balled and flushed, and re-video inspected. All reports shall use NASSCO Codes for Condition Assessments.

4.6.5 Air Pressure Testing

A. General: After the system is complete, including service connections and backfilling, the contractor shall conduct a low-pressure air test. The contractor shall provide all equipment and personnel for the test. The method, equipment, and personnel shall be subject to approval of the Public Works Department authorized representative. The Public Works Department authorized representative may, at any time, require a calibration check of the instrument used. The pressure gauge shall have minimum divisions of 0.10 psi and an accuracy of 0.0625 psi (one ounce per square inch). All air shall pass through one control panel.
B. Safety Precautions: All plugs used to close the sewer for the air test must be capable of resisting the internal pressures and must be securely braced. All air-testing equipment must be placed above ground. No one shall be permitted to enter a manhole or trench where a plugged line is under pressure. All pressure must be released before the plugs are removed. The testing equipment must include a pressure-relief device designed to relieve pressure in

the line under test at 10 psi or less and must allow continuous monitoring to avoid excessive test pressure. The contractor shall use care to prevent the air inlet from flooding with infiltrated groundwater. The contractor shall inject air at the upper plug if possible. Only qualified personnel shall be permitted to conduct the test.

C. Method: Air testing shall be by the time pressure drop method, as follows:
   1. Clean the lines to be tested and remove all debris.
   2. Wet the lines before testing (optional).
   3. Plug all open ends with suitable test plugs; brace each plug securely.
   4. Check the average height of groundwater over the line. Add air slowly to the section of the system being tested until the internal air pressure is 3.5 psi higher than the average pressure of groundwater (0.433 psi for each foot of average water depth over the line).
   5. After the internal test pressure is reached, allow at least two minutes for the air temperature to stabilize, adding only the amount of air required to maintain pressure.
   6. After the temperature stabilization period, disconnect the air supply.
   7. Determine and record the time (in seconds) required for the internal air pressure to drop from 3.5 psi to 2.5 psi.
   8. Compare the time recorded in step (g) above with the time required, as determined below.

D. Passing test: A passing test shall be based on meeting or exceeding the requirements below. The test method depends on the type of pipe material. If a line fails to meet the requirements, the contractor shall repair or replace all defective materials or workmanship.
   1. Concrete pipe
      Air pressure drop method: The tested section, when tested by the air pressure drop method, will be acceptable if the time required for the pressure to drop from 3.5 psi to 2.5 psi is not less than the time (T) in seconds (**Table 4.5**) computed by the following formula:

      $T = K/C$

      Where: $K = 0.011 \times d^2L$.
      $C = 1$ or $0.0003882 \times dL$, whichever is greater.
      $d =$ inside diameter of pipe (inches).
      $L =$ length of pipe (feet).

Table 4.5. AIR TESTING OF CONCRETE PIPE

	Pipe Diameter (inches)										
	4	**6**	**8**	**10**	**12**	**15**	**18**	**21**	**24**	**30**	**36**
Pipe Length (ft.)	**Time (sec)**	**Time (sec)**	**Time (sec)**	**Time (sec)**	**Time (sec)**	**Time (sec)**	**Time (sec)**	**Time (sec)**	**Time (sec)**	**Time (sec)**	**Time (sec)**
10	1.8	4.0	7.0	11.0	15.8	24.8	35.6	48.5	63.4	99.0	142.6
20	3.5	7.9	14.1	22.0	31.7	49.5	71.3	97.0	126.7	198.0	285.1
30	5.3	11.9	21.1	33.0	47.5	74.3	106.9	145.5	190.1	297.0	427.7
40	7.0	15.8	28.2	44.0	63.4	99.0	142.6	194.0	253.4	396.0	570.2
50	8.8	19.8	35.2	55.0	79.2	123.8	178.2	242.6	316.8	495.0	712.8
60	10.6	23.8	42.2	66.0	95.0	148.5	213.8	291.1	380.2	594.0	855.4
70	12.3	27.7	49.3	77.0	110.9	173.3	249.5	339.6	443.5	693.0	997.9
80	14.1	31.7	56.3	88.0	126.7	198.0	285.1	388.1	506.9	792.0	**1020.1**
90	15.8	35.6	63.4	99.0	142.6	222.8	320.8	436.6	570.2	**850.1**	*Same*
100	17.6	39.6	70.4	110.0	158.4	247.5	356.4	485.1	633.6	*Same*	*after*
110	19.4	43.6	77.4	121.0	174.2	272.3	392.0	533.6	**680.1**	*after*	*72 ft.*
120	21.1	47.5	84.5	132.0	190.1	297.0	427.7	582.1	*Same*	*86 ft.*	
130	22.9	51.5	91.5	143.0	205.9	321.8	463.3	**595.1**	*after*		
140	24.6	55.4	98.6	154.0	221.8	346.5	499.0	*Same*	*108 ft.*		
150	26.4	59.4	105.6	165.0	237.6	371.3	**510.0**	*after*			
160	28.2	63.4	112.6	176.0	253.4	396.0	*Same*	*123 ft.*			
170	29.9	67.3	119.7	187.0	269.3	420.8	*after*				
180	31.7	71.3	126.7	198.0	285.1	**425.0**	*144 ft.*				
190	33.4	75.2	133.8	209.0	301.0	*Same*					
200	35.2	79.2	140.8	220.0	316.8	*after*					
210	37.0	83.2	147.8	231.0	332.6	*172 ft.*					
220	38.7	87.1	154.9	242.0	**340.0**						
230	40.5	91.1	161.9	253.0	*Same*						
240	42.2	85.0	169.0	264.0	*after*						
250	44.0	99.0	176.0	275.0	*215 ft.*						
260	45.8	103.0	183.0	**283.4**							
270	47.5	106.9	190.1	*Same*							
280	49.3	110.9	197.1	*after*							
290	51.0	114.8	204.2	*258 ft.*							
300	52.8	118.8	211.2								
310	54.6	122.8	218.2								
320	56.3	126.7	225.3								
330	58.1	130.7	**226.7**								
340	59.8	134.6	*Same*								
350	61.6	138.6	*after*								
360	63.4	142.6	*322 ft.*								
370	65.1	146.5									
380	66.9	150.5									
390	68.6	154.4									
400	70.4	158.4									
410	72.2	162.4									
420	73.9	166.3									
430	75.7	**170.0**									
440	77.4	*Same*									
450	79.2	*after*									
460	81.0	*430 ft.*									
470	82.7										
480	84.5										
490	86.2										
500	88.0										

2. PVC, HDPE, and ductile iron pipe
   The minimum duration for the prescribed low-pressure exfiltration pressure drop between two consecutive manholes shall not be less than that shown in **Table 4.6** or **Table 4.7**. The table lists test duration values for pressure drops of 1.0 psi and 0.5 psi in excess of groundwater pressure above the top of the sewer pipe. Values accommodate both an allowable average loss per unit of surface area and an allowable maximum total leakage rate.
3. Record the diameter (inches), length (feet), end manhole number, time, pressure drop, and groundwater level of the test on an inspection form. The form shall become part of the permanent record for the project.

Table 4.6. AIR TESTING OF PVC, HDPE, AND DUCTILE IRON PIPE – 1.0 PSIG PRESSURE DROP[1]

Pipe Diameter	Minimum Time	Length for Minimum Time	Time for Longer Length	Specified Minimum for Length (L) Shown (min:sec)							
(inches)	**(min:sec)**	**(feet)**	**(sec)**	**100 ft.**	**150 ft.**	**200 ft.**	**250 ft.**	**300 ft.**	**350 ft.**	**400 ft.**	**450 ft.**
4	3:46	597	0.380L	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46
6	5:40	398	0.854L	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	298	1.520L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	239	2.374L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12	11:20	199	3.418L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	14:10	159	5.342L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18	17:00	133	7.692L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
21	19:50	114	10.470L	19:50	26:10	34:54	43:37	52:21	61:00	69:48	78:31
24	22:40	99	13.647L	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33
27	25:30	88	17.306L	28:51	43:16	57:41	72:07	86:32	100:57	115:22	129:48
30	28:20	80	21.366L	35:37	53:25	71:13	89:02	106:50	124:38	142:26	160:15
33	31:10	72	25.852L	43:05	64:38	86:10	107:43	129:16	150:43	172:21	193:53
36	34:00	66	30.768L	51:17	76:55	102:34	128:12	153:50	179:29	205:07	230:46
42	39:48	57	41.883L	69:48	104:42	139:37	174:30	209:24	244:19	279:13	314:07
48	45:34	50	54.705L	91:10	136:45	182:21	227:55	273:31	319:06	364:42	410:17

Specification Time Required for a 1.0 psig Pressure Drop for Size and Length of Pipe indicated for Q=0.0015, where Q is the allowable leakage rate in $ft^3/min/ft^2$ of inside surface area of pipe.
1. Data from the UNI-Bell® PVC Pipe Association

Table 4.7. AIR TESTING OF PVC, HDPE, AND DUCTILE IRON PIPE – 0.5 PSIG PRESSURE DROP[1]

Pipe Diameter	Minimum Time	Length for Minimum Time	Time for Longer Length	Specified Minimum for Length (L) Shown (min:sec)							
(inches)	(min:sec)	(feet)	(sec)	100 ft.	150 ft.	200 ft.	250 ft.	300 ft.	350 ft.	400 ft.	450 ft.
4	1:53	597	0.190L	1:53	1:53	1:53	1:53	1:53	1:53	1:53	1:53
6	2:50	398	0.427L	2:50	2:50	2:50	2:50	2:50	2:50	2:51	3:12
8	3:47	298	0.760L	3:47	3:47	3:47	3:47	3:48	4:26	5:04	5:42
10	4:43	239	1.187L	4:43	4:43	4:43	4:57	5:56	6:55	7:54	8:54
12	5:40	199	1.709L	5:40	5:40	5:42	7:08	8:33	9:58	11:24	12:50
15	7:05	159	2.671L	7:05	7:05	8:54	11:08	13:21	15:35	17:48	20:02
18	8:30	133	3.846L	8:30	9:37	12:49	16:01	19:14	22:26	25:38	28:51
21	9:55	114	5.235L	9:55	13:05	17:27	21:49	26:11	30:32	34:54	39:16
24	11:24	99	6.837L	11:24	17:57	22:48	28:30	34:11	39:24	45:35	51:17
27	14:25	88	8.653L	14:25	21:38	28:51	36:04	43:16	50:30	57:42	64:54
30	17:48	80	10.683L	17:48	26:43	35:37	44:31	53:25	62:19	71:13	80:07
33	21:33	72	12.926L	21:33	32:19	43:56	53:52	64:38	75:24	86:10	96:57
36	25:39	66	15.384L	25:39	38:28	51:17	64:06	76:55	89:44	102:34	115:23
42	34:54	57	20.942L	34:54	52:21	69:49	87:15	104:42	122:10	139:37	157:04
48	45:35	50	27.352L	45:35	68:23	91:11	113:58	136:46	159:33	182:21	205:09

Specification Time Required for a 0.5 psig Pressure Drop for Size and Length of Pipe indicated for Q=0.0015, where Q is the allowable leakage rate in $ft^3/min/ft^2$ of inside surface area of pipe.

1. Data from the UNI-Bell® PVC Pipe Association

4.6.6 Manhole Testing

Sanitary sewer manholes shall be tested for acceptance after the trench is backfilled, compaction requirements are met, the road base rock is installed, and the street paved, and chimney seals or concrete manhole closure collars are installed. If the manholes pass the tests but the castings were disturbed by construction and must be reinstalled, the manholes shall be retested.

A. Vacuum Testing: All manholes being constructed or rehabilitated shall be vacuum tested. The test shall consist of plugging all inlets and outlets. The test head shall be placed at the inside of the top of the cone and shall include grade rings and casting. The seal shall be inflated in accordance with the manufacturer’s recommendations. A vacuum of 10 inches of mercury shall be drawn and the vacuum pump shut off. With the valves closed, the time shall be measured for the vacuum to drop to 9 inches. The manhole shall pass if the time for the vacuum reading to drop to 9 inches meets or exceed the values listed in **Table 4-8**. The contractor shall repair all manholes that fail to pass the vacuum test; manholes shall be retested to verify the repair.

Table 4.8. VACUUM TESTING OF MANHOLES

Depth of Manhole (feet)	Diameter of Manhole		
	48 Inch	60 Inch	72 Inch
	Allowable Time (seconds)		
8	20	26	33
10	25	33	41
12	30	39	49
14	35	46	57
16	40	52	65
18	45	59	73
20	50	65	81
22	55	72	89
24	59	78	97
26	64	85	105
28	69	91	113
30	74	98	121

B. Hydrostatic Testing: When, in the opinion of the Public Works Department authorized representative, the groundwater table is too low to visually detect leaks, manholes may be hydrostatically tested. The test shall consist of plugging all inlets and outlets, then filling the manhole with water to a height determined by the Public Works Department authorized representative. Leakage in each manhole shall not exceed 0.2 gallons per hour per foot of head above the invert. Leakage will be determined by refilling to the rim using a calibrated or known volume container. A manhole may be filled 24 hours before the test, if desired, to permit normal absorption into the pipe walls to take place. The contractor shall repair all manholes that fail to pass the leakage test; manholes shall be retested to verify the repair.

4.6.7 Pressure Main Testing

Field testing of the force main and appurtenances shall be completed by a hydrostatic test that meets the following requirements. Contractor shall be responsible for making all necessary provisions for conveying water to the points of use and for disposal of the test water, including temporary taps and plugs.

A. Prior to the start of the hydrostatic test, all trenching shall be backfilled, compacted, and accepted per the requirements of Section 6, “Trench Excavation and Backfill Standards.”
B. When concrete thrust blocks are used, the hydrostatic test shall be conducted after at least five days elapse from when the concrete thrust blocking was installed. If high-early cement is used for the concrete thrust blocking, the time may be cut by two days.
C. Seal pipe ends and secure pipe with temporary thrust restraint, as required, to maintain line and grade and to prevent damage.
D. Fill the test section with water and allow it to stand at two-thirds of the test pressure for a minimum of 12 hours. All air shall be purged from the pipeline before it is checked for leaks or pressure, or acceptance tests are performed on the system.
E. Furnish all equipment and materials and perform testing in conformance with Chapter 5 Subsection “Hydrostatic Testing.”

F. If a large amount of water is required to increase the pressure during testing, entrapped air, leakage at joints, or a broken pipe can be suspected. In such cases, tests shall be discontinued until the source of trouble is identified and corrected.
G. Visible leaks in the wet well and vaults shall be eliminated regardless of the leakage amount.

4.7 WARRANTIES AND ACCEPTANCE

4.7.1 Legal Recordings

Dedication of any required easements or rights-of-way have been recorded with the County Recorder and the Engineering Department receives a reproducible copy of the recorded documents.

4.7.2 Project Completion

After completion of construction of the total project, and after all testing has been satisfactorily completed, project closeout shall proceed as outlined in Chapter 1 Subsection "Project Closeout."

4.7.3 Maintenance Period

A. The Contractor or Applicant shall be responsible for providing Maintenance Assurance for Public Improvements as outlined in Chapter 1 Subsection "Maintenance Assurance and Warranty." Public sanitary improvements shall be warranted for a minimum of one year; public landscape improvements shall be warranted for a minimum of two years.
B. At any time during the warranty period, the Public Works Department authorized representative has reason to believe the public sanitary improvements have defects that were the result of faulty workmanship or flaws in construction material, the responsible party shall be required, at that party's own cost, to video-inspect the sewer line and repair any problems or faults revealed during video inspection by replacing those sections. The video inspection shall be done during the winter, if possible, or during the wet weather months, to identify all leaks.
C. Before the end of the Construction Maintenance period, the City's authorized representative shall inspect the project for any remaining deficiencies. If the deficiencies that remain are determined to be the responsibility of the contractor or the applicant, the contractor or applicant shall then make such repairs.
D. The Landscape Maintenance assurance shall be released two years after acceptance of construction, providing the landscaping meets the 90% survival level (see Chapter 3 Subsection "Landscape Inspection for Warranty").