DS-01096
(Replaces DS-01046)

Iowa Department of Transportation

DEVELOPMENTAL SPECIFICATIONS
For
WATER MAIN
(SUDAS)

Effective Date
July 17, 2007

THE STANDARD SPECIFICATIONS, SERIES OF 2001, ARE AMENDED BY THE FOLLOWING ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

This Developmental Specification is a rewrite. Please read carefully.

TABLE OF CONTENTS

The applicable sections of the Urban Standard Specifications for Public Improvements (SUDAS) have been included and modified in these Developmental Specifications.

The applicable figures referenced in this Developmental Specification are included in the plans.

DIVISION 3. TRENCH, BACKFILL, AND TRENCHLESS

SECTION 3010 - TRENCH AND BACKFILL

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Trench excavation for pipe systems, utility accesses, and other structures.

B. Trench bedding and foundation stabilization.

C. Pipe and structure placement and backfill.

1.02 DESCRIPTION OF WORK

A. Perform all excavations required to complete the work shown in the plans.

B. Prepare trench excavations and shoring for new work, and install the utility lines, structures, and system components, including bedding and foundation stabilization.

C. Complete specified backfill operation.

1.03 SUBMITTALS

A. Samples, granular bedding material: submit 10 pounds (5 kg) samples of each type, if required.

B. Samples, granular backfill material: submit 10 pounds (5 kg) samples, if required.

C. Gradation reports for fill materials and bedding materials, if required.

D. Results of Proctor and In-Place Density Tests on backfill.

E. Provide material certifications to the Engineer.

1.04 SUBSTITUTIONS

Obtain approval of the Engineer for all substitutions prior to use.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Grade and shape stockpiles for drainage and protect adjacent areas from runoff. Provide erosion control around stockpiles.

B. Remove unsuitable and excess materials from the site.

1.06 SCHEDULING AND CONFLICTS

A. Construction Sequence:

1. Attend a preconstruction meeting if required by the Engineer.

2. Submit plan for construction sequence and schedule prior to commencing construction.

B. Conflict Avoidance:

1. Expose possible conflicts in advance of construction, such as utility lines and drainage structures. Verify elevations and locations of each and verify clearance for proposed construction.

2. Complete other elements of the work that can affect line and grade in advance of other open cut construction unless noted on plans.

3. Notify the Engineer of conflicts discovered or changes needed to accommodate unknown or changed conditions.

1.07 SPECIAL REQUIREMENTS

A. Stop Work: Stop work and notify the Engineer immediately if contaminated soils, historical artifacts, or other environmental or historic items are encountered.

B. Use of Explosives: Submit detailed plans outlining all proposed blasting operations, locations, methods, and use of mats and other safety measures to the Engineer.

1. Obtain written approval before using explosives.

2. Use personnel experienced with explosives.

C. Abandoned Utilities: Remove and dispose of abandoned utility lines including gas mains, water mains, sewer mains, telephone conduits, service lines, etc. required to complete the work. Said work shall be incidental to the project unless otherwise specified.

1.08 MEASUREMENT FOR PAYMENT

A. General: No separate payment will be made for unclassified excavation. Trenching, Bedding, Backfilling, Compaction, and Dewatering shall be included in the costs in the contract unit price for all pipe and structures, except as follows:

1. Rock Excavation: Rock, if encountered and verified by the Engineer, will be measured by the Engineer and paid for by the cubic yard (cubic meter) removed from the excavation, or will be paid for according to Article 1109.03, B of the Standard Specifications unless otherwise provided for in Contract Documents.

2. Over-excavation and trench bottom stabilization. (Measured by the Engineer):

- **a.** Authorized over-excavation and trench stabilization will be measured by the cubic yard (cubic meter) removed.
- **b.** The quantity of stabilization material placed in the over-excavation will be measured in tons (kilograms).
- **c.** Payment will be made for over-excavation, stabilization material, and placement on the basis of the contract unit price or according to Article 1109.03, B, of the Standard Specifications.

3. Unsuitable Backfill:

a. Where excavated material is found to be unsuitable for backfill and cannot be made suitable in the opinion of the Engineer, the Engineer will measure replacement material furnished by Contractor from outside the project limits by cubic yards (cubic meters), furnished, transported, and properly installed. Payment will be made at the contract unit price per cubic yard (cubic meter) or according to Article 1109.03, B, of the Standard Specifications.

b. Except for over-excavation, removal of unsuitable soil shall be considered as incidental to unclassified excavation.

c. If suitable backfill replacement material is within the project limits, it will not be measured and paid for separately.

B. Open Cut Casing and Carrier Pipe Installation: The length of properly installed casing will be measured along the centerline of the casing. Payment will be made for both the carrier pipe and casing pipe as a combined single bid unit for the appropriate method of installation.

C. Incidental Items: Unless otherwise stated in the contract documents, the following items will be included in the unit price for open cut casing and carrier pipe installation: guides, fillers, levels, backfill, and other appurtenances necessary to perform specified function.

D. Over-Excavation not for Stabilization and Repair of Same: No payment will be made.

E. Structure Removal: The Engineer will count the quantity of structures to be removed including each utility access and inlet removed in accordance with the plans. Payment will be for the number removed.

F. Surfacing Removal and Replacement: All temporary or permanent surface removals and replacements for both granular and hard surfaces for streets, drives, and sidewalks will be included in the contract unit prices for all pipe and structures.

G. Abandoned Utilities: Remove and dispose of abandoned utilities within the work zone. This work shall be considered incidental to the contract unit price for pipes and structures.

H. Compaction Testing: All contractor provided services associated with compaction testing shall be considered incidental to the pipe installation.

PART 2 - PRODUCTS

2.01 EXCAVATED MATERIALS

A. Unclassified Excavation: Excavation of all materials encountered, except rock and over-excavation.

B. Rock Excavation: Boulders or sedimentary deposits that cannot be removed without continuous use of pneumatic tools or blasting.

C. Over-Excavation: Excavation of soil or rock in trenches below the pipe zone, see Figure 3010.1 on the plans.

D. Suitable Excavated Materials for Backfill:

1. Soil, clay, silt, sand, and gravel with moisture content suitable to achieve required compaction. ASTM D 2321, Class II through IVA (see Section 3010, 2.01 E of this Developmental Specification).

2. Fine-grained soils according to ASTM D 2321 Class IVB (inorganic) (see Section 3010, 2.01, E of this Developmental Specification) may be used in the final backfill upon approval of the Engineer.

3. Adjust moisture content of excessively wet, but otherwise acceptable material by spreading, turning, aerating, and otherwise working material as necessary to achieve required moisture range.

4. Adjust moisture content of excessively dry, but otherwise acceptable material, by adding water, then turning, mixing, and otherwise blending the water uniformly throughout the material until the required moisture range is achieved.

5. Lime or fly ash may be added to earth material to produce a suitable backfill material. Uniformly mix soil and additive. Determine Standard Proctor maximum density and optimum moisture content of the modified material. Amount of additive applied is subject to the Engineer's approval.

E. Non-Manufactured (Excavated) Backfill Materials: (See Sections 3010, 2.03 and 2.04 of this Developmental Specification for manufactured backfill).

Class	Type	Soil Group Symbol ASTM D 2487	Description	Percentage Passing Sieve Sizes			Atterberg Limits		Coefficients	
				1½ in. (37.5 mm)	No. 4 (4.75 mm)	No. 200 (75 μm)	LL	PI	Uniformity C_u	Curvature C_c
II	Coarse-Grained Soils, clean	GW	Well-graded gravels and gravel-sand mixtures; little or no fines	100%	‹50% of "Course Fraction"	‹5%	Non Plastic		›4	1 to 3
		GP	Poorly-graded gravels and gravel-sand mixtures; little or no fines.						‹4	‹1 or ›3
		SW	Well-graded sands and gravelly sands; little or no fines.		›50% of "Coarse Fraction"				›6	1 to 3
		SP	Poorly-graded sands and gravelly sands; little or no fines.						‹6	‹1 or ›3
	Coarse-Grained Soils, borderline clean to w/fines	e.g. GW-GC, SP-SM	Sands and gravels that are borderline between clean and with fines.	100%	Varies	5% to 12%	Non Plastic		Same as for GW, GP, SW and SP	
III	Coarse-Grained Soils, with Fines	GM	Silty gravels, gravel-sand-silt mixtures.	100%	‹50% of "Coarse Fraction"	12% to 50%		‹4 or ‹"A" Line		
		GC	Clayey gravels, gravel-sand-clay mixtures.					‹7 and ›"A" Line		
		SM	Silty sands, sand-silt mixtures.		›50% of "Coarse Fraction"			›4 or ‹"A" Line		
		SC	Clayey sands, sand-clay mixtures.					›7 and ›"A" Line		
IVA	Fine-Grained Soils (inorganic)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, silts with slight plasticity.	100%	100%	›50%	‹50	‹4 or ‹"A" Line		
		CL	Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clay, lean clays.					›7 and ›"A" Line		
IVB (1)	Fine-Grained Soils (inorganic)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	100%	100%	›50%	›50	‹"A" Line		
		CH	Inorganic clays of high plasticity, fat clays.					›"A" Line		
V	Organic Soils (Unsuitable for backfill)	OL	Organic silts and organic silty clays of low plasticity.	100%	100%	›50%	‹50	‹4 or ‹"A" Line		
		OH	Organic Clays of Medium to high plasticity, organic silts.				›50	‹"A" Line		
	Highly Organic (Unsuitable for backfill)	PT	Peat and other high organic soils.							

(1) See Section 3010, 2.01 D, 2 of this Developmental Specification for restrictive use.

F. Unsuitable Material: Remove unsuitable materials from the site including, but not limited to, the following:

1. Rock with gradation not meeting the stated gradation for stabilization material.

2. Individual stones or concrete chunks larger than 6 inches (150 mm), and averaging more than one per each cubic foot (0.03 m^3) of soil.

3. Frozen materials.

4. Stumps, logs, branches, and brush.

5. Trash, metal, or construction waste.

6. Soil in clumps or clods larger than 6 inches (150 mm), and without sufficient fine materials to fill voids during placement.

7. Unsuitable soils, as defined in Article 2102.06, A, 2 of the Standard Specifications, excluding material used as topsoil.

8. Class V Material (ASTM D 2321) as defined in Section 3010, 2.08 of this Developmental Specification.

9. Environmentally contaminated soil.

G. Replacement of Unsuitable Soils:

1. If the excavated material is determined by the Engineer to be unsuitable and cannot be conditioned so that it becomes suitable, furnish all necessary backfill material.

2. Remove and dispose of unsuitable material from the site.

2.02 STABILIZATION (FOUNDATION) MATERIALS

A. Clean 2 1/2 inch (63.5 mm) crushed stone or crushed P.C. concrete material, with the following gradation:

Sieve	Percent Passing
2 1/2 inch (63 mm)	100
2 inch (50 mm)	90 to 100
1 1/2 inch (37.5 mm)	35 to 70
1 inch (25 mm)	0 to 20
1/2 inch (12.5 mm)	0 to 5

B. The Engineer may authorize a change in gradation subject to materials available locally at time of construction. Subject to the Engineer's approval, crushed concrete may be used if it is within ± 5% of the gradation for each size of material.

2.03 CLASS I GRANULAR BEDDING AND BACKFILL MATERIAL (STORM SEWERS AND SANITARY SEWERS)

A. Granular bedding shall be gravel or crushed stone complying with the following gradation:

Sieve	Percent Passing
1 1/2 inch (37.5 mm)	100
1 inch (25 mm)	95 to 100
1/2 inch (12.5 mm)	25 to 60
No. 4 (4.75 mm)	0 to 10
No. 8 (2.36)	0 to 5

Note: The Engineer may authorize the use of crushed PCC for pipe sizes up to 12 inches (300 mm) or a change in gradation subject to materials available locally at time of construction.

B. Use aggregates having a percentage of wear, Grading A or B, not exceeding 50%, determined according to AASHTO T 96.

C. Compaction: See Section 3010, 3.06 of this Developmental Specification.

2.04 CLASS II BACKFILL MATERIAL (WATER MAINS)

A. Class II material is manufactured and non-manufactured open graded (clean) or dense graded (clean) processed aggregate, clean sand, or coarse grained natural soils (clean) with little or no fines.

B. Class II material is non-plastic soil less than 1 1/2 inches (37.5 mm) in size and consists of the following:

SOIL TYPE	DESCRIPTION OF MATERIAL CLASSIFICATION	REMARKS SECTION
GW	Well-graded gravels and gravel-sand mixtures, little or no fines. 50% or more retained on No. 4 (4.75 mm) sieve. More than 95% retained on No. 200 (75 μm) sieve. Clean.	Where hydraulic gradient exists check gradation to minimize migration. Clean groups suitable for use as drainage blanket and underdrain.
GP	Poorly graded gravels and gravel sand mixtures, little or no fines. 50% or more retained on No. 4 (4.75 mm) sieve. More than 95% retained on No. 200 (75 μm) sieve. Clean.	
SW	Well-graded sands and gravelly sands, little or no fines. More than 50% passes No. 4 (4.75 mm) sieve. More than 95% retained on No. 200 (75 μm) sieve. Clean.	
SP	Poorly graded sands and gravelly sands, little or no fines. More than 50% passes No. 4 (4.75 mm) sieve. More than 95% retained on No. 200 (75 μm) sieve. Clean.	

C. Compaction: See Section 3010, 3.06 of this Developmental Specification.

D. Class II material may be specified in the contract documents, between the pipe embedment zone and the top 2 feet (0.6 m) of final backfill when the trench is under the pavement.

2.05 CLASS III BACKFILL MATERIAL (WATER MAINS)

A. Class III material is natural coarse grained soils with fines.

B. Class III material follows Section 3010, 2.01 of this Developmental Specification and consists of the following:

SOIL TYPE	DESCRIPTION OF MATERIAL CLASSIFICATION	REMARKS SECTION
GM	Silty gravels, gravel-sand-silt mixtures. 50% or more retained on No. 4 (4.75 mm) sieve. More than 50% retained on No. 200 (75 μm) sieve.	Do not use where water condition in trench may cause instability.
GC	Clayey gravels, gravel-sand-clay mixtures. 50% or more retained on No. 4 (4.75 mm) sieve. More than 50% retained on No. 200 (75 μm) sieve.	
SM	Silty sands, sand-silt mixtures. More than 50% passes No. 4 (4.75 mm) sieve. More than 50% retained on No. 200 (75 μm) sieve.	
SC	Clayey sands, sand-clay mixtures. More than 50% passes No. 4 (4.75 mm) sieve. More than 50% retained on No. 200 (75 μm) sieve.	

C. Compaction: See Section 3010, 3.06 of this Developmental Specification.

2.06 CLASS IVA BACKFILL MATERIAL (WATER MAINS)

A. Class IVA material is natural fine grained inorganic soils.

B. Class IVA material follows Section 3010, 2.01 of this Developmental Specification and consists of the following:

SOIL TYPE	DESCRIPTION OF MATERIAL CLASSIFICATION	REMARKS SECTION
ML	Inorganic silts, very fine sands, rockflous, silty, or clayey fine sands. Liquid limit 50% or less. 50% or more passes No. 200 (75 μm) sieve.	Obtain geotechnical evaluation of proposed material. May not be suitable under deep fills, surface applied wheel loads, and under heavy vibratory compactors and tampers. Do not use where water conditions in trench may cause instability.
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. Liquid limit 50% or less. 50% or more passes No. 200 (75 μm) sieve.	

C. Compaction: See Section 3010, 3.06 of this Developmental Specification.

D. Suitable only in dry trench conditions.

2.07 CLASS IVB BACKFILL MATERIAL (WATER MAINS)

A. Class IVB material is natural fine grained inorganic (high elastic silts and plastic clays - fat clay) with a liquid limit greater than 50%.

B. Class IVB material follows Section 3010, 2.01 of this Developmental Specification and consist of the following:

SOIL TYPE	DESCRIPTION OF MATERIAL CLASSIFICATION	REMARKS SECTION
MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts. Liquid limit greater than 50%. 50% or more passes No. 200 (75 μm) sieve.	Not to be used in pipe embedment zone.
CH	Inorganic clays of high plasticity, fat clays. Liquid limit greater than 50%. 50% or more passes No. 200 (75 μm) sieve.	

C. Compaction: See Section 3010, 3.06 of this Developmental Specification.

D. Upon the approval of the Engineer Class IVB materials may be used as final backfill in a dry trench.

E. Do not use Class IVB materials in the pipe embedment zone.

2.08 CLASS V BACKFILL MATERIAL (TOPSOIL)

A. Class V Material is natural highly organic soils with a liquid limit of greater than 50%. See Section 3010, 2.01 of this Developmental Specification.

B. Use Class V Material only as topsoil outside of the pavement, unless otherwise specified by the Engineer.

C. Do not use Class V Material in the pipe embedment zone.

2.09 INTENTIONALLY LEFT BLANK

2.10 INTENTIONALLY LEFT BLANK

2.11 SPECIAL PIPE EMBEDMENT MATERIAL

A. Concrete Supports: Where specified in the contract documents, construct concrete support systems in accordance with Figures 3010.2, 3010.3, 3010.4, 3010.5, 3010.6, and 3010.7 on the plans.

B. Concrete Bedding, Arch, or Encasement:

1. Concrete: commercial, 4,000 psi (27.6 MPa) compressive strength.

2. Unreinforced.

3. Minimum concrete thickness: 6 inches (150 mm).

C. Flowable Mortar:

1. Approximate quantities per cubic yard (cubic meter):

a.	Cement	100 pounds (60 kg)
b.	Fly ash	300 pounds (180 kg)
c.	Fine aggregate	2,600 pounds (1,545 kg)
d.	Water, approximate	70 gallons (345 L)

2. Compressive strength at 28 days: 100 psi to 200 psi (690 kPa to 1,380 kPa).

D. Controlled Low Strength Material (CLSM):

1. Approximate quantities per cubic yard (cubic meter):

a.	Cement	50 pounds (30 kg)
b.	Fly ash	250 pounds (150 kg)
c.	Fine aggregate	2910 pounds (1,729 kg)
d.	Water, approximate	60 gallons (296 L)

2. Compressive strength at 28 days: 50 psi (345 kPa).

2.12 CASING PIPE WITH CARRIER PIPE

See Sections 3020 2.01, 2.02, 2.03, and 2.04 of this Developmental Specification.

PART 3 - EXECUTION

3.01 PREPARATION

A. When natural soils for Class II, III and IV backfill material are required as specified in Figure 3010.1 on the plans, provide written certification from a testing laboratory that the material meets the class specified if so requested by the Engineer.

B. Locate, mark, and protect existing utilities and facilities in the work area.

C. Provide access to utility service locations, such as valves, utility accesses, and utility poles.

D. Identify owners of utilities on or near the site, and notify them of operations to occur.

E. Protect existing facilities and landscaping features, or replace as shown on the plans.

F. Protect bench marks, control points, and land survey monuments, or replace at Contractor's expense.

3.02 TRENCH EXCAVATION

A. Notify the Engineer prior to the start of excavation activities.

B. Remove and stockpile the top 8 inches (200 mm) of topsoil for subsequent reuse.

C. Place excavated material away from trench. Grade spoil piles to drain. Do not allow spoil piles to obstruct drainage.

D. Remove rock, rubbish, boulders, debris, and other unsuitable materials at least 6 inches (150 mm) below and on each side of the pipe. Restore grade using soil suitable for backfill.

E. Correct unauthorized excavation at no cost to Contracting Authority, using bedding or stabilization materials.

F. Provide protective fences and barricades around open excavations, appropriate to the surrounding area.

G. Provide scale tickets for stabilization material to the Engineer at the time of delivery.

H. Provide safety fence around open excavations.

I. Trench Excavation for Water Mains:

1. Maximum and minimum pipe trench width: See Figure 3010.1 on the plans.

2. Flat trench bottom, conduit bearing directly on trench bottom (not applicable for rock excavation) for water main pipe only with bell hole shaping.

a. Shape trench bottom to support pipe around 1/4 of perimeter for the full length of the pipe barrel.
b. Provide bell holes.

3. Trench bottom, conduit supported by bedding material.

a. Excavate trench as shown in detailed drawings.
b. Install bedding material to support the full length of the pipe barrel.

4. Trench depth:

a. See Figure 3010.1 on the plans.
b. For those material types not shown in Figure 3010.1 on the plans, the maximum height of bury shall be 20 feet (6 m) without a designed trench with the Engineer's certification.

J. Structure Excavation:

1. For concrete structures and parts of structures without footings, 18 inches (450 mm) outside the horizontal projection of the structure.

2. For concrete structures with footings, 18 inches (450 mm) outside the footings.

3. For anchor rods, 12 inches (300 mm) on each side of the rod.

4. For buried anchors, the face of the buried anchor on one side and 24 inches (600 mm) outside the buried anchor on the other face.

3.03 ROCK OR UNSTABLE SOILS IN TRENCH BOTTOM

A. Notify the Engineer prior to over-excavation.

B. The Engineer will determine the need for trench bottom stabilization prior to installation of pipes and structures.

C. See Figure 3010.1 on the plans for over-excavation of rock and wet or soft foundations.

D. Provide scale tickets for the stabilization material to the Engineer at the time of delivery.

3.04 SHEETING, SHORING, AND BRACING

A. Ensure sheeting and bracing of all excavations conforms to the latest state and federal regulations governing safety of workers in the construction industry.

B. Leave in place all temporary sheeting below 2 feet (600 mm) over top of pipe unless sheeting removal plan is approved by the Engineer.

C. Move trench boxes carefully to avoid excavated wall displacement or damage.

D. When necessary or required, install adequate sheeting and bracing to prevent ground movement that may cause damage or settlement to adjacent structures, pipelines, and utilities.

E. Damage due to settlement because of failure to use sheeting or because of inadequate bracing, or through negligence or fault of the Contractor in any other manner, shall be repaired at the Contractor's expense.

F. Shore, sheet, brace, slope, or otherwise support by means of sufficient strength all sides of trenches in unsuitable, loose or soft material to protect employees working within them.

G. Where excavations are made with vertical sides that require supporting, use sufficiently strong sheeting and bracing to sustain the sides of the excavations and to prevent movement that could in any way injure the work, or adjacent structures, or diminish the working space sufficiently to delay the work.

H. Select sheeting and bracing material which: (1) is of sufficient dimensions and strength to adequately support the sides of trenches and excavations; (2) does not split when driving; and (3) is free of imperfections that may impair its strength or durability.

I. Drive sheeting to true alignment. Ensure contact of adjacent pieces.

J. In wet excavation use grooved sheeting to prevent passage of soil. Fill all voids between sheeting and face of excavation with suitable material.

K. Do not remove sheeting and bracing before the completion of the work, unless otherwise directed in writing by the Engineer.

L. For sheeting that is left in place, cut off 18 inches (0.5 m) for clearance below the bottom of the pavement in streets/highways and 18 inches (0.5 m) below the original ground surface, unless otherwise required by the contract documents or the Engineer. Leave in place all temporary sheeting below 2 feet (0.6 m) over top of pipe unless sheeting removal plan is reviewed by the Engineer.

3.05 DEWATERING

A. Do all work in dry conditions; do not install pipes on excessively wet soil.

B. Submit a dewatering plan to the Engineer. Perform the dewatering operation according to the dewatering plan. Dewatering operations may be modified from the plan for actual field conditions, with approval of the Engineer.

C. Adequate dewatering is the Contractor's responsibility unless otherwise stated in the contract documents.

D. Install a dewatering system appropriate for the soil conditions.

E. Maintain water levels sufficiently below the bottom of trench excavation, (typically 2 feet (0.6 m)) to prevent upward seepage.

F. Provide for handling water encountered during construction:

1. Prevent surface water from flowing into excavation. Remove water as it accumulates.

2. Do not use sanitary sewers for disposal of trench water. Discharging water into storm sewers requires the Engineer's approval.

3. Do not discharge water onto adjacent property without property owner's written approval.

4. Maintain and control water discharge as necessary so not to create a safety hazard for vehicular and pedestrian traffic.

5. Direct water discharge away from electrical facilities or equipment, and intersections.

6. Use noise and fume reduction equipment to minimize disturbance.

7. Provide at least two operating pumps for each trench opened in wet ground and at the same time have one pump in reserve.

G. Place backfill in trenches prior to stopping dewatering operations.

H. Protect trench water discharge points from erosion.

I. Operate dewatering systems to prevent damage to adjoining structures and facilities.

J. Monitor adjoining structures and facilities during dewatering operations. Cease dewatering operations and notify the Engineer if damage is observed.

3.06 PIPE INSTALLATION

Refer to Figures 3010.1 to 3010.9, included on the plans, as appropriate for the installation being made. Use only the types of materials shown for each position within the trench, for the given groundwater conditions, for the compaction to be provided, and for the type of pipe being installed.

A. Pipe Bedding:

1. Shape pipe bed to evenly support pipe at the proper line and grade, with full contact under the bottom of the pipe.

2. Install pipe and system components.

3. Place bedding simultaneously on both sides of the pipe. Correct any pipe displacements before proceeding.

4. Place bedding in lifts not greater than 6 inches (150 mm) thick and consolidate.

5. Concrete encasement: Install where shown on the plans.

6. If required in the contract documents, or if approved by the Engineer, flowable mortar or controlled low strength material may be used in lieu of other bedding material types.

7. Secure pipe against displacement or flotation prior to placing flowable mortar or concrete encasement.

B. Haunch Support:

1. Place granular haunch material in lifts no greater than 6 inches (150 mm) thick and consolidate by slicing with a shovel or using other approved techniques.

2. If required in the contract documents or approved by the Engineer, concrete, flowable mortar, or controlled low strength material may be used instead of other haunch material types. Secure pipe against displacement or flotation prior to placing flowable mortar, controlled low strength material, or concrete encasement.

C. Primary and Secondary Backfill (Pipe Cover):

1. Place pipe cover material in 6 inches (150 mm) lifts and compact to densities required according to class of material. See Figure 3010.1 on the plans.

2. If required in the contract documents, or if approved by the Engineer, flowable mortar or controlled low strength material may be used in lieu of other cover material types.

3. Secure pipe against displacement or flotation prior to placing flowable mortar or concrete encasement.

4. Special Pipe Support: If required, provide special pipe support as shown on the plans (See Figures 3010.4 to 3010.6 on the plans).

D. Final Trench Backfill:

1. Place backfill in the trench immediately after recording locations of connections and appurtenances, or at the Engineer's direction.

2. Place backfill adjacent to structures immediately after concrete has reached design strength and connecting work has been completed.

3. Allow no more than 100 feet (30 m) of trench to be open overnight or when work is not in progress.

4. Place suitable excavated backfill:

- **a.** Carefully place backfill over top of pipe and around structures.
- **b.** Compact as required.

5. Compaction:

- **a.** Within street right-of-way, compact each lift to at least 95% of maximum Standard Proctor Density; otherwise, compact to at least 90%.
- **b.** In areas more than 3 feet (900 mm) below pavement structure, place backfill in lifts no thicker than 8 inches (200 mm).
- **c.** In areas less than 3 feet (900) feet below pavement structure, place backfill in lifts no thicker than 6 inches (150 mm). Terminate backfill at 8 inches (200 mm) below finish grade in areas to remain unpaved, and to subgrade elevation in areas to be paved. Place 8 inches (200 mm) of topsoil in unpaved areas.
- **d.** For Vitrified Clay Pipe (VCP), keep all heavy compaction equipment 5 vertical feet (1.5 vertical meters) above the top of the pipe. In the area less than 5 vertical feet (1.5 vertical meters), use hand held compactors. Do not allow the compactor to come in contact with the pipe.

6. Moisture Range: Obtain required compaction within a soil moisture range of optimum

moisture to 4% above optimum moisture content.

7. Dispose of surplus and unsuitable materials.

8. Hydraulic compaction (flooding with water) is not allowed unless authorized by the Engineer.

E. Casing Pipe: Place beding and backfill materials for casing pipes the same as for a rigid gravity flow pipe.

3.07 INTENTIONALLY LEFT BLANK

3.08 STRUCTURE BEDDING

A. Bedding for Structures Bearing on Undisturbed Soils:

1. Shape the bottom to accurate grade and size.

2. Remove loose material, large clods, stones, and foreign materials.

3. In unstable soils or rock conditions see Section 3010, 3.03 of this Developmental Specification for stabilization requirements.

B. Bedding for Structures Bearing on Bedding Material:

1. Over excavate to minimum of 8 inches (200 mm) or as specified in the contract documents.

2. Place bedding material for structures in accordance with the contract documents and with the material and control specified in Figure 3010.1 on the plans.

3.09 STRUCTURE BACKFILL

A. Removal of Forms and Falsework:

1. Remove forms for utility accesses and intake walls and tops according to Article 2403.18 of the Standard Specifications.

- **a.** References to culverts include all sanitary and storm structures.
- **b.** When allowed by the Engineer, compressive strengths as six times the stated flexural strengths may be used in determining concrete strength of structure roofs.

2. Chip out and repair any honeycomb areas per the direction of the Engineer.
3. Break back form ties and fill holes with Portland cement mortar.
4. Remove flashing and thin webs.

B. Backfill Placement: Place backfill after structure concrete has reached at least 80% of the design strength and connecting work has been completed, unless otherwise specified. Determine strengths under comparable conditions. If strength is not determined, place backfill after 14 days.

C. Backfill Against Walls and Around Structures:

1. Where backfill is required on both sides of a concrete wall and around sides of monolithic structures, proceed with filling operations simultaneously on all sides of walls and structures

so the fill is kept at approximately the same elevation at all times. Consider concrete box, arch, and circular culverts to be monolithic structures.

2. Compact the 3 feet (900 mm) closest to all walls or wing faces using pneumatic or hand tampers only.

D. Backfilling with Excavated Material:

Unless otherwise specified, see Section 3010, 3.06 D of this Developmental Specification for suitable excavated materials for backfill.

3.10 OPEN CUT CASING PIPE INSTALLATION

A. Casing Pipe: Install according to Section 3010, 3.01 to 3.07 of this Developmental Specification, as appropriate.

B. Carrier Pipe: Install according to Section 3020, 3.05 of this Developmental Specification.

3.11 FIELD QUALITY CONTROL

A. References:

1. ASTM C 136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

2. ASTM D 698, Standard Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Moisture Using 5.5 Pound (4.54 kg) Rammer and 12 inch (305 mm) Drop (Standard Proctor Method).

3. ASTM D 1556, Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.

4. ASTM 2216, Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

5. M D 2922 and D 3017, Test Methods for Density of Soil and Soil-Aggregate in Place and Water Content of Soil and Rock by Nuclear Methods (Shallow Depth).

6. ASTM D 4253 and D 4254, Test Methods for Maximum Index Density of Soils using a Vibratory Table and Minimum Index Density of Soils and Calculation of Relative Density.

B. Compaction Testing: Provide compaction testing of backfill, using the services of an independent testing laboratory approved by the Engineer, unless testing is provided by the Engineer.

C. Schedule Testing: Notify the Engineer when work is prepared for testing.

D. Soil Testing:

1. Cohesive soils: Determine moisture-density relationships by ASTM D 698 (Standard Proctor). Perform at least one test for each type of cohesive soil used.

2. Cohesive soils: Determine in-place density and moisture content using ASTM D 1556 (sand-cone method) and D 2216 or ASTM D 2922 and D 3017 (nuclear).

3. Non-cohesive soils: Determine maximum and minimum index density and calculate relative density using ASTM D 4253 and D 4254 (cohesionless soils).

4. **Gradation:** Test in accordance with ASTM C 136.

E. Testing Frequency and Locations: Perform testing of the final trench backfill, beginning at a depth of 2 feet (600 mm) above the top of the pipe, as follows:

1. Contractor Provided:

   a. Make one test per each 2 vertical feet (600 vertical mm) of consolidated fill at each street crossing.
   b. Make one test per each 2 vertical feet (600 vertical mm) of consolidated fill for each 200 horizontal feet (60 horizontal m) of trench.
   c. Additional testing may be required by the Engineer if non-compliance or a change in conditions occurs.
   d. Coordinate the timing of testing with the Engineer.
   e. The Engineer will determine the location of testing.
   f. If necessary, excavate to the depth and size as required by the Engineer to allow compaction tests. Place backfill and recompact.

2. Contracting Authority Provided:
   a. Coordinate the timing of testing with the Engineer.
   b. The Engineer will determine the location of testing.
   c. Test frequency will not exceed one test per each 2 vertical feet (600 vertical mm) of consolidated fill for each 200 horizontal feet (60 horizontal m) of trench.

F. Test Failure: Rework, recompact, and retest as necessary until specific compaction is achieved in all areas of the trench.

G. Retesting: In event of failed tests, the Engineer may require retesting as deemed necessary, at no additional cost to the Contracting Authority.

SECTION 3020 - TRENCHLESS CONSTRUCTION (BORING, JACKING, AND TUNNELING)

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Trenchless installation of carrier pipe with casing pipe.

B. Trenchless installation of carrier pipe without casing pipe.

1.02 DESCRIPTION OF WORK

A. Excavate launch and receiving pits.

B. Install casing pipe (if required).

C. Install carrier pipe.

D. Backfill excavations.

E. Possible methods of trenchless installation (refer to Section 3020, 3.05 of this Developmental Specification for restrictions):

1. **Auger Boring:** A boring method that utilizes a rotating cutting head to form the bore and

a series of rotating augers inside a casing pipe to remove the spoil.

2. Compaction Method: Boring methods that displace soil radially rather than removing spoil. Bore hole may be formed with a push rod or impact mole.

3. Directional Drilling: A boring method for installing pipe from a surface launched drilling rig. A pilot bore is formed and then enlarged by back reaming. The product pipe is then pulled in.

4. Pipe Ramming: A boring method that involves driving a steel casing pipe with a percussive hammer. The front end of the casing pipe may be open ended or closed. If open, spoil must be removed from the pipe.

5. Slurry Boring: A boring method that first forms a pilot bore by forcing a drill tube through the ground. The pilot hole is then enlarged by reaming. As the hole is enlarged with the reamer, drilling fluid (slurry) is pumped into the hole to hold the soil cuttings in suspension. After reaming, the product pipe is pulled into place.

6. Microtunneling: A boring method that consists of a remotely controlled pipe jacking operation utilizing a tunnel boring machine. Personnel entry is not required.

7. Pipe Jacking: A jacking method in which pipe is pushed into the ground with hydraulic rams while soil is simultaneously excavated. Excavation is normally completed with a tunnel boring machine. This method requires personnel to enter the tunnel during the excavation process.

8. Utility Tunneling: A method of forming large diameter tunnels. As excavation takes place at the front of the tunnel, a liner is constructed to temporarily support the tunnel. Upon completion of the tunnel, the product pipe is pushed in place.

9. Other proven methods not described here may be allowed upon approval of the Engineer.

1.03 SUBMITTALS

A. Proposed installation methods and equipment.

B. Samples, granular bedding material: submit 10 pound (5 kg) samples if required.

C. Samples, granular backfill material: submit 10 pound (5 kg) samples if required.

D. Gradation reports for fill materials and bedding materials unless the material used has been submitted and approved for related work on the project.

E. Results of Standard Proctor and In-Place Density Tests on pit backfill if required.

F. Construction sequence.

G. Catalog cuts, samples, and manufacturer's data and listing of applicable standards for special, unique, or proposed substitute materials if requested by the Engineer.

H. Certification that materials being provided meet the requirements of this Developmental Specification or that alternate materials or substitutions have received written approval of the Engineer. Include shop drawings of casing spacers and proposed spacing.

I. Project Record Documents.

J. Provide material certifications to the Engineer.

1.04 SUBSTITUTIONS

Obtain approval of the Engineer for all substitutions prior to use.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Grade and shape stockpiles for drainage and protect adjacent areas from runoff. Provide erosion control around stockpiles.

B. Remove unsuitable and excess materials from the site.

1.06 SCHEDULING AND CONFLICTS

A. Construction Sequence:

1. Attend a preconstruction meeting if required by the Engineer.

2. Submit plan for construction sequence and schedule prior to commencing construction.

B. Conflict Avoidance:

1. Expose possible conflicts in advance of construction, such as utility lines and drainage structures. Verify elevations and locations of each and verify clearance for proposed construction.

2. Complete other elements of the work that can affect line and grade in advance of other open cut construction unless noted on the plans.

3. Notify the Engineer of conflicts discovered or changes needed to accommodate unknown or changed conditions.

1.07 SPECIAL REQUIREMENTS

A. Stop Work: Stop work and notify the Engineer immediately if contaminated soils, historical artifacts, or other environmental or historic items are encountered.

B. Use of Explosives: Submit detailed plans outlining all proposed blasting operations, locations, methods, and use of mats and other safety measures to the Engineer.

1. Obtain written approval before using explosives.

2. Use personnel experienced with explosives.

1.08 MEASUREMENT FOR PAYMENT

A. Boring, Jacking, or Tunneling with Casing Pipe: The length of casing pipe and carrier pipe properly installed will be measured along the centerline of the casing. Payment will be made for both the carrier pipe and casing pipe as a combined single contract unit for the appropriate method of installation.

B. Jacking or Boring without a Casing Pipe: The length of the carrier pipe properly installed will be measured along the centerline of the carrier pipe.

C. Incidental Items: Unless otherwise specified in the contract documents the following items shall be included in the contract unit price for boring, jacking, or tunneling.

1. Launch or reception pits, or other construction excavations.

2. Placement, compaction, and testing of backfill material in excavations and pits.

3. Casing Spacers, annular space fillers, levels, backfill, casing and seals, and other appurtenances necessary to perform specified function.

PART 2 - PRODUCTS

2.01 CARRIER PIPE

See Section 4010, 2.01 or Section 5010, 2.01 of this Developmental Specification, or refer to the contract documents.

2.02 CASING PIPE

A. Casing Pipe: Use only new, welded, or seamless steel pipe per ASTM A139, Grade B; ASTM A252, Grade 2; or ASTM A53, Grade B.

B. Joints:

1. Comply with American Welding Society Code of Arc and Gas Welding in Building Construction. Fully weld all joints with full penetrating weld.

2. Upon approval of the Engineer, an interlocking casing pipe connection system may be used instead of field welding the sections of casing pipe.

C. Casing Pipe Diameter: Minimum inside diameter as shown on the plans. If not shown, use a minimum casing diameter of at least 4 inches (100 mm) greater than the largest outside diameter of the carrier pipe, including pipe bells.

D. Steel Casing Pipe Minimum Wall Thickness:

NOMINAL DIAMETER INCHES (mm)	WALL THICKNESS, MINIMUM INCHES (mm)	
	UNDER HIGHWAY	UNDER RAILROAD
6 thru 14 (150 thru 355)	0.188 (4.78)	0.25000 (6.35)
16 (465)	0.188 (4.78)	0.28125 (7.14)
18 (450)	0.25 (6.35)	0.31250 (7.94)
20 (510)	0.25 (6.35)	0.34375 (8.73)
22 (560)	0.25 (6.35)	0.34375 (8.73)
24 (600)	0.281 (7.14)	0.37500 (9.53)
26 (660)	0.281 (7.14)	0.40625 (10.32)
28 (710)	0.312 (7.92)	0.43750 (11.11)
30 (750)	0.312 (7.92)	0.46875 (11.91)
32 (815)	0.312 (7.92)	0.50000 (12.70)
34 (865)	0.312 (7.92)	0.53125 (13.49)

NOMINAL DIAMETER INCHES (mm)	WALL THICKNESS, MINIMUM INCHES (mm)	
	UNDER HIGHWAY	UNDER RAILROAD
36 (900)	0.344 (8.74)	0.53125 (13.49)
38 (965)	0.344 (8.74)	0.56250 (14.29)
40 (1015)	0.344 (8.74)	0.59375 (15.08)
42 (1050)	0.344 (8.74)	0.62500 (15.88)
44 (1120)	0.344 (8.74)	0.65625 (16.67)
46 (1170)	0.344 (8.74)	0.65625 (16.67)
48 (1200)	0.344 (8.74)	0.68750 (17.46)
50 (1270)	Sizes greater than 48 inches (1200 mm) diameter will be as specified in the contract documents	0.71875 (18.26)
52 (1320)		0.75000 (19.05)
54 (1370)		0.78125 (19.84)
56 (1420)		0.81250 (20.64)
58 (1470)		0.81250 (20.64)
60 (1525)		0.84375 (21.43)
62 (1575)		0.87500 (22.23)
64 (1625)		0.90625 (23.02)
66 (1675)		0.93750 (23.81)
68 (1725)		0.93750 (23.81)
70 (1780)		0.96875 (24.61)
72 (1830)		1.00000 (25.40)

2.03 CASING SPACERS

A. Use manufactured casing spacers to position carrier pipe in casing. Wood skids will not be allowed.

B. Use the following material requirements for casing spacers:

1. HDPE Band/Panel and Riser: ASTM D 638.

2. Stainless Steel or Carbon Steel Band/Panel and Riser: Type 304 stainless steel per ASTM A 240 or carbon steel per ASTM 36.

- **a. Liner:** Elastomeric PVC per ASTM D 149.
- **b. Spacer Skid/Runner:** Abrasion resistant polymer with a low coefficient of friction.
- **c. Fasteners:** Type 304 (18-8) stainless steel per ASTM A 193.

2.04 BACKFILL FOR ABANDONED TUNNELS

A. Option 1 - PCC, 3,000 psi (20.7 MPa) minimum, approximately 4 inch (100 mm) slump.

B. Option 2 - Flowable mortar or controlled low strength material (CLSM) per Section 3010, 2.11 of this Developmental Specification.

2.05 CASING END SEAL

A. Manufactured synthetic rubber casing end seal with a minimum 1/8 inch (3 mm) thickness and stainless steel bands and fasteners.

B. PCC meeting the requirements of Article 2403 of the Standard Specifications. Do not use PCC casing end seals with flexible pipes.

PART 3 - EXECUTION

3.01 PREPARATION

A. Verify suitability of excavated materials for reuse as backfill.

B. Locate, mark, and protect existing utilities and facilities in the work area.

C. Provide access to utility service locations, such as valves, utility accesses, and utility poles.

D. Identify owners of utilities on or near the site, and notify them of operations to occur.

E. Protect existing facilities and landscaping features or replace as shown on the plans.

F. Protect bench marks, control points, and land survey monuments or replace at Contractor's expense.

G. Select a method of installation that: (1) is appropriate for the soil conditions anticipated; (2) allows the pipe to be installed to the desired line and grade within the specified tolerances; and (3) prevents heaving or settlement of the ground surface or damage to nearby facilities.

3.02 EXCAVATION

A. Notify the Engineer prior to the start of tunneling activities.

B. Remove and stockpile the top 8 inches (200 mm) of topsoil for subsequent reuse. Do not mix topsoil with other excavated materials.

C. Place excavated material away from trench. Grade spoil piles to drain. Do not allow spoil piles to obstruct drainage.

D. Remove rock, rubbish, debris, and unsuitable materials.

E. Excavate the minimum size pits necessary to safely and properly perform the work.

3.03 SHEETING, SHORING, AND BRACING (See Section 3010, 3.04 of this Developmental Specification)

Provide and install sheeting, shoring, and bracing or trench boxes as required to safely perform work, protect nearby structures, and work under construction.

3.04 DEWATERING

See Section 3010, 3.05 of this Developmental Specification.

3.05 TRENCHLESS INSTALLATION

A. General:

1. Install pipes by boring, jacking, or tunneling only where required by the plans.

2. Place bedding and backfill of the carrier pipe beyond the end of the casing pipe, in tunneling pits, and in casing pipes installed by open-cut trenching according to Section 3010 of this Developmental Specification.

3. Install pipe at line and grade. Comply with the following:

- **a.** Line and grade permit the carrier pipe to be installed at its true starting elevation and grade within a maximum alignment deviation of the pipe centerline as specified in the contract documents.
- **b.** When no deviation tolerances are specified in the contract documents, the following maximums apply:

  1) **Gravity Pipe:**
  Horizontally: ±1.0 foot per 100 feet (±300 mm per 30 m);
  Vertically: ±0.2 foot up to 100 feet (±60 mm up to 30 m); an additional ±0.1 foot (±30 mm) per 100 feet (30 m) thereafter. Do not allow backfill in the pipe.
  2) **Pressurized Pipe:**
  Horizontally: ±2.0 foot (±600 mm)
  Vertically: ±1.0 foot (±300 mm). Maintain minimum depth specified by the local jurisdiction.

- **c.** Greater deviation or interference with other identified facilities may be cause for rejection.

4. Provide additional fittings, utility accesses, or appurtenances needed to accommodate any horizontal or vertical misalignment, if allowed by the Engineer, at no additional cost to the Contracting Authority.

5. The Contractor will be allowed to correct errors in grade of the casing pipe in order to achieve design grade of the carrier pipe by pouring an invert in the casing pipe, or by shimming the carrier pipe to a uniform grade, provided adequate clearance remains for proper installation of the carrier pipe.

6. Rejected tunnels shall be replaced at the Contractor's expense. This includes additional fittings, utility access, or appurtenances needed to replace the rejected work.

B. Casing Pipe or Un-cased Carrier Pipe Installation:

1. Install pipe by auger boring, pipe jacking, microtunneling, open-ended pipe ramming, directional drilling (back-reaming required), or utility tunneling.

2. Do not use methods that displace excess soil, rather than removing it, such as impact moling, push rod, or closed end pipe ramming unless specified in the contract documents, or permitted by the Engineer.

3. Water jetting will not be allowed.

4. Use a jacking collar, timbers, and other means as necessary to protect the driven end of the pipe from damage.

5. Fully support borehole at all times to prevent collapse. Insert pipe as earth is removed, or support bore with drilling fluid.

6. Fully weld all casing pipe joints or use an interlocking connection system according to Section 3020, 2.02 of this Developmental Specification.

7. Fill annular space between the inside of the bore hole and the outside of the pipe if the space is greater than 1 inch (25 mm). Use flowable mortar, CLSM (See Section 3010 of this Developmental Specification), or 3,000 psi (20.7 MPa) concrete.

C. Carrier Pipe Installation Through Casing:

1. Clean dirt and debris from the casing pipe after installation.

2. Install casing spacers to pipe sections as necessary to support pipe barrel according to the pipe manufacturer's recommendation.

- **a.** Space according to the pipe manufacturer's recommendation. As a minimum, place a spacer within 1 foot (900 mm) of each side of the joint and a maximum spacing of 6 feet (1.8 m).
- **b.** Do not allow pipe to be supported by joint bells.
- **c.** Lubricate casing spacers with drilling mud or flax soap. Do not use petroleum-based lubricants or oils.

3. Ensure that thrust loads will not damage carrier pipe joints. Provide thrust collars between joint shoulders of concrete pipe.

4. Provide timbers for sufficient cushioning between the end of the pipe pushed and the jacking equipment to prevent damage to the pipe. Do not allow steel jack face to thrust against unprotected pipe end.

5. Position jacks so the resulting force is applied along the centerline of the pipe, and the force is applied evenly to the entire end of the pipe.

6. Assemble pipe joints in the jacking pit before pushing the carrier pipe into the casing.

7. Close end of casing pipe around the carrier pipe with a casing end seal. Do not use the PCC casing end seals with flexible pipe.

8. Fill the annular space between the carrier and casing pipe, only if required on the plans, with flowable mortar or CLSM per Section 3010, 2.11 of this Developmental Specification.

3.06 FIELD QUALITY CONTROL

Provide compaction testing of backfill material and embankment, if required, as part of the field quality control for the carrier pipe line being constructed. Ensure that at least one compaction test site occurs at each pit.

DIVISION 4 – SEWERS AND DRAINS

SECTION 4010 - SANITARY SEWERS

PART 2 - PRODUCTS

2.01 SANITARY SEWERS (GRAVITY)

A thru F Intentionally Left Blank

G. Ductile Iron Pipe (DIP) 8 inch to 54 inch (200 mm to 1350 mm):

1. Conform to AWWA C 151/ANSI A 21.51.

2. Minimum pressure class: Class 52.

3. Interior linings.

- **a.** Provide interior lining for ductile iron pipe and fittings used for all gravity sewers and drop connections.
- **b.** Use linings specifically designed for sanitary sewer applications, which may include calcium aluminate, polyethylene, ceramic epoxy, and coal tar epoxy. Other lining types may be allowed upon approval of the Engineer.
- **c.** Apply lining to interior of unlined ductile iron pipe and fittings according to the published specifications from manufacturer.
- **d.** Seal all cut ends and repair field damaged areas according to the manufacturer's recommendations.

4. Exterior coating: asphalt.

5. Push on joint: AWWA C111/ANSI A 21.11.

6. Fittings: Mechanical joint AWWA C 110/ANSI A 21.10.

7. Polyethylene encasement:

- **a.** Conform to AWWA C 105/ANSI A 21.5.
- **b.** Minimum thickness: 8 mils (200 µm).
- **c.** Use for all ductile iron pipe and fittings in buried service.

DIVISION 5 - WATER MAIN AND APPURTENANCES

SECTION 5010 - PIPE AND FITTINGS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Pipe.

B. Fittings.

C. Special Fittings.

D. Pipeline Accessories.

1.02 DESCRIPTION OF WORK

Construct water mains and building service pipes.

1.03 SUBMITTALS

A. Manufacturer's instructions for installation for all pipe and fittings utilized.

B. Construction sequencing.

C. Catalog cuts, samples, manufacturer's data, and listing of applicable standards for special, unique, or proposed substitute materials if requested by Engineer.

D. Joint restraint system.

E. Project record documents.

F. Upon request provide material certifications to the Engineer.

1.04 SUBSTITUTIONS

Obtain written approval of the Engineer for all substitutions prior to use.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store materials in a protected environment, on pallets, or lagging.

B. Remove pipe and fittings contaminated with mud and surface water from the site. Do not use in construction unless they are thoroughly cleaned, inspected, and approved by Engineer.

C. Handle all materials so as to avoid damage. Replace damaged materials. Remove damaged materials from the site.

1.06 SCHEDULING AND CONFLICTS

A. Construction Sequence:

1. Attend a preconstruction meeting if required by Engineer.

2. Submit plan for construction sequence prior to commencing construction unless specifically not required by the Engineer.

B. Conflict Avoidance:

1. Expose possible conflicts in advance of construction, such as utility lines and drainage structures. Verify elevations of each and verify clearances for proposed construction.

2. Complete elements of the work that can affect line and grade in advance of other open cut construction unless noted on plans.

3. Notify Engineer of any conflicts discovered or any changes needed to accommodate unknown or changed conditions.

1.07 SPECIAL REQUIREMENTS

Stop work and notify the Engineer immediately if contaminated soils, historical artifacts, or other environmental or historic items are encountered.

1.08 MEASUREMENT FOR PAYMENT

A. Water Main Pipe:

1. Measurement of pipe will be in feet (meters) along the centerline of the pipe, including the length through the fittings, installed according to the plans.

2. For water main installed within casing pipe (Section 3020, 1.08 of this Developmental Specification) measurement will be the length in feet (meters) of casing and carrier pipe, along the centerline of the casing. Payment will be made for both carrier and casing pipe as a single unit price for the appropriate method of installation.

3. Payment will be made at the contract unit price for each type and size of pipe properly installed.

4. Trench and backfill and trenchless construction, tracer system, testing, disinfection, and polyethylene wrap for ductile iron pipe and fittings will be considered incidental to this item.

B. Water Service Stubs and Stop Box:

1. Each water service and stub and stop box, installed as a single item, from the water main to the stop box will be counted.

2. For each installation, payment will be made at the contract unit price.

3. Corporation, service pipe, stop, and box will be considered incidental to this item.

C. Fittings:

1. Fittings will be counted by type and size.

2. One of the following methods for payment will be specified:

a. Payment will be made at the unit price for each type and size of fitting properly installed.
b. Payment will be made based on a conversion to a weight basis according to the standard fitting weights as published in AWWA C 153 for ductile iron compact fittings.

3. Restrained joints and thrust blocks will be considered incidental to fittings.

PART 2 - PRODUCTS

2.01 WATER MAIN PIPE

A. Polyvinyl Chloride (PVC) Pipe:

1. Conform to ANSI/AWWA C900 or C905 with gray iron pipe equivalent outside diameters.

2. Minimum Wall Thicknesses:

a. 4 inch (100 mm) through 24 inch (600 mm) sizes: DR 18.
b. Sizes over 24 inch (600 mm): Refer to the contract documents.

3. Markings on Pipe:

a. Name of manufacturer.
b. Size and class.
c. Spigot insertion depth gauge.
d. National Sanitation Foundation (NSF) seal.

B. Ductile Iron Pipe:

1. Minimum Thickness Class:

a. 4 inch (100 mm) through 24 inch (600 mm) sizes: Class 52 per AWWA C151.
b. Sizes over 24 inches (600 mm): as shown in the contract documents.

2. Cement-mortar lined: per AWWA C104 with asphalt seal coat.

3. External coating: asphalt per AWWA C 151.

4. Joint Type: Use push-on type, except as otherwise required in the contract documents.

a. Push-on: per AWWA C111.
b. Mechanical: per AWWA C111.
c. Restrained, buried: Pipe manufacturer's standard field removable system.
d. Restrained, in structures: Restraining gland, flanged or grooved.
e. Flanged: AWWA C111.
f. Grooved: AWWA C606.
g. Gaskets: Per AWWA C111.

5. Markings on Pipe:

a. Name of manufacturer.
b. Size and class.
c. Spigot insertion depth gauge.

C. Prestressed Concrete Cylinder Pipe:

1. Designed and manufactured according to AWWA C301 and C304 to meet the following minimum conditions.

a. Internal pressure: 150 psi (1035 kPa).
b. Earth loads: actual trench depth, but not less than 6 feet (1.8 m).
c. Live loads: HS 20 vehicle over trench.
d. Surge pressure: allowance 60 psi (415 kPa).
e. Bedding: Type R2, AWWA C304, Figure 9.
f. Safety factor: 2.5.

2. Joints:

a. Steel joint rings with rubber gaskets per AWWA C301.
b. External joint filler: cement mortar with diapers.

c. Outlets: flanged, per ANSI B16.1, Class 125, with 1/8 inch (3 mm) minimum thickness rubber gaskets.

3. Manufactured according to AWWA C304.

2.02 BOLTS FOR WATER MAIN PIPE AND FITTINGS

Use corrosion resistant bolts.

A. Tee-bolts and Hexagonal Nuts for Mechanical Joints:

1. High strength, low alloy steel manufactured according to AWWA C 111.

2. Provide ceramic filled, baked on, fluorocarbon resin coating for bolts and nuts.

3. Include factory applied lubricant that produces low coefficient of friction for ease of installation.

B. Other Bolts and Nuts:

1. Stainless steel.

2. Ductile iron.

3. Zinc, zinc chromate, or cadmium plated.

2.03 FITTINGS

A. For Polyvinyl Chloride (PVC) Pipe:

1. AWWA C110 or AWWA C 153.

2. Joint Type:
- **a.** Use mechanical joint conforming to AWWA C 111 for pipe sizes 16 inches (400 mm) and less.
- **b.** For pipe sizes greater than 16 inches (400 mm), use restrained mechanical joint system. Provide follower gland using breakaway torque bolts to engage thrust restraint.
  - **1)** Minimum pressure rating of 250 psi (1725 kPa).
  - **2)** Suitable for buried service.
  - **3)** Provide stainless steel set screws on follower gland.
  - **4)** Joint restraint system to be field installable, field removable, and re-installable.

3. Cement mortar lined per AWWA C104 with asphalt coating.

4. Wall Thickness: AWWA C 153

5. Gaskets: Per AWWA C111

B. Fittings for Prestressed Concrete Cylinder Pipe: As required for prestressed concrete cylinder pipe.

C. Flange Adapter:

1. Body: Ductile iron conforming to the requirements of ASTM A 536.

2. End Rings (Follower Rings): Ductile iron conforming to the requirements of ASTM A 536.

3. Gaskets: New rubber compounded for water service and resistant to permanent set.

4. Bolts and Nuts: High strength, low alloy corrosion resistant steel or carbon steel bolts conforming to the requirements of ASTM A 307.

D. Pipe Coupling:

1. Center Sleeve (Center Ring): Steel pipe or tubing conforming to the requirements of ASTM A 53 or ASTM A 512, or formed carbon steel with a minimum yield of 30,000 psi (207 MPa).

2. End Ring (Follower Ring): ductile iron conforming to the requirements of ASTM A 536, or steel meeting or exceeding the requirements of ASTM A 576, grade 1010-1020.

3. Gaskets: New rubber compounded for water service and resistant to permanent set.

4. Bolts and nuts: High strength, low alloy corrosion resistant steel.

2.04 CONCRETE THRUST BLOCKS

A. Use concrete with compressive strength of 4000 psi (27.6 MPa)

B. Refer to the plans for dimensions and installation of thrust blocks. See Figure 5010.1 on the plans.

C. Use for all pipe sizes 16 inches (400 mm) in diameter or smaller when specified.

2.05 PIPELINE ACCESSORIES

A. Polyethylene Wrap:

1. Use on all ductile iron pipe and fittings in buried service.

2. Conform to AWWA C105.

3. Minimum thickness: 8 mil (200 µm).

B. Tracer System: See Figure 5010.3 on the plans.

1. Tracer Wire: #12 AWG solid single copper conductor.

a. Insulation material: Linear low-density polyethylene (LLDPE) installation suitable for direct burial applications.
b. Insulation thickness: 0.045 inches (1 mm), minimum.

2. Ground Rod: 3/8 inch (10 mm) diameter, 60 inch (1.5 m) long steel rod uniformly coated with metallically bonded electrolytic copper.

3. Ground-rod Clamp: High-strength, corrosion-resistant copper alloy.

4. Splice Kit: Inline resin splice kit with split bolt for 1 kV and 5 kV. Insulates and seals single conductor and unshielded cable splices for direct bury and submersible applications.

5. Tracer Wire Test Station: Refer to the contract documents for requirements.

2.06 SPECIAL GASKETS

A. For soils contaminated with gasoline, use neoprene or nitrile gaskets.

B. For soils contaminated with volatile organic compounds, use nitrile or fluorocarbon gaskets.

C. For other soil contaminants, refer to the Engineer for the required gasket.

2.07 WATER SERVICE PIPE AND APPURTENANCES

A. Controlling standards: Local plumbing and fire codes.

B. Materials (as allowed by the Engineer or specified in the contract documents):

1. Copper Pipe:

a. Conform to ASTM B 88.
b. Wall thickness: Type K.

2. Ductile Iron Pipe: As specified in Section 5010 2.01 of this Developmental Specification. Polyethylene wrap is required.

3. PVC Pipe: ASTM 1785, SDR 21, Schedule 80, Type S joints.

4. Brass Pipe: Red, seamless, per ASTM B 43.

5. Polyethylene Pipe: Class 200, per AWWA C901.

C. Corporations and Stop Boxes: Refer to the Jurisdiction for requirements.

PART 3 - EXECUTION

3.01 GENERAL PIPE INSTALLATION

A. Install only approved materials.

B. Protect pipe joints and valves from damage while handling and storing.

C. Do not use deformed, defective, gouged, or otherwise damaged pipe or fittings.

D. Excavate trench and place backfill according to Section 3010 of this Developmental Specification. If trenchless methods are used, install pipe according to Section 3020 of this Developmental Specification. Keep trench free of water.

E. Clean pipe interior prior to placement in the trench.

F. Provide uniform bearing along the full length of the pipe barrel. Provide bell holes.

G. Install pipe with fittings and valves to the lines and grades shown in the plans.

H. Clean joint surfaces thoroughly and apply lubricant approved for use with potable water.

I. Push the pipe joint to the indication line on the spigot end of the pipe before making any joint deflections.

J. Limit joint deflections to one degree less than pipe manufacturer's recommended maximum limit.

K. Tighten bolts in a joint evenly around the pipe.

L. Install concrete thrust blocks or joint restraints on pipes 16 inches (400 mm) in diameter or less (See Figure 5010.1 on the plans). For pipes larger than 16 inches (400 mm), install restrained joints.

M. Install remaining pipe bedding according to the plans using materials conforming to these specifications.

N. Keep exposed pipe ends closed with rodent-proof end gates at all times when pipe installation is not occurring.

O. Close ends of installed pipe with watertight plugs during nights and non-working days.

P. Do not allow any water from the new pipeline to enter existing distribution system piping.

3.02 ADDITIONAL REQUIREMENTS FOR DUCTILE IRON PIPE INSTALLATION

A. Install according to AWWA C600.

B. Cut the pipe perpendicular to the pipe barrel. Do not damage the cement lining. Bevel cut the ends for push-on joints according to AWWA C600.

C. Encase all pipe, valves, and fittings with polyethylene wrap. Refer to the plans.

3.03 ADDITIONAL REQUIREMENTS FOR PVC PIPE INSTALLATION

A. Cut the pipe perpendicular to the pipe barrel.

B. Bevel cut the end of the pipe barrel per the pipe manufacturer's recommendation.

C. Refer also to AWWA C605.

3.04 ADDITIONAL REQUIREMENTS FOR PRESTRESSED CONCRETE CYLINDER PIPE INSTALLATION

A. Install according to AWWA Manual M9.

B. Relieve gasket tension by inserting a small rod between the gasket and the gasket groove and running the tool around the pipe twice.

C. Check gasket position using a metal feeler gauge after the joint has been assembled.

D. Complete joint exterior grouting after pipe has been properly positioned using non-shrink grout.

3.05 POLYETHYLENE ENCASEMENT INSTALLATION

A. Apply to all buried ductile iron pipe, fittings, fire hydrants, and appurtenances.

B. Install according to AWWA C105.

C. The polyethylene encasement is to prevent contact between the pipe and the bedding material, but need not be airtight or watertight.

D. Secure and repair encasement material using polyethylene tape, or replace as necessary.

3.06 TRACER SYSTEM INSTALLATION

A. Install with all buried water main piping. See Figure 5010.3 on the plans for tracer wire installation.

B. Begin and terminate the system at all connections to existing mains.

C. Install wire continuously along the lower quadrant of pipe. Do not install wire along the bottom of pipe. Attach wire to pipe at the midpoint of each pipe length; use 2 inch (50 mm) wide 10 mil (250 µm) thickness polyethylene pressure sensitive tape.

D. Install splices only as authorized by the Engineer. Allow the Engineer to inspect all below grade splices of tracer wire prior to backfill.

E. Install ground rods adjacent to connections to existing piping and at locations shown on plans.

F. Bring two wires to the surface at each hydrant location and terminate with a tracer wire station (See Figure 5010.3 on the plans).

G. Final inspection of the tracer system will be conducted at the completion of the project and prior to acceptance by the Contracting Authority. Verify the electrical continuity of the system. Repair any discontinuities.

3.07 CONFLICTS

A. Provide temporary support for existing gas, telephone, power, or other utilities or services that cross trench.

B. Compact backfill under existing utility crossing as specified in Section 3010 of this Developmental Specification or construct utility line supports where indicated on plans.

C. Separate water mains from gravity sewers by a horizontal distance of at least 10 feet (3 m) unless:

1. The bottom of the water main is at least 18 inches (0.5 m) above top of sewer.

2. The sewer is placed in a separate trench or in the same trench on a bench of undisturbed earth with at least 3 feet (1 m) separation from the water main.

D. Use ductile iron pipe as specified in Section 4010, 2.01 of this Developmental Specification for gravity sewers with less than 10 feet (3 m) horizontal distance and the bottom of the water main is less than 18 inches (0.5 m) above the top of the sewer. Maintain at least 2 feet (0.6 m) of linear separation.

E. Where the water main crosses under the gravity sewer or where the bottom of the water main

is less than 18 inches (0.5 m) above the top of the sewer:

1. If physical conditions prohibit the separation, the water main may not be placed closer than 6 inches (150 mm) above a sewer or 18 inches (0.5 m) below a sewer. Use the maximum feasible separation distance in all cases.

2. Use a full length of ductile iron pipe as specified in Section 4010, 2.01 of this Developmental Specification for gravity sewer centered on water main.

3. The water main and sewer must be adequately supported and have watertight joints.

4. Place backfill the trench with low permeability soil for a 10 foot (3 m) length centered on crossing.

F. Separate water mains from sanitary sewer force mains by horizontal distance of at least 10 feet (3 m) unless the force main is constructed of water main materials meeting minimum pressure rating of 200 psi (1380 kPa) and is installed at least 4 feet (1.2 m) horizontally from the water main.

3.08 TRANSITIONS IN PIPING SYSTEMS

Where the specified material of piping system entering or exiting a structure changes, make the change at the outside of the structure wall, beyond any wall pipe or wall fitting required, unless otherwise shown or specified.

3.09 STRUCTURE PENETRATIONS

A. Wall Pipes:

1. Install where pipes penetrate and terminate at a wall or floor surface of a concrete structure, or where the pipe protrudes through the concrete wall or floor and the protrusion is otherwise unsupported.

2. Provide a waterstop flange near the center of the embedment length. The waterstop is to be cast integrally with the wall pipe, or fully welded to it around the pipe circumference.

B. Wall Sleeves:

1. Install where a pipe passes through a structure wall.

2. Sleeves in concrete walls are to be supplied with a waterstop collar, fully welded, and cast in place in the concrete.

3.10 WATER SERVICE STUB

A. Install water service pipe, corporations, stops, and stop boxes according to local Jurisdiction requirements.

B. Install 1 inch (25 mm) and smaller corporation valves tapped at 45 degrees above horizontal at a minimum distance of 18 inches (0.5 m) from pipe bell, or other corporation. Install 1 1/2 inch (38 mm) and 2 inch (50 mm) corporation valves tapped horizontal a minimum distance of 24 inches (600 mm) from pipe bell or other corporation.

C. Construct trench drain and backfill according to Section 3010 of this Developmental Specification.

3.11 TESTING AND DISINFECTION

Test and disinfect according to Section 5030 of this Developmental Specification.

SECTION 5020. VALVES, HYDRANTS, AND APPURTENANCES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Butterfly valves.

B. Gate valves.

C. Tapping valve assemblies.

D. Fire hydrant assemblies.

E. Flushing Devices (blowoffs).

F. Valve boxes.

1.02 DESCRIPTION OF WORK

Install valves, hydrants, and appurtenances for water mains.

1.03 SUBMITTALS

Refer to Division 11 of the Standard Specifications.

1.04 SUBSTITUTIONS

Refer to Division 11 of the Standard Specifications.

1.05 DELIVERY, STORAGE, AND HANDLING

Refer to Division 11 of the Standard Specifications and the following:

Remove valve, fire hydrants, and appurtenances contaminated with mud and surface water from the site. Do not use these unless thoroughly cleaned, inspected and approved by the Contracting Authority.

1.06 SCHEDULING AND CONFLICTS

Refer to Division 11 of the Standard Specifications.

1.07 SPECIAL REQUIREMENTS

Refer to Division 11 of the Standard Specifications.

1.08 MEASUREMENT FOR PAYMENT

A. Valve (Butterfly or Gate):

1. Each size and type of valve installed will be counted.

2. Payment will be at the contract unit price for each size and type of valve properly installed.

3. Valve includes all components attached to the valve or required for its complete installation, including, but not limited to, underground or above ground operator, square valve operating nut, valve box and cover, valve box extension, valve stem extension, and hand wheels.

B. Tapping Valve Assembly:

1. Each installed tapping valve assembly of each size will be counted.

2. Payment will be at the contract unit price for each tapping valve assembly properly installed.

3. Contract unit price includes tapping sleeve, tapping valve, the tap, valve box and cover, valve box extension, valve stem extension, and all other components needed to complete the installation, and for successful completion of the tap.

C. Fire Hydrant Assembly:

1. Each fire hydrant assembly installed will be counted.

2. Payment will be at the unit price for each fire hydrant assembly properly installed.

3. Fire hydrant assembly includes the fire hydrant, barrel extensions sufficient to achieve proper bury depth of anchoring pipe and height of fire hydrant above finished grade, and components to connect the fire hydrant to the water main, including anchoring pipe, fittings, thrust blocks, pea gravel or porous backfill, and fire hydrant gate valve, except tapping valve assembly if used.

D. Flushing Device (Blowoff):

1. Each installed flushing device of each size will be counted. Each blowoff assembly includes the valve, fittings, and all pipe segments.

2. Payment will be at the contact unit price for each flushing device properly installed.

PART 2 - PRODUCTS

2.01 VALVES

A. General:

1. Same size as pipeline in which it is installed, unless noted otherwise in the plans.

2. Manufacturer's name or initial and working pressure cast on valve body.

3. Direction of Opening: The opening direction is counterclockwise as viewed from the top, unless otherwise specified in the contract documents or as directed by the Jurisdiction. Open

when turned counterclockwise for most situations.

4. Joints:

a. For buried installations, use mechanical joints per AWWA C 111. See Section 5010 of this Developmental Specification for joint nuts and bolts.
b. For Installation within structures, flanged with dimensions and drillings per AWWA C 110 or ANSI B16.1 class 125.

B. Gate Valves:

1. Comply with AWWA C509 (gray iron or ductile iron) or AWWA C515 (ductile iron) and NSF61

2. Stem Seals: Double O-rings permanently lubricated between seals. Lubricant certified for use in potable water.

3. External Bolts and Hex Nuts: Stainless steel per ASTM A 240, Type 304.

C. Butterfly Valves:

1. Comply with AWWA C504 class 150B (gray iron or ductile iron) and NSF 61.

2. Disc: Ductile iron or gray iron with plasma applied nickel chromium edge or stainless steel edge per ASTM A 240, Type 316, and mechanically fixed stainless steel pins.

3. Stem: Stainless stell per ASTM A 240, Type 304, turned, ground, and polished.

4. Seat: Synthetic rubber compound bonded or mechanically retained to the body.

5. External Bolts and Hex Nuts: Stainless steel per ASTM A 240, Type 304.

D. Tapping Valve Assemblies:

1. Tapping Valve: Gate valve conforming to AWWA C509 or AWWA C515.

2. Sleeve:

a. Minimum 14 gauge.
b. Stainless steel per ASTM A 240, Type 304.
c. Working pressure 150 psi (1035 kPa).
d. Must fully surround pipe.
e. Flanged with dimensions and drillings per AWWA C110 or ANSI B16.1 class 125.

3. Minimum Sleeve Length:

Outlet Flange Size, inches (mm)	Minimum Sleeve Length, inches (mm)
4 (100)	15 (375)
6 (150)	15 (375)
8 (200)	20 (500)
10 (250)	25 (625)
12 (300)	25 (625)
Sizes over 12 (300)	As approved by the Engineer

4. Gasket:

a. To completely surround pipe.
b. Minimum thickness 0.125 inch (3 mm).
c. Use nitrile rubber.

5. Outlet Flange:

a. Stainless steel, ASTM A 240, Type 304.
b. ANSI B16.1, 125 pound pattern.

6. Hex Nuts and Bolts: Stainless steel per ASTM A 240, Type 304.

7. Use tapping valve assemblies only where shown on the plans.

2.02 FIRE HYDRANT ASSEMBLY

A. Material: Conform to ANSI/AWWA C502, as modified herein.

B. Manufacturers: As allowed by the Engineer or as specified in the contract documents.

C. Features:

1. Break-away stem coupling and breakaway flange.

2. Inlet nominal size: 6 inch (150 mm) diameter.

3. Inlet connection type: Mechanical Joint.

4. Hose nozzles: two, each 2 1/2 inch (63 mm) in diameter.

5. Direction of Opening: Conterclockwise, unless otherwise specified.

6. The following items will be specified by the Jurisdiction or the contract documents:

a. Operating nut.
b. Pumper nozzle.
c. Nozzle threads.
d. Nominal bury length: Same depth as water main.
e. Main valve nominal opening size.

D. Painting:

1. Shop coating: per AWWA C502.

2. Field coating above grade exterior coating type and color will be selected by the Engineer.

E. External Bolts and Hex Nuts: Stainless steel per ASTM 193, Grade B 8.

F. Gate Valve: See Section 5020, 2.01 of this Developmental Specification.

G. Pipe Fittings: See Section 5010 of this Developmental Specification.

2.03 APPURTENANCES

A. Flushing Device (Blowoff): As specified in the contract documents.

B. Valve Box:

1. Applicability: For all buried valves.

2. Manufacturer: As allowed by the Jurisdiction or specified in the contract documents.

3. Type:

a. In paved areas, use a slide type.
b. In all other areas, use a screw type extension.

4. Material: Gray iron.

5. Cover: Gray iron, labeled "WATER"

6. Wall thickness: 3/16 inch (4.8 mm), minimum.

7. Inside diameter: 5 inches (127 mm), minimum.

8. Length: Adequate to bring top to finish grade, including valve box extensions, if necessary.

9. Factory finish: Asphalt coating.

10. Valve box centering ring: Include in installation.

C. Valve Stem Extension: For all buried valves, provide as necessary to raise 2 inch (50 mm) operating nut to within 3 feet (1 m) of the finish grade. Stem diameter per valve manufacturer's recommendations, but not less than 1 inch (25 mm).

PART 3 - EXECUTION

3.01 GENERAL

A. Install according to the contract documents.

B. Apply polyethylene wrap to all iron pipe, valves, fire hydrants, and fittings.

C. Set tops of valve boxes to finish grade, unless otherwise directed by the Engineer.

D. Check the working order of all valves by opening and closing through entire range. Before opening the valves, check with the Engineer on operating requirements.

E. Test and disinfect all valves, fire hydrants, and appurtenances as components of the completed water main according to Section 5030 of this Developmental Specification.

3.02 FLUSHING DEVICE (BLOWOFF)

Install where shown on the plans and construct as specified in the contract documents.

3.03 FIRE HYDRANT

A. Install according to Figure 5020.1 on the plans.

B. If the fire hydrant valve is positioned adjacent to the water main, attach it to an anchoring tee.

C. If the fire hydrant valve is positioned away from water main, restrain all joints between the valve and water main.

D. Fire Hydrant Depth Setting:

1. Use adjacent finish grade to determine setting depth.

2. Set bottom of breakaway flange between 2 and 5 inches (25 and 125 mm) above finish grade.

3. If finish grade is not to be completed during the current project, consult with the Engineer for proper setting depth.

E. Coordinate installation with tracer wire installation.

F. Orient fire hydrant nozzles as directed by the Engineer.

SECTION 5030. TESTING AND DISINFECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Pressure and leak testing of water system.

B. Disinfection of potable water systems.

1.02 DESCRIPTION OF WORK

A. Test and disinfect water mains, valves, hydrants, and appurtenances.

1.03 SUBMITTALS

Refer to Division 11 of the Standard Specifications.

1.04 SUBSTITUTIONS

Refer to Division 11 of the Standard Specifications.

1.05 DELIVERY, STORAGE, AND HANDLING

Refer to Division 11 of the Standard Specifications.

1.06 SCHEDULING AND CONFLICTS

A. Notify Engineer 2 working days in advance of testing or disinfection operations to coordinate the operations.

B. The Engineer must be in attendance during testing or disinfection.

1.07 SPECIAL REQUIREMENTS

A. Conform to the standards of the Iowa Department of Natural Resources.

1.08 MEASUREMENT FOR PAYMENT

Testing and inspection of water systems will be considered incidental to the construction of pipe and fittings.

PART 2 - PRODUCTS

2.01 DISINFECTION AGENT - CHLORINE

A. Liquid Chlorine, per AWWA B300 and AWWA B301.

B. Sodium Hypochlorite, per AWWA B300.

C. Calcium Hypochlorite, per AWWA B300.

D. All disinfecting agents to be NSF 60 certified. Supply and store in the original container.

PART 3 - EXECUTION

3.01 SEQUENCE OF TESTING AND DISINFECTION

A. Perform operations according to AWWA C651 in the following sequence:

1. Continuous Feed or Slug Method (After Water Main Installation): The sequence of testing and disinfection may be modified with approval of the Engineer.

a. Perform initial flush.

b. Perform disinfection.

c. Flush after disinfection.

d. Perform pressure and leak testing.

2. Tablet Method (Concurrent with Water Main Installation): Use this method only if approved by the Engineer. Modify the procedure for flushing, disinfection, and pressure and leak testing as needed if tablet method is used.

a. Perform disinfection.

b. Flush after disinfection.

c. Perform pressure and leak testing.

B. Successfully complete each operation before continuing to the next operation.

C. The Jurisdiction will provide reasonable quantities of water for flushing and testing.

3.02 INITIAL FLUSHING

A. Flushing:

1. Coordinate flushing with the Jurisdiction.

2. Flush pipe prior to disinfection using potable water.

3. Measure flushing velocity.

4. Obtain a minimum flushing velocity of 2.5 feet (0.76 m) per second in the pipe to be disinfected.

B. Minimum Flushing Rate per AWWA C651, Table 3, based on 40 psi (276 kPa) residual pressure:

Pipe Diameter, inches (mm)	Flow Rate for Flushing, gallons/minute (L/s)	Number of Taps[2]			Number of 2 1/2 inch (63.5 mm) Fire Hydrant Outlets[1]
		1inch (25 mm)	1 1/2 inch (38 mm)	2 inch (50 mm)	
4 (100)	100 (6.3)	**1**	**-**	**-**	**1**
6 (150)	200 (12.6)	**-**	**1**	**-**	**1**
8 (200)	400 (25.2)	**-**	**2**	**1**	**1**
10 (250)	600 (37.9)	**-**	**3**	**2**	**1**
12 (300)	900 (56.8)	**-**	**-**	**2**	**2**
16 (400)	1,600 (100.9)	**-**	**-**	**4**	**2**

[1]With a 40 psi (276 kPa) pressure in the main with the hydrant flowing to atmosphere, a 2 1/2 inch (63.5 mm) fire hydrant outlet will discharge approximately 1000 gallons (3780 L) per minute; and a 4 1/2 inch (115 mm) fire hydrant will discharge approximately 2500 gallons (9464 L) per minute
[2]Number of taps on pipe based on discharge through 5 feet (1.5 m) of galvanized iron pipe with one 90 degree elbow.

C. Property Protection: Protect public and private property from damage during flushing operations.

3.03 DISINFECTION

A. General:

1. Disinfect according to AWWA C651. The tablet method contained in AWWA C651 is not to be used unless approved by the Engineer.

2. Keep piping to be chlorinated isolated from lines in service and from points of use.

3. Coordinate disinfection and testing with the Engineer.

4. Obtain and test water samples, unless otherwise provided by the Engineer.

B. Procedure:

1. Induce flow of potable water through the pipe.

2. Introduce highly chlorinated water to the pipe at a point within 5 pipe diameters of the pipe's connection to an existing potable system, or within 5 pipe diameters of a closed end, if there is no connection to an existing system.

3. Introduce water containing 25 mg/L free chlorine minimum until the entire new pipe contains a minimum of 25 mg/L free chlorine.

4. Retain chlorinated water in pipe for at least 24 hours and not more than 48 hours.

3.04 FINAL FLUSHING

A. Flush pipe using potable water until chlorine residual equals that of the existing potable water system.

B. Dispose of chlorinated water, which is flushed from the new piping, to prevent damage to the environment. Dechlorinate highly chlorinated water from testing before releasing into the ground or sewers. Obtain Jurisdiction approval prior to flushing activities.

1. Check with the local sewer department for the conditions of disposal to the sanitary sewer.

2. Chlorine residual of water being disposed will be neutralized by treating with one of the chemicals listed in the following table:

Amounts of Chemicals Required to Neutralize Various Residual Chlorine Concentrations in 100,000 gallons (378,500 L) of water

Residual Chlorine Concentration	Sulfur Dioxide (SO_2)	Sodium Bisulfite ($NaHSO_3$)	Sodium Sulfite (Na_2SO_3)	Sodium Thiosulfate ($Na_2S_2O_3 + 5H_2O$)	Ascorbic Acid ($C_6O_8H_6$)
mg/L	pounds (kg)	pounds (kg)	pounds (kg)	pounds (kg)	pounds (kg)
1	0.8 (0.36)	1.2 (0.54)	1.4 (0.64)	1.2 (0.54)	2.1 (0.95)
2	1.7 (0.77)	2.5 (1.13)	2.9 (1.32)	2.4 (1.09)	4.2 (1.91)
10	8.3 (3.76)	12.5 (5.67)	14.6 (6.62)	12.0 (5.44)	20.9 (9.48)
50	41.7 (18.91)	62.6 (28.39)	73.0 (33.11)	60.0 (27.22)	104 (47.17)

3.05 PRESSURE AND LEAK TESTING

A. Remove any debris from within pipe. Clean and swab out pipe if required.

B. Secure unrestrained pipe ends against uncontrolled movement.

C. Isolate new piping from the existing water system.

D. Fill and flush all new piping with potable water. Ensure all trapped air is removed.

E. Pressurize the new pipe to the test pressure at the highest point in the isolated system. Do not pressurize to more than 5 psi (34 kPa) over the test pressure at the highest point in the

isolated system.

F. Test and monitor the completed piping system at 1 1/2 times the system working pressure or 150 psi (1035 kPa), whichever is greater, for 2 continuous hours.

G. If at any time during the test the pressure drops to 5 psi (34 kPa) below the test pressure, repressurize the pipe by pumping in potable water in sufficient quantity to bring the pressure back to the original test pressure.

H. Accurately measure the amount of water required to repressurize the system to the test pressure.

I. Maximum allowable leakage rate per AWWA C600:

English Units

$$L = \frac{(N)(D)(P)^{1/2}}{7400}$$

Where:
L = leakage allowable, in gallons per hour.
N = number of pipe joints in pipe test section.
D = pipe diameter, in inches.
P = average test pressure, psig.

Metric Units

$$L = \frac{(N)(D)(P)^{1/2}}{130{,}400}$$

Where:
L_m = leakage allowable, in liters per hour.
N = number of pipe joints in pipe test section.
D = pipe diameter, in millimeters.
P = average test pressure, kPa.

The following table assumes an average test pressure of 150 psi (1035 kPa), 18 foot (5.5 m) pipe lengths, and no fittings:

Pipe Diameter		Maximum Allowable Leakage Rate	
inches	mm	gallons per hour per 1,000 feet of pipe	liters per hour per 300 meters of pipe
4	100	0.37	1.32
6	150	0.55	1.99
8	200	0.74	2.65
10	250	0.92	3.31
12	300	1.10	3.98
14	350	1.29	4.64
16	400	1.47	5.30
18	450	1.66	5.97
20	500	1.84	6.63
24	600	2.21	7.96
30	750	2.76	9.95
36	900	3.31	11.94

J. If the average measured leakage per hour exceeds the maximum allowable leakage rate, repair and retest the water main.

K. If the measured pressure loss does not exceed 5 psi (34 kPa) the test will be considered acceptable.

L. Repair all visible leaks regardless of the amount of leakage.

3.06 BACTERIAL SAMPLING

Test water mains according to AWWA C651. If the initial disinfection procedure fails to produce satisfactory bacteriological results or if other water quality is affected, repeat the disinfection procedure.

3.07 PUTTING WATER MAIN IN SERVICE

Put the completed water system in service only after obtaining the Engineer’s permission.