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Attachments: Worksheet, Figure No. 1, Attachment B Manhole Test Record

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PART 1 - GENERAL

1.1 Scope

- A.** These Specifications cover the furnishing and installation of gravity sewer lines, pressure sewer lines, service lines, irrigation lines, manholes, cleanouts, and miscellaneous appurtenances. The work includes, unless otherwise specified, furnishing all labor, materials, tools, equipment, and incidentals required to construct a complete sewer system ready for service as outlined in the Drawings and Specifications. Requirements for excavation and backfill of trenches, surface restoration, traffic control, and special appurtenances are specified under separate sections.
- B.** Items included in this Technical Specification are intended to be broad in scope and may not always apply to all items of work to be constructed. All applicable sections, as determined by the City and/or City Engineer, shall control the work outlined in the Drawings and Specifications.

1.2 Specifications References

Specification references made herein for manufactured materials such as pipe, fittings, and manhole rings and covers refer to designations for the American Public Works Association (APWA), the American Water Works Association (AWWA), or the American Society for Testing and Materials (ASTM) as they are effective on the date of call for bids.

1.3 Submittals

Catalog information on all materials and/or equipment to be installed shall be submitted to the City and/or City Engineer for review prior to installation.

1.4 Care and Handling of Materials

- A.** Adequate precautions shall be taken to prevent damage to pipes, fittings, manhole components, and all other materials used in construction of a sewerage system. Pipe and other materials during transport shall be secured individually by use of wood spacer blocks or wood crates, or otherwise protected to prevent collision of individual pieces and the possible subsequent damage.
- B.** All pipe, fittings, manhole components, and valves shall be loaded and unloaded in a manner to prevent shock or damage. Under no circumstances shall such material be dropped. All materials on the ground shall be protected from damage. All pipes, fittings, manhole components, valves, and all other materials used in the construction of the sewerage system shall be carefully inspected by the Contractor prior to installation. All

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defective materials shall be rejected. All materials which are delivered considerably in advance of their installation shall be stored in a satisfactory manner. The Contractor will receive no payment for materials on hand that are not so protected.

- C. Proper materials, tools and equipment shall be used by the Contractor for safe and convenient prosecution of the work. All pipes, fittings, etc., shall be carefully lowered into the trench piece by piece in such a manner to prevent any damage to the materials. Under no circumstances shall sewage system materials be dropped or dumped into the trenches.

1.5 Materials Furnished by the City

The Contractor's responsibility for material furnished by the City shall begin at the point of delivery to the Contractor. Materials already on the site shall become the Contractor's responsibility on the start work date of the Contract. The Contractor shall examine all material furnished by the City at the time and place of delivery to him and shall reject all defective material. Any material furnished by the City that becomes damaged by the Contractor shall be replaced by the Contractor at his own expense. The Contractor shall assume full responsibility for materials furnished by the City once they are received by the Contractor.

1.6 Certification by Manufacturer

If requested to do so, the Contractor shall furnish to the City a sworn statement from the manufacturer, stating that inspection and all specified tests have been made on the supplied material and that the results thereof comply with appropriate specifications. The statement shall also state that all materials furnished are in accordance with these Drawings and Specifications, and that all materials are new.

1.7 Restoration, Finishing, and Cleanup

The Contractor shall restore or replace all paved surfaces, graveled surfaces, curbing, sidewalks, trees and shrubbery, lawns, pastures, fences, and other existing facilities to their original condition. See Technical Specifications - "Excavation and Backfill of Trenches" and Technical Specifications - "Surface Restoration" for specific requirements.

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PART 2 - MATERIALS

2.1 Pipe

A. PVC Gravity Pipe

PVC gravity sewer pipe and fittings 15-inch diameter and smaller shall conform to ASTM D 3034, SDR 35 unless called for otherwise on the Drawings. Pipes 18-inch diameter to 24-inch diameter shall conform to ASTM F 679 unless called for otherwise on the Drawings. The joints shall be flexible joint with rubber ring gasket.

B. PVC Pressure Pipe

1. PVC pipe for pressure sewer lines shall conform to AWWA C900, DR 18 (150 psi pipe), or as otherwise specified. The pipe shall have flexible rubber gasketed joints conforming to ASTM D 3139.

C. Ductile Iron Pipe

1. Ductile iron pipe and fittings shall conform to AWWA C150, AWWA C115, AWWA C151, AWWA C153, and AWWA C110 and shall be minimum pressure Class 350 unless specified otherwise. All ductile iron pipe shall have a bituminous sealed cement mortar lining conforming to AWWA C104. All joints, unless otherwise specified, shall be push-on rubber gasket joints conforming to AWWA C111.
2. When flanged pipe is required, the Contractor shall provide the D.I. pipe class required by the flange manufacturer to ensure the pipe and flange units are compatible. This data shall be provided to the City Engineer for review prior to ordering these materials. Flanges for couplings and fittings shall conform to ANSI 16.1, 125-pound bolt hole template.

D. High Density Polyethylene Pressure Pipe

1. High density polyethylene pipe shall conform to AWWA C906 and shall have the SDR requirements called for on the Drawings. All joints shall be by the heat fusion method in accordance with the manufacturer's requirements.
2. Fittings shall be standard commercial products manufactured by injection molding or by extrusion and machining or fabricated from AWWA C906 pipe.

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3. The Contractor shall provide detailed shop drawings for all joints and connections, including provisions for expansion and contraction as recommended by the pipe manufacturer.

2.2 Fittings

A. Fittings for Iron and PVC Pipe

Unless specified otherwise, all fittings such as elbows, tees, crosses, etc., shall be mechanical joint short-bodied compact ductile iron fittings conforming to AWWA C153, Class 350. When called for, flanged cast iron fittings shall conform to AWWA C110 with ANSI B16.1, 125-pound bolt hole template. All fittings shall be cement mortar lined in accordance with AWWA C104. Gaskets for flanges shall be either ring or full faced, 1/8 inch thick conforming to AWWA C111, Appendix B.

B. Fittings for Sewer Service Connection

Main line fittings for sewer service connections when installing new gravity sewer pipe shall be a gasketed tee suitable for ASTM D 3034 or ASTM F 679 sewer pipe. When service connections are required on existing sewer lines, a sewer tapping saddle shall be used, such as "Geneco Sealtite," of the type and model required to match the sewer main line and service line pipe materials, or approved equal.

C. Couplings

Couplings shall have stainless steel shear rings of the size and style required to match the pipe size and type being utilized. Couplings shall be manufactured by Fernco with stainless steel shear rings or approved equal.

D. Restrained Pipe Joints and Fittings

Where called for on the Drawings, restrained pipe joints shall be mechanical joint ductile iron with "MEGALUG" field-installed restraint devices as manufactured by Ebaa Iron, Inc., or approved equal.

2.3 Valves and Appurtenances

A. Plug Valves

1. All plug valves shall conform to AWWA C504. The valve body shall be constructed of cast iron (semi-steel) conforming to ASTM A 126 Class B and shall be protected with a factory-applied fusion-bonded coating meeting AWWA C550. The shaft and plug shall be integrally constructed of cast iron

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(semi-steel) and shall be 100 percent encapsulated with Buna N rubber. The stem seals shall be Buna N multiple "V" ring stem packing seals. The valve seat surface shall be raised welded-in overlay of not less than 90 percent nickel.

2. Flange dimensions, facing, and drilling shall conform to ANSI B16.1, Class 125. Mechanical joints shall meet the requirements of AWWA C111/ANSI A21.11.
3. The valve shall have a 2-inch AWWA operator nut for buried services and hand wheel operator for non-buried services or as called for on the Drawings. Worm gear operators shall be furnished for all 4-inch or larger valves.
4. Valves shall be M&H 1820 eccentric plug valves, Pratt Ballcentric plug valves, or approved equal.

B. Valve Boxes

Each valve shall be equipped with an adjustable cast iron box of the sliding type with a base large enough to cover the top casting of the valve. The diameter of the valve box shall be not less than five (5) inches, and shall be of such length so as to provide the depth of cover over the pipe without full extension. Materials and installation workmanship for valve boxes shall be in accordance with AWWA C600, Section 10.3.

2.4 Thrust and Anchor Blocks

Thrust and anchor blocks shall be located and sized as shown on the Drawings, and at all changes in direction, or as required by the City Engineer. Concrete used for the blocks shall be Portland Cement concrete with a minimum 28-day strength of 2,500 psi. All concrete shall be placed so that pipe joints and fittings will be accessible for repair. Concrete shall be placed against undisturbed material. Anchor rods shall be 3/4-inch diameter galvanized steel, embedded a minimum of 18 inches in concrete.

2.5 Manholes

A. Cast-in-place Concrete Base Sections

1. Cast-in-place concrete base sections for manhole construction shall have a minimum 28-day strength of 3,000 psi, unless approved otherwise by the City Engineer, and shall not be less than 6 inches in thickness in any section.
2. Required "U" shaped channels shall be constructed by the use of properly shaped forms. Intersecting flow channels shall have smooth uniform transitions. All channels shall have smooth troweled finishes. All shelf area shall be uniformly

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shaped, have a rough float finish and shall slightly slope towards the channel. The shelf shall be above the top of the sewer pipe.

3. The Contractor shall be responsible for the determination of pipe hole orientation and grade. Cast-in-place base sections will only be used where called for specifically on the Drawings or where required by the City.

B. Precast Concrete Base Sections

1. Precast concrete base sections shall be approved by the City Engineer and shall conform to ASTM C 478. Concrete shall be consolidated by mechanical vibration. Reinforcing shall be provided in the base and walls. Minimum concrete thickness shall be 5 inches unless otherwise required for deep manholes.
2. Required "U" shaped channels shall be constructed by the use of properly shaped forms. Intersecting flow channels shall have smooth uniform transitions. All channels shall have smooth troweled finishes. All shelf area shall be uniformly shaped, have a rough float finish and shall slightly slope towards the channel. The shelf shall be above the top of the sewer pipe.
3. The Contractor shall be responsible for the determination of pipe hole orientation and grade. Precast base sections shall be used unless specifically called for otherwise on the Drawings or by the City Engineer.

C. Precast Concrete Manhole Sections

1. Precast concrete manhole sections shall conform to ASTM C 478 and consist of circular sections in the standard 48-inch diameter, unless otherwise noted. No more than two lift holes shall be cast into each section. Holes shall be located as to not damage reinforcing or expose it to corrosion. All lift holes shall be patched to prevent water seepage into the manhole, utilizing an approved, non-shrink grout.
2. Precast manhole cones shall be eccentric unless otherwise specified and shall meet ASTM C 478.
3. Flat slab covers for manholes shall conform to ASTM C 478. Slabs, cones and ring sections shall be free from fractures, cracks, rock pockets, or exposed reinforcement. Joint seal material shall be "Kent seal" mastic acrylic polymeric sealant, O-ring rubber gasket, or approved equal.

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4. Manholes which have a depth of 5-1/2 feet or less, from the top of the manhole cover to the pipe invert, shall utilize a 48-inch diameter section and flat slab cover. Cone sections shall not be used for manholes less than 5-1/2 feet in depth. Manholes with a flat slab cover may be required for depths greater than 5-1/2 feet when called for on the Drawings.

D. Pipe Connection to Manholes

1. All pipe connections to manholes shall be constructed as shown on the Drawings, shall be flexible, and shall allow movement of the sewer pipe in all directions. Manhole pipe couplings shall be suitable for the sewer pipe type connecting to the manhole.
2. A-Lok field sleeve, or approved equal, may be used for cast-in-place manhole bases.
3. When precast base sections are used, an A-Lok pipe connector as manufactured by A-Lok Products, Inc., PSX Flexible Connector as manufactured by Press Seal Gasket Corporation, Kor-N-Seal as manufactured by Core and Seal Company, or approved equal shall be used.
4. Fittings for drop manholes shall be of the same material as the attached sewer pipe.

E. Manhole Rings and Covers

1. Castings shall be tough, close-grained, gray iron free from blow holes, shrinkage and cold sheets.
2. Manhole rings and covers shall conform to ASTM A 48 and shall be smooth, sound, clean and free from blisters and defects. Castings and covers shall be planed and ground when necessary to insure flat and true surfaces. Covers shall be true and shall seat within the ring at all points.
3. Manhole rings and covers shall be Inland Foundry Co., Inc., No. 802 Suburban, 2 hole cover, or approved equal.
4. When watertight cover is called for on the Drawings, an Inland Foundry No. 804 frame with watertight cover shall be provided, or equal. Provide 2 extra gaskets for each watertight cover furnished.

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F. Manhole Stubouts

1. Manhole stubouts shall be constructed as called for on the Drawings or as directed by the City Engineer. The stubouts shall have the appropriate flexible connection at the manhole.
2. The outside end of the stubout shall be secured, sealed watertight with a block and plug with rubber ring seal.
3. All stubouts shall be 8-inch unless otherwise approved or shown.

2.6 Cleanouts

A. Cast Iron Rings and Covers

Main line cleanouts shall have cast iron rings and covers such as Inland Foundry Co., Inc., No. 240, for 8-inch riser pipes, and No. 241 for 6-inch riser pipes, or approved equal. Service line cleanouts shall have cast iron rings and covers such as Inland Foundry Co., Inc., No. 274, or approved equal.

B. Pipe

Pipe used in the construction of cleanouts shall be consistent with type of sewer pipe to which it is connected.

2.7 Locating Wire

- A. Locating wire shall be a minimum of 12 awg UF solid copper with green colored insulation. The use of THHN wire will not be acceptable.
- B. At all splices the connecting ends of the wires shall be overlapped and tied. The ends shall be stripped and connected with a wire nut to ensure an electrical connection and made waterproof with an approved silicone splice kit.
- C. Where location wire is to be secured to exterior of manhole cleanouts, valve boxes, etc., stainless steel pipe straps shall be used.

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PART 3 - EXECUTION

3.1 Gravity Sewer Construction

A. Trench Excavation and Backfill

Trench excavation and backfill shall be performed as specified in the Technical Specifications – "Excavation and Backfill of Trenches."

B. Installation of Pipe

1. Gravity sewer pipe shall be installed in accordance with the best current practices and as required by the manufacturer. Gravity sewer pipe, unless otherwise approved by the City, shall be laid by progressing up grade from the existing or newly constructed sewer; the sewer pipe shall be installed with bell ends laid upgrade unless otherwise approved. Each pipe shall be properly bedded so as to be supported along the full length of the pipe. A suitable foundation shall be achieved by a slight excavation for the bell at each joint.
2. All rubber ring joints shall be lubricated, except when using rolling rubber gaskets with concrete pipe, and installed in accordance with the installation instructions of the pipe manufacturer, taking particular care to avoid pinching or otherwise causing damage to the rubber ring. All joints shall be free of dirt and other foreign matter prior to the joining of the next pipe. All pipe shall be installed to prevent creep and misalignment of joints. All 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 socket.
3. Gravity sewer pipe shall be installed with the use of a laser beam and target. Unless the work involves deep excavations, traffic problems, water problems, or approved by the City, the trench for the first 100 feet shall not be backfilled until the sewer grade has been checked. The Contractor shall set and aim the laser as controlled by the "cuts" and "slopes." Careful attention shall be given to the setting up of the laser and the periodic checking of its aim, etc. All grade checking of laser shall be the responsibility of the Contractor. All pipe shall be installed true to line and grade. A tolerance of plus or minus 1/4 inch deviation from true grade at each joint will be allowed. Extra care shall be given to the installation of sewer lines at minimum slopes to avoid flat slopes in the line. All pipe shall be installed true to line. Except when approved or specified, the Contractor may not install a pipeline on a curve.

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- a. For rubber gasketed ductile iron pipe installed on a curve, the pipe shall be joined in a straight alignment, then deflected. The amount of deflection shall not exceed 80 percent of the recommended maximum deflection specified in AWWA C600.
 - b. For PVC pipe installed on a curve, deflection of the pipe shall be achieved by bending the pipe within the limitations specified by the pipe manufacturer. Joint deflection of PVC pipe is not allowed.
4. All foreign matter and gravel shall be removed from the inside of the pipe and fittings before being installed and the pipe and fittings shall be kept clean during placement. No pipe shall be laid in water or when conditions exist that in the opinion of the City are unsuitable for the placing of pipe. All pipe and manholes shall be covered or plugged at night and whenever the work is not supervised.
 5. The Contractor may elect, at his own option, to drain or pump groundwater from the trenches into previously placed new sewer lines as long as adequate disposal is provided. The Contractor shall not discharge any groundwater into existing live sewer lines. Adequate provisions shall be made by the Contractor for final disposal of the groundwater from trenches as approved by the City. Any water discharged into new sewer lines shall be properly screened to prevent the entrance of debris and gravel. At the termination of dewatering operations the Contractor shall thoroughly clean the sewer lines that were used. No sewer lines will be accepted as completed until being cleaned as approved by the City.
 6. All pipe/manhole connections shall be watertight. The manhole pipe couplings shall be installed in accordance with all manufacturer instructions. All connections shall match the grade and alignment of the pipe entering and exiting each manhole. Manhole pipe connections shall be constructed so that the wastewater flow through the manhole is not restricted in any way.

3.2 Gravity Service Lines

- A. Gravity service lines shall be constructed in accordance with the Drawings, Specifications, and applicable provisions of the International Plumbing Code (IPC) as amended by the State. The minimum slope of service lines shall be 1/4-inch per foot unless otherwise approved by the City and/or City Engineer. The pipe size of gravity service lines shall be a minimum 4-inch diameter unless otherwise specified. The Contractor shall end gravity service lines at the location as per the Drawings and at the invert elevation as shown on the Drawings or as set by the City Engineer. Dead ends of service lines shall be marked with steel fence posts installed in the ground as shown on the Drawings.

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- B.** Connection of service lines to new or existing gravity sewer main lines shall be as per the Drawings and shall be inspected and accepted by the City and/or City Engineer prior to backfilling. All sewer service connections shall be watertight utilizing appropriate sewer service saddles or wyes. An approved tee fitting shall be used when new sewer mains are being installed. All holes and taps into an existing sewer main shall be cut using an approved tapping machine.
- C.** In the construction of new sewage collection systems, connection of new services allowing sewage into the system shall not be made until approval for connections has been given by the City. No existing sewer service shall be interrupted without the approval of the City and service owner. Connections of new service lines to existing service lines shall be by the proper adaptor coupling.
- D.** The Contractor shall obtain all necessary permits required to construct service lines on private property. The Contractor must utilize a licensed plumber for service line work on private property when required by state or local regulations.

3.3 Gravity Sewer Testing

A. General

The Contractor shall furnish all labor, necessary equipment, and other apparatus including, but not limited to, gauges, mechanical or pneumatic plugs, and air hoses, necessary to properly perform the testing of sewer lines as specified. The Contractor may low pressure test sections of sewer lines before backfilling at his own option; but the acceptance test shall be performed only after backfilling, cleaning, and flushing has been completed.

B. Acceptance Test

The Contractor shall perform all preliminary testing required to determine that the lines to be tested are acceptable and comply with the requirements of this section of the Specifications. After the Contractor has determined that the lines will pass the required test, the Contractor shall arrange for an acceptance test to be witnessed by the City. The Contractor shall coordinate the timing of this acceptance test with the City. The lines will not be accepted until the acceptance test has been witnessed and documented as passing.

C. Test Procedure

The method of testing follows the procedures outlined in the Oregon Standard Specifications for Construction, Part 00400, Section 00445.72(c), current edition. All air testing shall be by the Time Pressure Drop Method. Specific questions concerning test

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procedures may be referred to this publication. To facilitate test verification by the City, all air used shall pass through a single, above-ground control panel. The pressure gauge used in air testing shall have minimum divisions of 0.10 psi and have an accuracy of 0.0625 psi (one ounce per square inch). The City shall have the option of requiring the use of their own gauge. Test procedures are summarized below:

1. Field Test
 - a. The Contractor may wet the lines prior to testing.
 - b. Determine the average height of the groundwater over the line. The test pressures required shall be increased 0.433 psi for each foot of average water depth over the exterior crown of the pipe, but no greater than 9.0 psig.
 - c. Add air slowly to the section of system being tested until the internal air pressure is raised to 4.0 psig greater than the average back pressure due to groundwater.
 - d. After the 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.
 - e. After the temperature stabilization period, disconnect the air supply.
 - f. Record the time in seconds that is required for the internal air pressure to drop from 3.5 psig to 2.5 psig greater than the average back pressure due to groundwater.
 - g. Compare the time recorded in the above step with the test time determined hereafter.
2. Acceptance
 - a. Record the diameter in inches and the length in feet of all pipe in the section to be tested, including the service connections on the work sheet found at the end of Technical Specifications – "Sanitary Sewer Lines."
 - b. Using the nomograph (Figure No. 1) found at the end of Technical Specifications – "Sanitary Sewer Lines," place a straightedge from the "d" column (diameter in inches) to the "L" column (length in feet). Read

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the corresponding "K" and "C" values for each of the pipes listed above, and record them on the work sheet.

- c. Add all values of "K" and all values of "C" for the section being tested.
 - d. If the total of all the "C" values is less than one, the time shall be the total of all the "K" values.
 - e. If the total of all the "C" values is greater than one, the time shall be found by dividing the total of all the "K" values by the total of all the "C" values. The result is the maximum test time. To make this division using the nomograph (Figure No. 1), use the total "C" and "K" values and read the time from the "t_q" scale.
 - f. In the event that the "d" and "L" values for a particular section of the system do not fall within the limits of the nomograph, the values of "K" and "C" may be computed from the following equations: "K" = 0.011d²L; "C" = 0.0003882dL.
3. If the "actual time" (field test) is equal to or greater than the "test time" required for the pipe section being tested, the pipe section will have passed the pressure test. (See work sheet.)

D. Infiltration Allowance

Groundwater infiltration to the collection system, including manholes, shall not exceed 50 gallons/inch diameter of pipe/mile/day. Any infiltration in excess of this amount shall be corrected at the Contractor's expense.

E. Deflection Test for PVC Pipe

1. All sanitary sewers constructed of PVC pipe shall be able to pass a deflection test. The test shall be conducted by pulling a go-nogo solid pointed mandrel or sewer ball through the completed pipeline. The diameter of the mandrel or ball shall not be less than 95 percent of the base inside pipe diameter as defined by ASTM D 3034, SDR 35 and ASTM F 679, T-1 pipe. The base inside pipe diameter and minimum mandrel diameter are as follows:

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Nominal Pipe Size, In.	Minimum Mandrel Dia., In.	Base Inside Pipe Dia., In.
6"	5.46	5.742
8"	7.28	7.665
10"	9.08	9.568
12"	10.79	11.361
15"	13.20	13.898
18"	16.13	16.970
21"	19.00	20.004
24"	21.36	22.480
27"	24.06	25.327

2. All lines shall be tested unless determined otherwise by the City based upon their observations during pipeline installation and visual inspection of the pipeline. Testing shall be conducted on a manhole to manhole basis and shall be done after the line has been completely cleaned and flushed with water. The Contractor shall, at his own expense, locate and repair any sections failing to pass the deflection test. All areas failing the deflection test shall be retested after corrective action has been taken.

F. Equipment

The Contractor shall perform all work and furnish all materials and equipment as required to perform all required tests.

3.4 Pressure Sewer Construction

A. Pipeline

1. The Contractor shall construct pressure sewer lines of the size, type, and class specified on the Drawings. Pipe shall meet the material specifications contained herein. All work performed in the installation of pressure sewer lines shall be performed as per the Drawings, the applicable portions of subsection "Gravity Sewers-Construction" contained herein, and as required by the manufacturer. When it is necessary to deflect pipe joints to conform to the profile and alignment of the sewage forcemain, the amount of deflection per joint shall not exceed 70

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percent of the deflection recommended by the Manufacturer. All pressure sewer lines shall be installed to grade as shown on the Drawings.

2. Installation of service line pipe shall be in accordance with the applicable requirements contained herein. The Contractor shall end pressure service lines at the location as per the Drawings and at the invert elevation as shown on the Drawings. Dead ends of service lines shall be marked with steel fence posts installed in the ground as shown on the Drawings.
3. In the construction of new sewage collection systems, connection of new services allowing sewage into the system shall not be made until approval for connections has been given by the City. No existing sewer service shall be interrupted without the approval of the City and service owner.
4. The Contractor shall obtain all necessary permits required to construct service lines on private property.

B. Testing

1. General

The Contractor shall be responsible for determining the length of any given section of line to be tested. It is recommended that the length of line to be tested not be excessive so that the identification of any problem areas can be readily made. It is also recommended that testing follow closely after the pipe installation and backfill.

2. Hydrostatic Testing of Pressure Sewer Lines

- a. Each section of the lines before being placed into service shall be isolated and slowly filled with water. Air should be expelled from the lines through taps made at the high points. The Contractor shall be responsible for making any necessary taps in addition to those shown on the Drawings, and such additional taps shall be at no additional cost to the City.
- b. All lines shall be pressure tested by the Contractor at 100 psi pressure, at the lowest pipe elevation, for one hour. Any cracked or defective pipe or fitting shall be removed and replaced.

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3. Leakage Test

- a. Each section of the line before being placed into service shall be tested by the Contractor for leakage for a period of two hours at an average gage pressure of 60 psi. The pressure during the test shall not fall below 40 psi. The allowable leakage is defined by the following equation: $L=ND(P)^{0.5}/7400$ in which L = allowable leakage (gal/hr), N = number of joints or connections, D = nominal diameter in inches, P = average gage pressure during the test in psi.
- b. Leakage is defined as the quantity of water supplied into the section of line being tested, during and at the end of the test, that quantity being such that the pressure at the end of the test is equal to the pressure at the beginning of the test.
- c. Should any test disclose leakage greater than that specified, the Contractor shall locate and repair the defective joints until the leakage is within the specified allowance.

4. Equipment

The Contractor shall perform and provide all equipment and materials necessary to perform the required test.

3.5 Manhole Construction

A. Installation

1. Manholes shall be constructed to the line, grade and detail as shown on the Drawings. Excavation and backfill of the manhole shall be performed in the same manner as specified in Technical Specifications - "Excavation and Backfill of Trenches," where applicable. Backfill shall be brought up evenly on all sides of the manhole.
2. The manhole base section shall be carefully placed on a prepared base of 6-inch minimum deep crushed rock so as to be fully and uniformly supported in true alignment, and making sure that all entering pipes can be inserted on proper grade.
3. All connections and joints made at manholes shall be watertight. All manholes are to be watertight and any leakage shall be corrected in an approved manner.

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B. Testing

1. The Contractor shall be responsible for providing all equipment, labor, and materials necessary for performing manhole testing.
2. All manholes shall be individually tested to verify their watertightness. Each manhole shall be tested for acceptance after all work has been completed including restoration work. Preliminary testing prior to final acceptance is advised.
3. The testing shall be by a vacuum test in conformance with ASTM C 1244 "Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test." All manholes must be watertight. Any points of leakage must be repaired by the Contractor, even if the manhole passed the vacuum test.
4. The vacuum test shall generally follow the following procedures:
 - a. All pipes entering the manhole shall be temporarily plugged, taking care to securely brace the pipes and plugs to prevent them from being drawn into the manhole.
 - b. The test head shall be placed at the top of the manhole in accordance with the manufacturer's recommendations.
 - c. A vacuum of 10 inches of mercury shall be drawn on the manhole, the valve on the vacuum line of the test head closed, and the vacuum pump shut off. The time shall be measured for the vacuum to drop to 9 inches of mercury.
 - d. The manhole shall pass if the time for the vacuum reading to drop from 10 inches of mercury to 9 inches of mercury meets or exceeds the values indicated in Table 1.
 - e. If the manhole fails the initial test, necessary repairs shall be made by an approved method. The manhole shall then be retested until a satisfactory test is obtained.
 - f. The results of the manhole test shall be reported on the "Attachment B - Manhole Test Record" form, a copy of which is located at the end of this section. The Contractor shall complete this form and provide it to the City prior to Substantial Completion.

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TABLE 1 - Minimum Test Times for Various Manhole Diameters

Depth (ft.)	Diameter, inches								
	30	33	36	42	48	54	60	66	72
	Time, seconds								
≤8	11	12	14	17	20	23	26	29	33
10	14	15	18	21	25	29	33	36	41
12	17	18	21	25	30	35	39	43	49
14	20	21	25	30	35	41	46	51	57
16	22	24	30	34	40	46	52	58	67
18	25	27	32	38	45	52	59	65	73
20	28	30	35	42	50	53	65	72	81
22	31	33	39	46	55	64	72	79	89
24	33	36	42	51	59	64	78	87	97
26	36	39	46	55	64	75	85	94	105
28	39	42	49	59	69	81	91	101	113
30	42	45	53	63	74	87	98	108	121

C. Connection to Existing Manhole

1. Connections to existing manholes when required on the Drawings shall be made by the Contractor. All connections shall be made in such a manner as to leave the existing manhole watertight.
2. All flow lines shall be properly shaped, and all new concrete shall be placed against a clean and sound surface.
3. An approved bonding agent shall be used on all existing surfaces to be bonded to new concrete or mortar. All applicable conditions for new manholes described previously shall apply.

3.6 Cleanout Construction

A. Main Line Cleanouts

Main line cleanouts shall be constructed as shown on the Drawings. The select backfill shall be carefully compacted around the cleanout riser pipe to prevent damage or displacement of the pipe.

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B. Service Line Cleanouts

Service line cleanouts in public rights-of-way shall be constructed as per the Drawings and approved by the City. Service line cleanouts on private property shall be constructed in accordance with the Uniform Plumbing Code.

C. Testing

Cleanouts shall be tested as a part of the lines to which they are connected.

3.7 Water-Sewer Crossing

- A.** Wherever possible, the bottom of new or existing water lines shall be 1.5 feet or more above the top of the sanitary sewer line. Where the water line crosses over the sanitary sewer line but with a clearance of less than 1.5 feet, the Contractor shall center one full length of the new sewer pipe at the crossing point. Use PVC pressure pipe, ASTM D 2241, SDR 32.5, (125 psi) at the crossing point. Where the water line crosses under the sanitary sewer line, the Contractor shall center one full length of the new sewer pipe at the crossing point.
- B.** If the City determines that conditions are not favorable or finds evidence of poor water line condition, the existing water line shall be replaced with a full length of water pipe centered at the crossing point.
- C.** When constructing sewer service lines, the City may require the depth of the service lines to be revised in order to eliminate the need for a water-sewer line crossing.

3.8 Locating Wire

- A.** A continuous solid copper tracer or locating wire shall be taped along the top of all pressure sewer lines, including service lines. This wire shall be secured to the top of the pipe at maximum 10-foot intervals using 6-inch strips of 2-inch wide duct tape. All splices shall be tied, electrically continuous, and made waterproof.
- B.** The location wire shall be brought to the surface at all valve boxes, cleanouts, and terminal line marker fence posts. The wire shall be secured to valve boxes, cleanouts, and posts with stainless steel pipe clamps.
- C.** Access to terminal ends of the locating wire shall be made at all manholes, cleanouts, valve boxes, terminal line marker fence posts, and as shown on the Drawings, etc. The result of this installation shall be a continuous wire circuit electrically isolated from ground.

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- D.** The Contractor shall be responsible for testing continuity and for testing isolation from ground in the wire after all work has been completed on the test section. The Contractor is advised to do intermediate testing on his own after backfilling operations and prior to surface restoration work to be sure continuity is maintained. If there is a break or defect in the wire, it shall be the Contractor's responsibility to locate and repair the defect.
- E.** The continuity of the location wire shall be tested from one test load point to the next by use of a temporary wire laid between test points in-line with an ohmmeter. Resistance shall be measured with an approved ohmmeter that has been properly calibrated. The continuity of a test section will be accepted if the resistance of the test section does not exceed 5 ohms per 500 feet of location wire being tested. Isolation from ground shall be measured with a megohm meter and shall be a minimum of 20 megohms for any section of location wire tested.
- F.** The City shall witness the acceptance test.

3.9 Cleaning and Flushing of Completed and Tested Sewers

- A.** Prior to final inspection of the sewer system by the City, the Contractor shall flush and clean all parts of the system. All accumulated construction debris, rocks, gravel, sand, silt, and other foreign material shall be removed from the sewer system at or near the closest downstream manhole. If necessary, mechanical rodding or bucketing equipment shall be used.
- B.** All sewer pipes including gravity sewers, pressure sewer lines, service lines, etc., installed shall be flushed, as thoroughly as possible with the water pressure and outlets available. Flushing shall be done after the pressure test has been made. It must be understood that flushing removes only the lighter solids and cannot be relied upon to remove heavy material allowed to get into the sewers during construction. The Contractor shall provide sufficient water and appropriately sized taps at either end of the line to develop a velocity in the sewers during flushing of at least 2.5 fps.

END OF SECTION

**WORKSHEET FOR THE
GRAVITY SEWER LINE LOW PRESSURE AIR TEST
BY THE TIME PRESSURE DROP METHOD**

Project Name _____

Date _____ **Job No.** _____

Location of Test/Stationing _____

1. Wetted Line: Yes _____ No _____
2. Average height of groundwater over crown of sewer line _____ ft.
3. Internal Air Pressure (P₁):
P₁ = 4.0 psig + Groundwater Ht. x 0.433 psi = 4.0 + (_____ ' x .433) = _____ psig
4. Initial Starting Test Air Pressure (P₂):
P₂ = P₁ - 0.5 psig = _____ - 0.5 = _____ psig
5. Ending Test Air Pressure (P₃):
P₃ = P₂ - 1.0 psig = _____ - 1.0 = _____ psig
6. Time of test from P₂ to P₃ (in seconds)
Start Time T₁ _____
End Time T₂ _____

Actual Time = T₂ - T₁ _____ seconds

7. Test Time

Pipe Diameter (inches)	Length of Pipe	"C" Value*	"K" Value*
TOTAL			

*See Figure No. 1 for "C" & "K" Values

If Total "C" Value is <1.0 , use Total "K" Value as Test Time in seconds.

If Total "C" Value is ≥ 1.0 , use Total "K" Value \div Total "C" Value as Test Time in seconds.

Results of Test

Actual time = _____ seconds

Test time = _____ seconds

If Actual Time is equal to or greater than test time required for the pipe section being tested, the pipe section will have passed the Pressure Test.

Test Passed: _____yes _____no

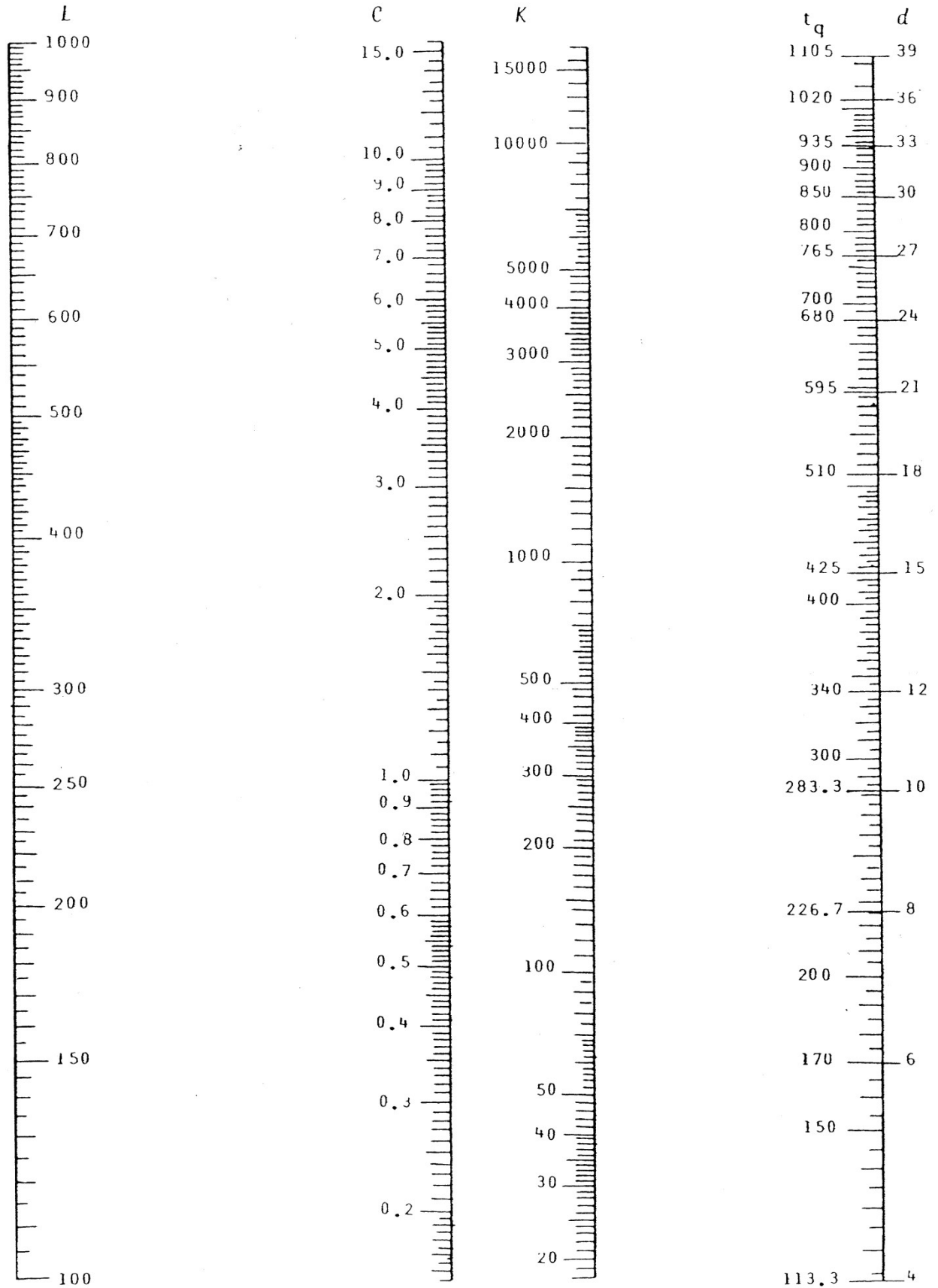
Corrective Measures: _____

Contractor's Firm Name: _____

Contractor's Representative Signature: _____ Title: _____

City's Representative Signature: _____ Title: _____

FIGURE NO. 1



Nomograph for the solution of $K = .011d^2L$, $C = .0003882dL$, $t_q = K \div C$

