Section 300

High Density Polyethylene (HDPE) Pipe for Stormwater

300.1. General

300.1.1 Description

A. This section includes all labor, materials, equipment and incidentals required and installation of high-density polyethylene (HDPE) pipe and fittings, eighteen (18) inch diameter to forty-eight (48) inch diameter to be used as storm sewers, for areas as shown on the drawings and as specified herein.

300.1.2 Related Sections

A. Section XXX – Stormwater Utilities

300.1.3 Quality Control

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M252 - Standard Specification for Corrugated Polyethylene Drainage Tubing.
2. AASHTO M294 - Standard Specification for Corrugated Polyethylene Pipe.
3. AASHTO, Section 18-Soil Thermoplastic Pipe Interaction Systems.

B. American Society for Testing and Materials (ASTM):

1. ASTM D1056 - Specification for Flexible Cellular Materials - Sponge and Expanded Rubber.
2. ASTM D1248 - Specification for Polyethylene Plastics Molding and Extrusion Materials
3. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
4. ASTM D3212 - Standard Specifications for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
5. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Material.
6. ASTM F477-Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

7. ASTM F667-Standard Specification for Large Diameter Corrugated Polyethylene Tubing and Fittings.

C. Where reference is made to one of the above standards, the latest revision shall apply.

300.1.4 Submittals

A. Submit to the ENGINEER completely detailed working drawings and schedules of all HDPE pipe and fittings required.

B. Prior to each shipment of pipe, submit certified test reports that the pipe was manufactured and tested in accordance with the ASTM and AASHTO Standards specified herein.

C. Submit to ENGINEER shop drawings showing pipe layout, joint, method of manufacture and installation of pipe, specials and fittings and a schedule of pipe lengths (including length of individual pipes by diameter) for the entire project.

D. Complete specifications and data covering the materials to be furnished and detailed drawings covering the installation shall be submitted.

300.1.5 Quality Assurance

A. Manufacturer:

1. Experienced in the design, manufacture, and commercial supplying of the specific material for a minimum period of five (5) years.

2. Experienced in the design, manufacture, and commercial supplying of the specific size of pipe for a period of one (1) year.

3. Certify to above minimum experience requirements.

B. All HDPE pipe and fittings shall be from a single manufacturer, all HDPE pipe to be installed may be inspected at the factory for compliance with these Specifications by an independent testing laboratory provided by the CITY. The CONTRACTOR shall require the manufacturer's cooperation in these inspections. The cost of these plant inspections of all pipe approved, plus the cost of inspection of a reasonable amount of disapproved pipe, will be borne by the CITY.

C. Inspection of the pipe shall also be made by the ENGINEER/CITY after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the Specification requirements, even though pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall immediately be removed from the job.

300.2. Products

300.2.1 Pipe and Fittings

A. All pipe and fittings shall be free from all defects, including indentations, delaminations, cracks, bubbles, pinholes, inclusions or occlusions, which, due to their nature, degree, or extent, detrimentally affect the strength and serviceability of the pipe. Any pipe or fittings with such defects which, in the judgment of the engineer or CITY, will affect the strength and serviceability, shall be repaired or rejected.

B. HDPE pipe and fittings shall have a smooth interior and corrugated exterior. Eighteen inch through forty-eight inch (18”-48”) pipe shall meet the requirements of AASHTO M294 Type S. The pipe shall have a full circular cross-section with an annular corrugations. Pipe shall be produced to constant internal diameters.

C. Pipe and Fittings shall be made of high density, high molecular weight polyethylene material meeting the requirements of cell classification 324420C or higher in accordance with ASTM D3350. Clean rework material generated by the manufacturer's own production may be used so long as the pipe or fittings produced meet all the requirements of this specification.

D. Each pipe or fitting shall have plainly marked on the interior of the pipe wall the pipe class and size, date of manufacture, manufacturer's name or trademark, and deflection angle for bends.

300.2.2 Joints:

A. Water-tight joints shall be accomplished by rubber gasket, in accordance with ASTM D3212.

B. Gaskets shall be closed-cell synthetic, expanded rubber meeting the requirements of ASTM D1056, Grade 2A2 or made of polyisoprene meeting ASTM F477. Gaskets shall be installed on the connection by the pipe manufacturer.

C. Lubricant shall have no detrimental effect on the gasket of on the pipe.

D. Integral bell and spigot gasketed joints shall be designed so that when assembled, the elastomeric gasket, contained in a machined groove on the pipe spigot, is compressed radially in the pipe bell to form a positive seal. The joint shall be designed to avoid displacement of the gasket when installed in accordance with the manufacturer's recommendations.

300.2.3 Fittings:

A. Elbows and fittings shall be mitered from pipe sections welded together on the interior and exterior at all junction.

B. The pipe sections forming the miters shall be cut to fit with no gap.

C. Tolerances on the angle of all elbows shall be plus or minus one degree (±1°).

D. The standard turning radius of elbows shall be one and one-half (1 ½) times the inside diameter. Special turning radii shall be used for special applications.

E. Elbows shall conform to the following requirements:

Angle of Elbow (degrees)	Number of Miters
0 to 45	1
45 to 90	2

F. Elbows shall be designed to prevent joint rupture resulting from dynamic forces or application of a test pressure of twenty-five (25) psi.

300.3. Execution

300.3.1 Installation:

A. Pipe Installation: See Section XXX - Stormwater Utilities.

300.3.2 Testing and Cleaning:

A. Pipe testing and cleaning shall be as specified in Section XXX - Stormwater Utilities.

END OF SECTION

Section 301
Rip Rap

301.1. General

301.1.1 Description

A. The work of this section shall include excavation, grading, and installation of all riprap, bedding, boulders, grouted boulders, stacked grouted boulders, and grouted rock retaining walls. The materials to be used and the construction of such structures shall be as specified herein.

301.1.2 Related Sections

A. Sections 100-110 for general specifications.

301.1.3 References

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):
    a. T85, Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate.
    b. T96, Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
    c. T103, Standard Method of Test for Soundness of Aggregates by Freezing and Thawing.
    d. T104, Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
    e. T248, Reducing Field Samples of Aggregate Test Size.
2. ASTM International (ASTM): D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3 (600 kN-m/m3).

301.1.4 Submittals

A. The Contractor shall cooperate with the Engineer of Record in obtaining and providing samples of all specified materials if requested to do so by the Town.

B. The Contractor shall submit certified laboratory test certificates for all items required in this section.

301.2. Materials

301.2.1 Riprap

A. Riprap used shall be the type designated on the Construction Drawings and shall conform to the following:

Riprap Design	% Smaller than Given Size by Weight	Intermediate Rock Dimension (inches)	Mean Particle Size d_{50} (inches)
TYPE VL	70-100	12	6
	50-70	9	
	35-50	6	
	2-10	2	
TYPE L	70-100	15	9
	50-70	12	
	35-50	9	
	2-10	3	
TYPE M	70-100	21	12
	50-70	18	
	35-50	12	
	2-10	4	
TYPE H	70-100	30	18
	50-70	24	
	35-50	18	
	2-10	6	
TYPE VH	70-100	41	24
	50-70	33	
	35-50	24	
	2-10	9	

B. The riprap designation and total thickness of riprap shall be as shown on the Construction Drawings. The maximum stone size shall not be larger than the thickness of the riprap.

C. Neither width nor thickness of a single stone of riprap shall be less than one-third (1/3) of its length.

D. The specific gravity of the riprap shall be two and one-half (2.5) or greater.

E. Broken concrete or asphalt rubble shall not be acceptable for use in the work.

F. Rounded riprap (river rock) is not acceptable unless specifically designated on the Construction Drawings.

G. Riprap specific gravity shall be according to the bulk-saturated, surface-dry basis, in accordance with AASHTO T85.

H. The bulk density for the riprap shall be 1.3 ton/cy or greater.

I. The riprap shall have a percentage loss of not more than forty percent (40%) after five hundred (500) revolutions when tested in accordance with AASHTO T96.

J. The riprap shall have a percentage loss of not more than ten percent (10%) after five (5) cycles when tested in accordance with AASHTO T104 for ledge rock using sodium sulfate.

K. The riprap shall have a percentage loss of not more than ten percent (10%) after twelve (12) cycles of freezing and thawing when tested in accordance with AASHTO T103 for ledge rock, Procedure A.

L. Rock shall be free of calcite intrusions.

301.2.2 Gradation:

A. Each load of riprap shall be reasonably well graded from the smallest to the largest size specified.

B. Stones smaller than the two to ten percent (2 to 10%) size will not be permitted in an amount exceeding ten percent (10%) by weight of each load.

C. Control of gradation shall be by visual inspection. In the event Contractor or Engineer of Record determines the riprap to be unacceptable, Engineer of Record shall pick two (2) random truckloads to be dumped and checked for gradation.

D. Mechanical equipment and labor needed to assist in checking gradation shall be provided by the Contractor at no additional cost.

301.2.3 Riprap Color:

A. The color of the riprap shall be gray with gray/blue hues or other acceptable colors approved by the Engineer of Record and verified to be consistent with the approved Construction Improvement Drawings prior to delivery to the project site.

B. Color shall be consistent on the entire project and shall match the color of rock to be used for all other portions of the work.

301.2.4 Grout: Concrete for the grout shall be an approved batch meeting the following requirements:

A. All concrete shall develop 4,000 psi compressive strength within 28 days.

B. The cement shall be Type V.

C. The stone aggregate shall have a maximum diameter of ½ inch.

D. The slump shall be within a range of 3 inches to 6 inches.

E. Use of a stiffer mix or other measures as approved by the Engineer of Record for steeper slopes or for vertical joints.

F. The water/cement ratio shall not exceed 0.48.

G. Add 1.5 pounds per cubic yard of synthetic fiber reinforcement per manufacturer's instructions.

H. The Contractor shall submit a mix design in writing to the Engineer for approval prior to the placement of any grout.

I. The grout shall contain both an air entraining admixture and water reducing agent. The job site air content shall be 6 ½% +/- 1 ½% by volume. A water reducing agent such as WRDA-64 or equal shall be used.

301.2.5 Boulders

A. Boulders used shall be the type designated on the Construction Drawings and shall conform to the following:

Boulder Classification	Nominal Size (inches)	Range in Smallest Dimension of Individual Rock Boulders (inches)	Maximum Ration of Largest to Smallest Rock Dimension of Individual Boulders
B18	18	17-20	1.50
B24	24	22-26	1.50
B30	30	28-32	1.50
B36	36	34-38	1.50
B42	42	40-44	1.50
B48	48	45-51	1.50

B. The specific gravity of the boulders shall be two and one-half (2.5) or greater.

C. Boulder specific gravity shall be according to the bulk-saturated, surface-dry basis, in accordance with AASHTO T85.

D. The bulk density for the boulder shall be 1.3 ton/cy or greater.

E. The boulders shall have a percentage loss of not more than forty percent (40%) after five hundred (500) revolutions when tested in accordance with AASHTO T96.

F. The boulders shall have a percentage loss of not more than ten percent (10%) after five (5) cycles when tested in accordance with AASHTO T104 for ledge rock using sodium sulfate.

G. The boulders shall have a percentage loss of not more than ten percent (10%) after twelve (12) cycles of freezing and thawing when tested in accordance with AASHTO T103 for ledge rock, procedure A.

H. Rock shall be free of calcite intrusions.

I. Boulder Color:

1. The color of the boulders shall be gray with gray/blue hues or other acceptable colors as approved by the Town on the approved Construction Improvement Drawings. The Engineer of Record shall verify boulder color prior to delivery to the project site.

2. Color shall be consistent on the entire project and shall match the color of rock to be used for all other portions of the work.

J. Soil Riprap

1. Rock requirements are to comply with riprap as specified in Section 301.5.

2. The soil material shall be native or topsoil and mixed with sixty-five percent (65%) riprap and thirty five percent (35%) soil by volume.

3. Soil riprap shall consist of a uniform mixture of soil and riprap without voids.

K. Bedding

1. Gradation for Granular Bedding:

U.S. Standard Sieve Size	**Percent by Weight Passing Square-Mesh Sieves**	
	Type 1 (CDOT Section 703.01)	**Type II (CDOT Section 703.09, Class A)**
3 inches	-	90-100
1 1/2 inches	-	-
¾ inch	-	20-90
3/8 inch	100	-
No.4	95 – 100	0-20
No. 16	45 – 80	-
No. 50	10 - 30	-
No. 100	2 - 10	-
No. 200	0 - 2	0-3

2. Granular bedding designation and total thickness of bedding shall be as shown on the Construction Drawings.

3. Granular bedding shall meet the same requirements for specific gravity, absorption, abrasion, sodium sulfate soundness, calcite intrusion, and freeze-thaw durability as required for riprap.

a. Broken concrete asphalt pavement or sledge, shall not be acceptable for use in the work. Rounded river rock is not acceptable unless specifically designated on the Construction Drawings.

b. The requirements for the wear test in AASHTO T96 shall not apply.

L. Geotextile Fabric:

1. Geotextile fabric shall be placed directly on excavated slopes, channel beds, etc. prior to the placement of any riprap bedding or riprap.

2. The extent and location of geotextile placement will be shown on the Construction Improvement Drawings.

3. Geotextile fabric shall be Trevira S1135 or approved equal under all rock drop structures and Trevira S1120 or approved equal under all riprap.

M. Feature Boulders:

1. Feature Boulders shall consist of the same material as boulders, differing only by size.

2. Feature Boulders shall meet the same requirements for specific gravity, absorption, abrasion, sodium sulfate soundness, calcite intrusion, and freeze-thaw durability as required for boulders.

3. Feature Boulders shall have a minimum dimension of four (4) feet, or as shown on the Construction Drawings.

301.3. Execution

301.3.1 Preparation:

A. Channel slope, bottom, or other areas that are to be protected with riprap, boulders or soil riprap shall be free of brush, trees, stumps, and other objectionable material and be graded to a smooth compacted surface as shown on the Construction Drawings.

B. Contractor shall excavate areas to receive riprap to the subgrade as shown on the Construction Drawings accounting for granular bedding.

C. Contractor shall excavate areas to receive boulders or soil riprap to the specified depth (bedding material is not required for boulders and soil riprap).

D. Subgrade Materials:

1. The subgrade materials shall be stable.

2. If unsuitable materials are encountered, they shall be removed and replaced as Muck Excavation in accordance with Section 02315, Excavation and Embankment, for subgrade that has been excavated in undisturbed soil.

E. Additional Compaction:

1. Additional compaction shall not be required unless specified by Engineer.

2. When subgrade is built up with embankment material it shall be compacted to ninety five percent (95%) maximum density (ASTM D698).

F. Bedding:

1. After an acceptable subgrade is established, bedding shall be immediately placed and leveled to the specified elevation on the Construction Drawings.

2. Immediately following the placement of the bedding material, the riprap shall be placed.

3. If bedding material is disturbed for any reason, it shall be replaced and graded at Contractor's expense.

G. Contamination:

1. In-place bedding materials shall not be contaminated with soils, debris or vegetation before the riprap is placed.

2. If contaminated, the bedding material shall be removed and replaced by the Contractor, at Contractor's expense.

301.3.2 Placement

A. Riprap

1. Following acceptable placement of granular bedding, riprap placement shall commence as follows:

a. Machine Placed Riprap:

i. Riprap shall be placed on the prepared slope or channel bottom areas in a manner which will produce a reasonably well graded mass of stone with the minimum practicable percentage of voids.

ii. Riprap shall be machine placed, unless otherwise stipulated in the drawings or specifications.

iii. It is the intent of these specifications to produce a fairly compact riprap protection in which all sizes of material are placed in their proper proportions.

iv. Unless otherwise authorized by the Town, the riprap protection shall be placed in conjunction with the construction of embankment or channel bottom with only sufficient delay in construction of the riprap protection, as may be necessary, to allow for proper construction of the portion of the embankment and channel bottom which is to be protected.

B. Slope Placement:

1. When riprap is placed on slope, placement shall commence at the bottom of the slope working up the slope.
2. The entire mass of riprap shall be placed on either channel slope or bottom so as to be in conformance with the required gradation mixture and to line, grade, and thickness shown on the drawings.
3. Riprap shall be placed to full course thickness at one operation and in such a manner as to avoid displacing the underlying bedding material. Placing of riprap in layers, or by dumping into chutes, or by similar methods shall not be permitted.
4. All material used for riprap protection for channel slope or bottom shall be placed and distributed such that there shall be no large accumulations of either the larger or smaller sizes of stone. Some hand placement may be required to achieve this distribution.
5. The basic procedure shall result in larger materials flush to the top surface with faces and shapes arranged to minimize voids, and smaller material below and between larger materials.
6. Surface grade shall be a plane or as indicated, but projections above or depressions under the finished design grade by more than ten percent (10%) of the rock layer thickness shall not be allowed.
7. Smaller rock shall be securely locked between the larger stone. It is essential that the material between the larger stones not be loose or easily displaced by flow or by vandalism.
8. The stone shall be consolidated by the bucket of the backhoe or other means that will cause interlocking of the material.
9. All rock is to be placed in a dewatered condition beginning at the toe of the slope or other lowest point.
10. Contractor shall maintain the riprap protection until accepted. Any material displaced for any reason shall be replaced to the lines and

grades shown on the Construction Drawings at no additional cost to owner. If the bedding materials are removed or disturbed, such material shall be replaced prior to replacing the displaced riprap.

C. Hand Placed Riprap:

1. Hand placed riprap shall be performed during machine placement of riprap and shall conform to all the requirements of Part 2, above.
2. Hand placed riprap shall also be required when the depth of riprap is less than two (2) times the nominal stone size, or when required by the Construction Drawings or Specifications.
3. After the riprap has been placed, hand placing or rearranging of individual stones by mechanical equipment shall be required to the extent necessary to secure a flat uniform surface and the specified depth of riprap, to the lines and grades as shown on the Construction Drawings.

D. Soil Replacement Over Riprap:

1. Where riprap is designated to be buried, place onsite excavated material that is free from trash and organic matter in riprap voids by washing and rodding.
2. Prevent excessive washing of material into stream.
3. When voids are filled and the surface accepted by Engineer, place a nominal six (6) inches of topsoil over the area, or as designated on the Construction Drawings.
4. Fine grade, seed, and mulch per the Specifications.

E. Boulders:

1. Following excavation and acceptance of subgrade by Engineer Boulder placement shall commence as follows:
2. Boulders shall be placed on the prepared subgrade in a manner which will minimize voids.
3. Voids between boulders exceeding 4" shall be chinked.

F. Soil Riprap:

1. Adjacent stockpiles of riprap and soil shall be created and mixing done at the stockpile location, not at the location where soil riprap is to be placed.
2. Mix thirty-five percent (35%) soil by volume with stockpiled riprap, using additional moisture and control procedures that ensure a

homogenous mixture, where the soil fills the inherent voids in the riprap without displacing riprap.

3. With prior approval of Engineer of Record, layering the riprap and soil instead of premixing may be allowed if the native soil is granular.
4. Place a first layer of smaller soil riprap of approximate d50 thickness. Then place the top layer with surface rocks that are largely d50 or greater, filling voids as necessary with smaller planted riprap. Create a smooth plane as described in Paragraph A.
5. The mixture shall be consolidated by large vibratory equipment or backhoe bucket to create a tight, dense interlocking mass.
6. The soil shall be further wetted to encourage void filling with soil.
7. Any large voids shall be filled with rock and small voids filled with soil.
8. Excessively thick zones of soil prone to washing away shall not be created (for example, no thicknesses greater than six (6) inches).
9. For buried soil riprap, the top surface shall be covered with four (4) inches of topsoil such that no rock points are protruding.
10. The final surface shall be thoroughly wetted for good compaction, smoothed and compacted by vibrating equipment; the surface shall then be hand raked to receive planting or seeding.

G. Feature Boulders:

1. Feature Boulders serve an aesthetic function and as such shall be placed and rotated into final position as directed by Engineer of Record in order to achieve the desired result.

H. Grouted Riprap and Grouted Boulders:

1. The subgrade to receive each boulder shall be excavated and any unstable material shall be removed. Approved material shall be placed and compacted in a maximum of 4-inch lifts to 95% of Maximum Standard Proctor Density (ASTM D698) to re-establish the subgrade of each boulder.
2. Unstable material shall be removed from the project site and disposed of by the Contractor.
3. Removal and replacement of unstable material shall only be completed at the direction of the Engineer of Record.
4. Backfill behind boulders shall be compacted to 95% Maximum Standard Proctor Density (ASTM D698). Care shall be taken during

compaction to avoid disturbing and/or damaging the integrity of the boulder channel edge.

5. The top of all boulders shall be as indicated on the approved Construction Improvement Drawings. Finished grades and subgrades for boulders will be determined from the height of each boulder used.
6. The boulders shall be carefully picked and arranged so that adjacent rock surfaces match within 2 inches in top elevation and 2 inches along the vertical exposed face or channel side of rock.
7. Boulders shall be placed such that adjacent boulders "touch" each other and voids do not exceed 4 inches. It is the intent of construction to minimize voids and grout placed between boulders.
8. Smaller rocks shall be "chinked in" to fill all voids behind the boulders. Placement shall be approved by the Engineer of Record prior to grouting.
9. Prior to placing the grout, any type of debris, fines, smaller rock or silt shall be removed from around or under the boulders.
10. Dewatering shall be implemented to guarantee that the grout will not be placed in water and for a period of 24 hours after the grout has been placed.
11. Keep boulders receiving grout wet at all times prior to receiving grout.
12. The concrete grout shall be placed by injection methods by pumping under low pressure, through a 2-inch maximum diameter hose to ensure complete penetration of the grout into the void area as detailed on the Construction Improvement Drawings.
13. Grout will be placed up to 6 inches from the top of boulders, or as directed by the Engineer. The operator shall be able to stop the flow and will place grout in the voids and not on the surface of the rocks.
14. Grout should be troweled out and finished to minimize visibility.
15. Clean and wash any spillage before the grout sets. The visual surfaces of boulders will be free of grout to provide a clean natural appearance. If washing does not clean off grout residue, the Contractor shall wash off any grout residue with muriatic acid and water, using a brush to scrub off the residue.
16. A "pencil" vibrator shall be used to make sure all voids are filled between the boulders. The intent is to fill all voids from the subgrade level around the boulders to a depth as shown on the Construction Improvement Drawings. The "pencil" vibrator may be used to smooth

the appearance of the surface, but the Contractor shall use a wood float to smooth and grade the grout around the boulders.

17. The grout mix shall be stiffened and other measures taken to retain the grout between the boulders.

18. The Contractor shall support the boulders from falling over before and during the placement of riprap, grout, backfill, and compaction work on either side of the boulder.

19. Grout shall receive cold weather protection in accordance with Section XX of these Specifications.

I. Rejection of Work and Materials:

1. The Town will reject placed riprap, boulders, soil riprap and bedding that do not conform to this section. Contractor shall immediately remove and re-lay the riprap, boulders, soil riprap and bedding to conform to Specifications.

2. Riprap, boulders, soil riprap and bedding shall be rejected, which is either delivered to the job site or placed, that does not conform to this Section.

3. Rejected riprap, boulders, soil riprap and bedding shall be removed from the project site by the Contractor at Contractor's expense.

END OF SECTION

Section 302

Cured in Place Pipe (CIPP)

302.1. General

302.1.1 Description

A. This section covers the reconstruction of pipelines and conduits by the installation of a resin-impregnated flexible tube that is tightly formed to the original conduit. The resin is cured using either hot water under hydrostatic pressure, steam pressure within the tube, or ultraviolet light. The Cured-In-Place Pipe (CIPP) will be continuous and tight fitting.

302.1.2 Quality Assurance

A. ASTM F1216 (Rehabilitation of pipelines by the inversion and curing of a resin-impregnated tube)

B. ASTM F1743 (Rehabilitation of pipelines by pulled-in-place installation of a cured-in-place thermosetting resin pipe)

C. ASTM F2019 (Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP Cured-In-Place Thermosetting Resin Pipe (CIPP))

D. ASTM D790 (Test methods for flexural properties of non-reinforced plastics)

302.1.3 Submittals

A. Certification: Submit Manufacturer's certification that products meet referenced standards.

B. Shop Drawings: Submit Manufacturer's specifications, cut sheets and any other applicable information for insituform materials.

302.2. Products

302.2.1 CIPP (ASTM F1216 or ASTM F1743)

A. Tube

1. The sewn Tube shall consist of one or more layers of absorbent non-woven felt fabric and meet the requirements of ASTM F1216 or ASTM F1743, Section 5. The tube shall be constructed to withstand installation pressures, have sufficient strength to bridge missing pipe, and stretch to fit irregular pipe sections.

2. The wet out Tube shall have a uniform thickness that when compressed at installation pressures will meet or exceed the calculated Design thickness.

3. The Tube shall be sewn to a size that when installed will tightly fit the internal circumference and length of the original pipe. Allowance should be made for circumferential stretching during inversion. Overlapped layers of felt in longitudinal seams that cause lumps in the final product shall not be utilized.

4. The outside layer of the Tube (before wet out) shall be coated with an impermeable, flexible membrane that will contain the resin and facilitate monitoring of resin saturation during the resin impregnation (wet out) procedure.

5. The Tube shall be homogeneous across the entire wall thickness containing no intermediate or encapsulated elastomeric layers. No material shall be included in the Tube that may cause delamination in the cured CIPP. No dry or unsaturated layers shall be evident.

6. The wall color of the interior pipe surface of CIPP after installation shall be a light reflective color so that a clear detailed examination with closed circuit television inspection equipment may be made.

7. Seams in the Tube shall be stronger than the non-seamed felt.

8. The outside of the Tube shall be marked for distance at regular intervals along its entire length, not to exceed five feet (5').

B. Resin.

1. The resin system shall be a corrosion resistant polyester, vinyl ester, or epoxy and catalyst system that when properly cured within the tube composite meets the requirements of ASTM F1216 and ASTM F1743, the physical properties herein, and those which are to be utilized in the Design of the CIPP for this project. The resin shall produce CIPP which will comply with the structural and chemical resistance requirements of applicable ASTM Standards.

302.2.2 CIPP (ASTM F2019)

A. Tube

1. Fabric tube shall consist of at least two separate tubes made of corrosion resistant (E-CR) glass fibers in accordance with ASTM D 578.

2. Internal surface shall consist of a veil preferably made of polyester. Constructed with unidirectional glass.

3. External foils – shall consist of one or more layers of styrene resistant or light proof, or both, tube-shaped plastic foils.

B. Resin:

1. The resin system shall consist of a chemically resistant isophthalic polyester or vinylester thermoset resin and catalyst system or an epoxy resin and hardener that is compatible to the installation process. The resin shall produce CIPP which will comply with the structural and chemical resistance requirements of applicable ASTM Standards.

302.2.3 Design Considerations.

A. The CIPP shall be designed as per ASTM F1216 Appendix X.1. The CIPP design shall assume no bonding to the original pipe wall.

B. Design

1. The Enhancement Factor 'K' to be used in 'Partially Deteriorated' Design conditions shall be assigned a value of seven (7). Application of Enhancement (K) Factors in excess of seven (7) shall be substantiated through independent test data.

2. The layers of the cured CIPP shall be uniformly bonded.

3. The cured pipe material (CIPP) shall conform to the structural properties, as listed in applicable ASTM Standards.

4. The required structural CIPP wall thickness shall be based as a minimum, on the physical properties in Section b.3 and in accordance with the Design Equations in the appendix of ASTM F 1216 and the following design parameters:

Design Safety Factor (typically used value)	=	2.0
Retention Factor for Long-Term Flexural Modulus to be used in Design (As determined by long-term tests described in section 5.2 and approved by the Owner)	=	1% - 60%
Ovality* (calculated from (X1.1of ASTM F1216)	=	%
Enhancement Factor, K	=	See Section b.1
Groundwater Depth (above invert of existing pipe)*	=	ft.
Soil Depth (above crown of existing pipe)*	=	ft.
Soil Modulus**	=	psi
Soil Density**	=	pcf
Live Load**	=	H20 Highway
Design Condition (partially or fully deteriorated)***	=	***

* Denotes information, which can be provided here or in inspection videotapes or project construction plans. Multiple lines segments may require a table of values.

** Denotes information required only for fully deteriorated design conditions.

*** Based on review of video logs, conditions of pipeline can be fully or partially deteriorated. (See ASTM F1216 Appendix) The Owner will be sole judge as to pipe conditions and parameters utilized in design.

5. Refer to the Dimensional Ratio table for specific pipe section requirements, based on the pipe condition, depth, ovality, etc. as computed for the conditions shown, using ASTM F 1216 Design Equations.

CIPP WALL THICKNESS

FULLY DETERIORATED DESIGN (FD)

		Required DR (D / t)			
		Ei = 250,000 psi		Ei = 400,000 psi	
		Ground Water Depth			
Ovality	**Range of Depth to invert (feet)**	**50% Depth**	**Full Depth**	**50% Depth**	**Full Depth**
2 % *	4 - 8	49	43	58	51
	8 - 12	49	43	58	51
	12 - 16	44	39	52	46
	16 - 20	40	36	47	41
	20 - 24	37	33	44	38
5 %	4 - 8	41	37	48	43
	8 - 12	41	36	48	43
	12 - 16	37	33	44	38
	16 - 20	34	30	40	35
	20 - 24	31	27	37	32
8 %	4 - 8	35	31	40	36
	8 - 12	35	30	41	36
	12 - 16	31	27	37	32
	16 - 20	28	25	33	29
	20 - 24	26	23	31	27

FD wall thickness considers groundwater, soil and live loads upon the CIPP pipe. The table assumes two heights of groundwater, 120-lbs/cu. ft. of soil density and an AASHTO H20 highway load. The table represents CIPP pipe wall thickness for a host pipe range of 8 to 48 inches. This is a guideline only. Specific calculations should refer to ASTM F-1216, Appendix X.1.

Design Parameters:
Factor of Safety = 2.0
DR = Dimension Ratio = Diameter / thickness => t = D / DR
Effective reduction of Ei-modulus to approximate effects of creep = 50 %
Soil Modulus = 1,000 psi, assumed for highway loads or depths ≥ 10 feet (all others 700 psi).
Ovality % = 100 x (Mean Dia. - Minimum Dia.) / Mean Dia.
* 2% ovality is typically assumed when the host pipe measurements have not been field verified.

6. Any layers of the tube that are not saturated with resin prior to insertion into the existing pipe shall not be included in the structural CIPP wall thickness computation.

302.2.4 Testing Requirements

A. Chemical Resistance - The CIPP shall meet the chemical resistance requirements of ASTM F1216, Appendix X2, or of ASTM D5813 as applicable. CIPP samples for testing shall be of tube and resin system similar to that proposed for actual construction. It is required that CIPP samples with and without plastic coating meet these chemical testing requirements.

B. Hydraulic Capacity - Overall, the hydraulic profile shall be maintained as large as possible. The CIPP shall have a minimum of the full flow capacity of the original pipe before rehabilitation.

302.3. Execution

302.3.1 Initial Work

A. If a street must be closed to traffic because of the orientation of the sewer, the CONTRACTOR shall institute the actions necessary to do this for the mutually agreed time period.

B. The TOWN shall provide free access to water hydrants for cleaning, inversion and other work items requiring water.

C. Cleaning of Sewer Lines - The CONTRACTOR shall remove all internal debris out of the sewer line that will interfere with the installation of CIPP, and coordinate with the TOWN a dump site for all debris removed from the sewers during the cleaning operation.

D. Bypassing Sewage – The CONTRACTOR, when required, shall provide for the flow of sewage around the section or sections of pipe designated for repair. Plugging the line at an existing upstream manhole and pumping the flow into a downstream manhole or adjacent system shall make the bypass. The pump(s) and bypass line(s) shall be of adequate capacity to accommodate the sewage flow.

E. Inspection of Pipelines - Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles and service connections by close circuit television. The interior of the pipeline shall be carefully inspected to determine the location of any conditions which may prevent proper installation of CIPP into the pipelines, and it shall be noted so that these conditions can be corrected. A video tape and suitable log shall be kept for later reference by the TOWN.

F. Line Obstructions - It shall be the responsibility of the CONTRACTOR to clear the line of obstructions such as solids and roots that will prevent the insertion of CIPP. If pre-installation inspection reveals an obstruction such as a protruding service connection, dropped joint, or a collapse that will prevent the inversion process, and it cannot be removed by conventional sewer cleaning equipment, then the CONTRACTOR shall make a point repair excavation to uncover and remove or repair the obstruction. Such excavation shall be approved by the TOWN prior to the commencement of the work and shall be considered as a separate pay item.

G. Public Notification - The CONTRACTOR shall make every effort to maintain service usage throughout the duration of the project. In the event that a service will be out of service, the maximum amount of time of no service shall be 8 hours for any property served by the sewer. A public notification program shall be implemented, and shall as a minimum, require the CONTRACTOR to be responsible for contacting each home or business connected to the sanitary sewer and informing them of the work to be conducted, and when the sewer will be off-line. The CONTRACTOR shall also provide the following:

1. Written notice to be delivered to each home or business the day prior to the beginning of work being conducted on the section, and a local telephone number of the CONTRACTOR they can call to discuss the project or any problems which could arise.

2. Personal contact with any home or business, which cannot be reconnected within the time stated in the written notice.

H. The CONTRACTOR shall be responsible for confirming the locations of all branch service connections prior to installing and curing the CIPP.

302.3.2 Installation.

A. CIPP installation shall be in accordance with ASTM F1216, Section 7, or ASTM F1743, Section 6, or ASTM F2019, Section 6 with the following modifications:

1. Resin Impregnation - The quantity of resin used for tube impregnation shall be sufficient to fill the volume of air voids in the tube with

additional allowances for polymerization shrinkage and the loss of resin through cracks and irregularities in the original pipe wall. Certification, documentation concerning date, type of resin, resin calculation and volume shall be provided to OWNER.

2. Tube Insertion – The wet out tube shall be positioned in the pipeline using either inversion or a pull-in method. If pulled into place, a power winch should be utilized and care should be exercised not to damage the tube as a result of pull-in friction. The tube should be pulled-in or inverted through an existing manhole or approved access point and fully extend to the next designated manhole or termination point.

3. Once the inversion/tube installation has started, the pressure shall be maintained between the manufacturer's minimum and maximum pressures until the installation of the tube has been completed and the finished pipe is fully cured. Should the pressure deviate from the minimum and maximum allowable range the tube shall be removed from the existing conduit and discarded.

4. CIPP (ASTM F2019)

   CIPP installation shall be in accordance with ASTM F2019, Section 6. Ultraviolet Light Curing shall follow a full protocol for time, rate of travel etc.

302.3.3 Reinstatement of branch connections.

A. It is the intent of these specifications that branch connections to buildings be reopened without excavation, utilizing a remote controlled cutting device, monitored by a video TV camera. Unless otherwise directed by the owner or his authorized representative, all laterals will be reinstated to a minimum of 95% and a maximum of 100%. No additional payment will be made for excavations for the purpose of reopening connections and the CONTRACTOR will be responsible for all costs and liability associated with such excavation and restoration work.

302.3.4 Inspection.

A. CIPP samples shall be prepared and physical properties tested in accordance with ASTM F1216 or ASTM F1743, Section 8, or ASTM F2019 Section 7 using methods described. Samples The flexural properties must meet or exceed the values listed in Table 1 of the applicable ASTM.

B. Wall thickness of samples shall be determined as described, the minimum wall thickness at any point shall not be less than eighty seven and one-half percent (87½%) of the design thickness as calculated in paragraph 5.6 of this document.

302.3.5 Clean-up.

A. Upon acceptance of the installation work and testing, the CONTRACTOR shall restore the project area affected by the operations to a condition at least equal to that existing prior to the work.

END OF SECTION

Section 303

Reinforced Concrete Pipe for Stormwater

300.1. General

300.1.1 Description

A. This section includes all labor, materials, equipment, and incidentals required, installation of twelve (12) inch diameter and larger concrete pipe, and fittings to be used as storm sewers. The following is included:

1. ASTM C361 - Reinforced Low-Head Pressure Pipe.
2. ASTM C76 - Reinforced Concrete Pipe.
3. ASTM C655 - Reinforced Concrete D-Load Pipe.

300.1.2 Related Sections

A. Section XXX – Stormwater Utilities

300.1.3 Quality Control

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M170 - Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
2. AASHTO M242 - Reinforced Concrete D-Load Culvert, Storm Drain, and Storm Sewer Pipe.

B. American Society for Testing and Materials (ASTM):

1. ASTM C33 - Standard Specification for Concrete Aggregates.
2. ASTM C76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipes.
3. ASTM C150 - Standard Specification for Portland Cement.
4. ASTM C361 - Standard Specification for Reinforced Low-Head Pressure Pipe.
5. ASTM C443 - Standard "Specification for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
6. ASTM C655 - Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe.

7. ASTM E329 - Standard Practice for Use in the Evaluation of Testing and Inspection Agencies as Used in Construction.

C. Federal Specification (FS):

1. SS-S-00210 - Sealing compound, Preformed Plastic for Expansion Joints and Pipe Joints.

D. Where reference is made to one of the above standards, the latest revision shall apply.

300.1.4 Submittals

A. Submit to ENGINEER, the name of the pipe and fitting suppliers and a list of materials to be furnished.

B. Submit to ENGINEER, shop drawings showing layout and details of reinforcement, joint, method of manufacture and installation of pipe, specials and fittings, and a schedule of pipe lengths (including length of individual pipes by diameter) for the entire project.

C. Submit to ENGINEER documentation (signed and sealed by a Professional Engineer from a qualified independent commercial materials testing laboratory that conforms fully to ASTM E329 and is regularly inspected by the Cement and Concrete Reinforcement Laboratory of the National Bureau of Standards) that the fine and course aggregate to be used in manufacture of the concrete pipe comply with the requirements of these specifications. Said documentation shall be current (less than 6 months old) and shall indicate the source of the aggregates and the date of the analysis. The CITY reserves the right to have independent analysis of aggregates or quality assurance tests of the pipe indicate non-compliance with aggregate requirements.

D. Prior to each shipment of pipe, submit certified test reports that pipe was manufactured and tested in accordance with the ASTM Standards specified herein.

E. Complete specifications and data covering the materials to be furnished and detailed drawings covering the installation shall be submitted.

300.1.5 Quality Assurance

A. Manufacturer:

1. Experienced in the design, manufacturer, and commercial supplying of the specific material for a minimum period of five (5) years.

2. Experienced in the design, manufacturer, and commercial supplying of the specific size of pipe for a period of one (1) year.

3. Certify to above minimum experience requirements.

B. All pipe and fittings shall be from a single manufacturer.

C. The manufacturer shall be responsible for the performance of all acceptance tests as specified in Paragraph 5.1.2 of ASTM C76, or Paragraph 4.1.1. of ASTM C655, or Paragraph 5 of ASTM C361.

D. Inspection of the pipe shall also be made by the ENGINEER/CITY after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the Specification requirements, even though pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall immediately be removed from the project. The ENGINEER may allow patching/repair of the pipe. If allowed, the pipe repair procedure shall be submitted to the ENGINEER for approval.

E. In addition, preliminary testing identified herein shall be made at the CONTRACTOR's expense. Reports covering the following tests on each size and class of pipe shall be submitted for review before any pipe is manufactured for this Contract:

1. Joint Leakage: As specified herein.
2. Joint Shear: Suitable arrangement to apply the specified loads.
3. Cement: Mill test report showing tricalcium aluminate content.
4. Three-edge-bearing: ASTM C497, indicating either the load required to produce a 0.01-inch crack one foot (1') long, or at the option of the ENGINEER, for ultimate destruction.

F. Tests for joint shear, and three-edge-bearing are for proof of design only. It is not required that such tests be made on pipe manufactured specifically for this contract. Reports covering tests made on other pipe of the same size, class, and design as specified herein, and manufactured from materials of equivalent type and quality may be acceptable.

300.2. Products

300.2.1 Reinforced Concrete Pipe

A. Diameter of Pipe: The diameter indicated on the drawings shall mean the inside diameter of the pipe.

B. Except as otherwise specified herein, pipe shall conform to ASTM C76, ASTM C655, or ASTM C361.

C. Pipe shall meet the minimum design requirements for Class II pipe as stipulated in ASTM C76. Each pipe or fitting shall have plainly and permanently marked on the interior of the pipe wall the pipe class and

size, date of manufacture, manufacturer's name or trademark, and deflection angle for bends.

D. Admixtures:

1. All admixtures used in the concrete mix shall be from the same manufacturer and shall be compatible.

2. Performance: Provide dense, durable concrete resistant to chemical attack, wear, rebar corrosion, freeze-thaw attack, cracking, and segregation.

3. Air-Entraining Admixture:

a. Meet ASTM C260, and shall contain no chlorides and shall be non-corrosion.

b. Maintain air percentage as batched, within plus or minus one and one-half percent (1.5%).

4. Water-Reducing Admixture:

a. Meet ASTM C494, Type A. or D.

b. Complex, multi-component, non-chloride, non-corrosive.

E. Fine aggregate shall consist of washed, inert natural sand conforming to the requirements of ASTM C33, except for gradation, with a maximum loss of eight (8) percent when subjected to five (5) cycles of the soundness test using magnesium sulfate. Coarse aggregate shall consist of well-graded, crushed stone, or washed gravel, conforming to the requirements of ASTM C33, except for gradation, with a maximum loss of eight (8) percent when subjected to five (5) cycles of the soundness test using magnesium sulfate. Documentation that the aggregates to be used in the manufacture of reinforced concrete pipe meet these requirements shall be submitted to the CITY. Use of artificial or manufactured sand shall not be acceptable. Maximum absorption for aggregate shall be five (5) percent.

F. Concrete Mix Design:

1. Design, select, and proportion ingredients, and test concrete mix through an approved testing laboratory meeting ASTM E329.

G. Reinforcement: Reinforcement shall be circular for all concrete pipe with an inner and outer cage. Longitudinal steel shall be spaced uniformly around the pipe and shall consist of continuous or lap spliced wires or bars in each cage. Quadrant steel shall not be used. Reinforcement shall be installed in both the bell and the spigot. At least three (3) circumferential bars shall be provided in each pipe bell. The bars shall be placed within one and one-half (1 1/2) times the socket

depth from the end of the pipe and shall be equal in area to an equivalent length of the outside cage in the pipe barrel. The end circumferential bar shall be placed one inch (1") from the face of the bell. The inside cage in the pipe barrel shall be extended to within one inch (1") of the end of the spigot on twenty-four inch (24") or larger pipe. Cores indicating reinforcing steel having less than eighty-five percent (85%) bond shall be cause for rejection of the lot of pipes.

H. Pipe may be rejected for any of the following reasons:

1. Transverse reinforcing steel found to be in excess of one quarter inch (1/4") out of specified position after the pipe is molded.
2. Any shattering or flaking of concrete at a crack.
3. Voids, with the exception of a few minor bug holes, on the interior and exterior surfaces of the pipe exceeding one-half inch (1/2") in depth or ten (10) square inches in area, unless properly and soundly pointed with mortar or other approved material.
4. A wall thickness that varies more than plus or minus five percent (±5%) from the specified wall thickness of pipe larger or one-half inch (1/2"), whichever is greater. The deficiencies in wall thickness permitted herein do not apply to gasket contact surfaces in gasketed joint pipe.
5. A variation from the specified internal diameter in excess of one percent (1%) or three-eighths inch (3/8"), whichever is greater, or interior surfaces which have been reworked after placing of concrete. The variation in internal diameter permitted herein does not apply to gasket contact surface in gasketed joint pipe.
6. A hollow spot (identified by tapping the internal surface of the pipe) which is greater than thirty inches (30") in length or wider than three (3) times the specified wall thickness. Repair of such defective areas not exceeding these limitations may be made as specified.
7. Defects that indicate imperfect molding of concrete; or any surface defect indicating honeycomb or open texture (rock pockets) greater in size than area equal to a square with a side dimension of two and one-half (2-1/2) times the wall thickness, or deeper than two (2) times the maximum graded aggregate size; or local deficiency of cement resulting in loosely bonded concrete, the area of which exceeds in size the limits of area, described in Paragraph 9 above, when the defective concrete is removed. Repair of such defects not exceeding these limits may be made as specified.
8. Any of the following cracks:

a. A crack having a width of 0.005-inch to 0.01-inch throughout a continuous length of thirty-six inches (36") or more.

b. A crack having a width of 0.01-inch to 0.03-inch or more throughout a continuous length of one foot (1') or more.

c. Any crack greater than 0.005-inch extending through the wall of the pipe and having a length in excess of the wall thickness.

d. Any crack showing two visible lines of separation for a continuous length of two feet (2') or more, or an interrupted length of three feet (3') or more anywhere in evidence, both inside and outside.

e. Cracks anywhere greater than 0.03-inch in width.

I. The pipe shall be clearly marked as required by ASTM on the interior of the pipe wall the pipe class and size, date of manufacture, Manufacturer's name or trademark, and deflection angle for bands. The markings may be at either end of the pipe for the convenience or the manufacturer, but for any one size shall always be at the same end of each pipe length. Pipe shall not be shipped until the compressive strength of the concrete has attained three thousand (3,000) psi and not before five (5) days after manufacture and/or repair, whichever is the longer.

J. Pipe shall have a minimum laying length of seven and one-half feet (7 ½'), except for closure and other special pieces as approved by the ENGINEER/TOWN. Short lengths of pipe made for closure may be used in the pipeline at the end of construction, if properly spaced. The length of the incoming and outgoing concrete pipe at each structure shall not exceed four feet (4') feet, except where the joint is cast flush with the exterior wall of the structure, where steel wall fittings are provided or where otherwise noted on the drawings. Maximum laying length shall not exceed sixteen feet (16'), but the installation of sixteen-foot (16') lengths shall depend upon the ability of the CONTRACTOR to handle such lengths of pipe in sheeted trenches, comply with trench width requirements, maintain the integrity of the sheeting and avoid disturbance to adjacent ground. If in the opinion of the ENGINEER/TOWN the use of sixteen-foot (16') lengths is impractical, shorter lengths shall be used.

K. During manufacturing, measuring devices shall be used to assure joint assembly is within the tolerance of ASTM C76 and these Specifications.

L. TOWN shall have the right to cut cores from such pieces of the finished pipe. Holes left by the removal of cores shall be filled in an approved manner by and at the expense of the manufacturer.

M. TOWN shall also have the right to take samples of the concrete after it has been mixed, or as it is being placed in the forms or molds and to make such inspection and tests thereof.

N. At the start of the work, a set of test cylinders shall be taken each day on which pipe is manufactured for the project or more often, if required. This may ultimately be reduced to one set of three specimens for every fifty (50) cubic yards of concrete placed, if the uniformity of results warrants and if approved by TOWN. At the start of the work, a relationship shall be established between ultimate strength of test cylinders stored in a standard manner as compared to cylinders steam cured with the pipe and as compared to cores taken from the corresponding finished pipe. At least five (5) sets of tests shall be made.

O. Test cores may be taken, if required by TOWN. Cores may be drilled in any manner which shall provide a smooth core face. All pipe cylinders and cores shall be a minimum of two inches (2") in diameter. Cores shall be carefully saw-trimmed and capped in a vertical position with a sulfur cap of minimum thickness, at least one day before being tested.

P. Core testing shall conform to Standard ASTM methods and shall include absorption testing.

Q. At the time of inspection, the pipe shall be carefully examined for compliance with the appropriate ASTM and project specifications and shop drawings. All pipes shall be inspected for general appearance, dimension, blisters, cracks, roughness, soundness, etc. The surface shall be dense and close-textured. Cores also shall serve as a basis for rejection of pipe, particularly if lamination or poor bond of reinforcement is apparent.

R. Unsatisfactory or damaged pipe shall be either permanently rejected or returned for minor repairs. Only that pipe actually conforming to the specifications and accepted shall be listed for approval, shipment, and payment. Approved pipe shall be so stamped or stenciled on the inside before it is shipped. All pipe which has been damaged after delivery shall be rejected and if such pipe already has been placed, it shall be acceptably repaired, if permitted, or removed and replaced, entirely at the CONTRACTOR's expense.

S. Pits, blisters, rough spots, breakage, and other imperfections may be repaired, subject to the approval of the ENGINEER, after demonstration by the manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final approval. Non-shrink cement mortar used for repairs shall have a minimum compressive strength of six thousand (6,000) psi at the end of seven (7) days, and seven

thousand (7,000) psi at the end of twenty-eight (28) days, when tested in three inch (3") cylinders stored in the standard manner. Epoxy mortar may be utilized for repairs subject to the approval of the ENGINEER.

T. Lift holes shall not be allowed.

300.2.2 Joints

A. Joints and jointing material for concrete storm sewer installations shall be bell and spigot with rubber gasket in conformance with ASTM standards.

B. Each concrete pipe joint shall be designed to withstand, without cracking, the gasket compression plus a differential load across the joint equal to four thousand (4,000) pounds per foot of internal diameter. Joint design details, including calculations, shall be submitted for review.

C. Steel joint rings shall be galvanized A36 steel. The diameters of the joint surfaces which compress the gasket shall not vary from the diameters by more than three-sixteenths inch (3/16"). Alternate joint designs which meet, or exceed, all other requirements of this specification may be submitted to the ENGINEER for approval.

D. The rubber gaskets shall conform to ASTM C443, except as otherwise specified herein. Tensile strength shall be one thousand two hundred (1,200) psi, hardness shall be thirty-five (35) to fifty-five (55), maximum water absorption shall be ten percent (10%), and polymer shall be neoprene or other synthetic rubber. Natural rubber shall not be acceptable.

E. The gaskets shall be designed and manufactured so that the completed joint shall withstand an internal water pressure in excess of thirteen (13) psi for a period of ten (10) minutes without showing any gasket leakage or displacement, per ASTM C443. The pipe manufacturer shall provide facilities for testing the effectiveness of the joints against leakage and one (1) such test may be required for each five hundred feet (500') of pipe for each type of joint manufactured. Such tests shall be made by an internal or external pressure against the joint of at least thirteen (13) psi for a period of ten (10) minutes.

F. The joint assemblies shall be accurately formed so that when each pipe section is forced together in the trench the assembled pipe shall form a continuous watertight conduit with a smooth and uniform interior surface, and shall provide for slight movement of any piece of the pipeline due to expansion, contraction, settlement, or lateral displacement. If a gasketed joint is used, the gasket shall be the sole element of the joint providing water tightness. The ends of the pipe shall be in places at right-angles to the longitudinal center line of the

pipe, except where bevel-end pipe is required. The ends shall be finished to regular smooth surfaces.

300.3. Execution

300.2.3 Installation:

A. Pipe Installation: See Section XXX – Stormwater Utilities

300.2.4 Testing and Cleaning:

A. Pipe testing and cleaning shall be as specified in Section XXX – Stormwater Utilities

END OF SECTION

Section 304
Stormwater System

300.1. General

300.1.1 Description

A. This section covers the handling and installation of gravity pipes and storm sewers, fittings, specials, and other appurtenances as indicated or specified.

B. Definition of manhole or inlet depth: The distance measured at centerline from the invert of the lowest pipe to the top of the ring and cover.

300.1.2 Related Sections

A. Section XXX – Manholes.

B. Section XXX – Storm Drains?

C. Section XXX – Reinforced Concrete Pipe for Storm Sewers.

D. Section XXX – Polyvinyl Chloride Pipe for Storm Sewers.

E. Section XXX – High-Density Polyethylene Pipe for Storm Sewers.

300.1.3 Quality Assurance

A. Lay pipe and set manhole and inlet inverts true to the line and grade shown on the Drawings. Under no circumstances shall inverts result in a level invert, reverse slope invert, or grade flatter than will accommodate design flows.

300.1.4 Delivery, Storage, and Handling

A. Handle in a manner to ensure installation in sound and undamaged condition.

1. Do not drop or bump.
2. Use slings, lifting lugs, hooks, or other devices designed to protect the pipe, joint elements, linings, and coatings.
3. Prevent foreign material from entering pipe.

B. Ship, move, and store with provisions to prevent movement or shock contact with adjacent units.

C. Handle with equipment capable of work with adequate factor of safety against overturning or other unsafe procedures.

300.1.5 Job Conditions.

A. Precaution shall be taken to minimize damage to newly installed pipeline.

1. Prevent foreign material from entering the pipe.
2. Do not place debris, tools, clothing, or other materials in the pipe.
3. Whenever pipe laying is interrupted close the open end of the pipe with a tight fitting plug or cap to prevent the entry of foreign material into the pipe. No pipe shall be left open overnight or during lunch breaks.
4. Use effective measures to prevent the uplift or floating of the line prior to completion of the backfilling operation.
5. Under no circumstances shall the sewer line be used to remove excess water which has infiltrated into the trenches.

300.2. Products

300.2.1 Pipe Materials

A. Type: Reinforced Concrete Pipe (RCP), refer to Section XXX – Reinforced Concrete Pipe for Storm Sewers.

B. Type: Polyvinyl Chloride Pipe (PVC), refer to Section XXX – Polyvinyl Chloride Pipe for Storm Sewers.

C. Type: High-Density Polyethylene Pipe (HDPE), refer to Section XXX – High-Density Polyethylene Pipe for Storm Sewers.

300.2.2 Manhole and Inlet Materials.

A. Refer to Section xxx - Manholes.

B. Refer to Section xxx – Storm Inlet Drains

300.2.3 Flexible Couplings.

A. When jointing two pipes of dissimilar material or two pipes with different outside diameters use the following:

1. Pipe sized fifteen inches (15") or smaller.
   a. Fernco, Inc.
   b. Mission Rubber Company
   c. Or equal.

2. In pipe sizes larger than fifteen inches (15") inside diameter wrap the joint with two laps of rubber or vinyl and band each pipe with a stainless-steel band.

    a. Lap joint downward at springline of pipe.

    b. Rubber or vinyl shall extend at least six inches (6") on each pipe past the joint, minimum thickness one sixteenth inch (1/16") rubber or thirty-two (32)-ounce vinyl.

B. Encase flexible couplings in a concrete collar a minimum of six inches (6") thick and extending a minimum of six inches (6") either side of the joint.

300.3. Execution

300.2.4 Preparation.

A. Perform excavation in accordance with Section xxx – Trenching, Backfilling, and Compaction.

B. Where connections are to be made to existing pipes or appurtenances, the exact location of which cannot be determined without exposing the existing appurtenance, excavate and expose the existing improvement before installing any pipe. TOWN will examine pipe or appurtenance and specify any necessary adjustments in line or grade of the proposed pipe to accomplish the connection.

300.2.5 Pipe Installation.

A. General:

1. Utilize equipment, methods, and materials ensuring installation to lines and grades indicated.

    a. Maintain within tolerances specified or acceptable laying schedule.

        i. Alignment: Plus or minus one inch (±1") inch per one hundred feet (100') in open cut or tunnel.

        ii. Grade: Plus or minus one inch (±1") inch per one hundred feet (100').

    b. Do not lay pipe on blocks unless pipe is to receive total concrete encasement.

B. Pipe Laying.

1. Begin pipe laying at the lowest point, unless otherwise directed by the TOWN, and install the pipe with the spigot ends pointing in the direction of flow.

2. Lay pipe true to line and grade and join in such a manner that the offset of the inside of the pipe at any joint is held to a minimum at the invert. The maximum offset at the invert shall be one percent (1%) of the inside diameter, or three-eighths inch (3/8"), whichever is smaller.

3. As each length of pipe is placed in trench, complete the joint in accordance with the applicable pipe material specification and adjust the pipe to the correct line and grade. Make adjustments by scraping away or filling pipe bedding under the body of the pipe, and not by wedging or blocking up the bells.

4. Secure the pipe in place with the specified bedding tamped under and around the pipe. Do not walk on small diameter pipe or otherwise disturb any pipe after the jointing has been completed.

5. Clean interior of all pipe, fittings, and joints prior to installation. Exclude entrance of foreign matter during discontinuance of installation.

    a. Close open ends of pipe with snug-fitting closures.

    b. Do not let water fill trench. Include provisions to prevent flotation should water control measures prove inadequate.

    c. Remove water, sand, mud and other undesirable materials from trench before removal of end cap.

6. Brace or anchor as required to prevent displacement after establishing final position.

7. Perform only when weather and trench conditions are suitable. Do not lay in water.

8. Observe extra precaution when hazardous atmospheres might be encountered.

C. Waterline Crossing.

1. Where sewer lines cross watermains, and the sewer is above the watermain or less than eighteen inches (18") clear distance vertically below the watermain, construct the crossing by one of the following methods:

    a. Using one length of pipe, PVC, or DIP, at least eighteen feet (18') long centered over or under the watermain. Use Flexible Couplings when jointing two pipes of dissimilar materials or two pipes with different outside diameters. Encase couplings in concrete as specified herein.

b. Encase the sewer pipe with reinforced concrete at least six inches (6") thick at all locations within ten (10) feet either side of the waterline and in conformance with the Standard Details.

2. In all cases, provide suitable backfill or other structural protection to preclude settling or failure of the higher pipe.

300.2.6 Manhole and Inlet Construction.

A. Construct manholes in accordance with Section XXX – Manholes and Storm Inlets in accordance with Section XXX – Storm Drains.

B. Connections to existing manholes and inlets.

1. Construct in such a manner that the finished work conforms to the requirements specified for new manholes (where practical).

2. Where no provision has been made for additional tie-ins, break out as small of an opening as necessary to insert the new pipe.

3. Chip out existing invert to accommodate the cross section of the newly inserted pipe, finish with mortar to form a smooth, continuous invert, and seal space between the new pipe and the manhole wall with non-shrink grout.

300.2.7 Field Quality Control.

A. Each section of sewer shall meet the requirements of the following tests. Furnish all equipment, labor and incidentals necessary and conduct tests in the presence of ENGINEER/TOWN.

B. Stop all work, locate leaks, make repairs, and correct construction methods as needed as indicated as a result of any of the following tests.

C. Acceptance Tests.

1. Alignment:

a. ENGINEER/TOWN may lamp each section of sewer between manholes to determine whether any displacement of the pipe has occurred, or by physical passage as space permits. CONTRACTOR shall provide suitable assistants to help TOWN. A full diameter ("full moon") of the pipe should be visible when viewed between manholes. Determine from Illumination or Physical Inspection:

i. Presence of any misaligned, displaced, or broken pipe.

ii. Presence of visible infiltration or other defects.

b. CONTRACTOR shall clean pipe of excess mortar, joint sealant, and other dirt and debris prior to inspection.

2. Deflection Testing:

    a. TOWN may require CONTRACTOR to test flexible pipe after backfill has been in place thirty (30) days and again after eleven (11) months if deemed necessary.

        i. Provide rigid ball or mandrel deflection testing equipment and labor.

        ii. Obtain approval of equipment and method for use by ENGINEER.

        iii. Test shall be performed without mechanical pulling devices.

        iv. Remove and replace pipe exceeding deflection limits.

    b. Maximum installed deflections of flexible pipe if required shall be as follows:

Type of Pipe	Deflection % of Mean Internal Dia.
ASP	5%
PVC	5%
HDPE	5%

300.2.8 Cleaning.

A. Prior to initial acceptance, remove all accumulated construction debris, rocks, gravel, sand, silt and other foreign material from the sewer system. Use mechanical rodding or bucketing equipment as required. After all paving activities have been completed, all mains must be flushed and cleaned.

B. At the time of final acceptance, all mains must be flushed and cleaned again.

300.2.9 Acceptance.

A. Initial Acceptance. After the completion of paving, all public mains will be considered initially accepted by the TOWN for a period of one (1) year upon:

1. Successful inspection of all "initial punch list" item remedies.

2. Successful lamp test and visual inspection of the manhole rings and covers.

3. Receipt of paper and electronic as-builts. Format for the electronic version shall be confirmed with the TOWN.

4. Receipt of full system video record, taken at the time of request of initial acceptance. Format for the video shall be confirmed with the TOWN.

B. Final Acceptance. At the end of the one (1) year initial acceptance period, all public mains will accepted by the TOWN upon:

1. Successful inspection of all "final punch list" item remedies.

END OF SECTION

Section 305

Polyvinyl Chloride (PVC) Pipe for Stormwater

305.1. General

305.1.1 Description

A. This specification covers material requirement, inspection and testing, marking and delivery, installation, and field performance and acceptance tests of polyvinyl chloride (PVC) sewer pipe and fittings for use in gravity stormwater installations.

305.1.2 Related Sections

A. Section XXX – Stormwater Utilities

305.1.3 Quality Control

A. American Association of State Highway and Transportation Officials (AASHTO):

1. M304M-911 - Polyvinyl Chloride (PVC) Ribbed Drain Pipe and Fittings Based on Controlled Inside Diameter.

B. American Society for Testing and Materials (ASTM):

1. ASTM D2321 - Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications.
2. ASTM D3212 - Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
3. ASTM F477 - Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
4. ASTM F679 - Polyvinyl Chloride (PVC) Large Diameter Plastic Gravity Sewer Pipe and Fittings.
5. ASTM F794 - Polyvinyl Chloride (PVC) Ribbed Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.

C. Where reference is made to one of the above standards, the latest revision shall apply.

305.1.4 Submittals:

A. Submit to ENGINEER, the name of the pipe and fitting suppliers and a list of materials to be furnished.

B. Submit to ENGINEER shop drawings showing pipe layout, joint, method of manufacture and installation of pipe, specials and fittings and a schedule of pipe lengths (including length of individual pipes by diameter) for the entire project.

C. Prior to each shipment of pipe, submit certified test reports that pipe was manufactured and tested in accordance with the ASTM Standards specified herein.

D. Complete specifications and data covering the materials to be furnished and detailed drawings covering the installation shall be submitted.

305.1.5 Quality Assurance:

A. Manufacturer:

1. Experienced in the design, manufacture, and commercial supplying of the specific material for a minimum period of five (5) years.

2. Experienced in the design, manufacture, and commercial supplying of the specific size of pipe for a period of one (1) year.

3. Certify to above minimum experience requirements.

B. All PVC pipe and fittings shall be from a single manufacturer.

C. Inspection of the pipe shall also be made by the ENGINEER/CITY after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall immediately be removed from the project.

305.2. Products

305.2.1 Pipe and Fittings

A. PVC large-diameter plastic gravity sewer pipe and fitting shall conform to ASTM F679 or ASTM F794, with minimum pipe stiffness of forty-six (46) psi.

B. Each pipe or fitting shall have plainly and permanently marked on the interior of the pipe wall the pipe class and size, date of manufacture, manufacturer's name or trademark, and deflection angle for bends.

C. All pipe and fittings shall be free from all defects, including indentations, delaminations, cracks, bubbles, pinholes, inclusions or occlusions, which, due to their nature, degree, or extent, detrimentally affect the strength and serviceability of the pipe. Any pipe or fittings with such defects which, in the judgment of the ENGINEER/CITY will affect the strength and serviceability, shall be repaired or rejected.

305.2.2 Joints:

A. Pipe joints shall be air-tight and of the bell spigot type with elastomeric gaskets conforming to the requirements of ASTM D3212.

B. Gaskets shall comply in all aspects with physical requirements specified in ASTM F477.

C. Gaskets shall be neoprene or synthetic elastomer. Natural rubber is not acceptable.

1. The gasket shall be the only element depended upon to make the joint flexible and water tight.

D. Lubricant used for assembly shall have no detrimental effect on the gasket or the pipe.

E. Integral bell and spigot gasketed joints shall be designed so that when assembled, the elastomeric gasket, contained in a machined groove on the pipe spigot, is compressed radially in the pipe bell to form a positive seal. The joint shall be designed to avoid displacement of the gasket when installed in accordance with the manufacturer's recommendations.

305.3. Execution

305.2.3 Installation.

A. Pipe Installation: See Section XXX - Stormwater Utiliities.

305.2.4 Testing and Cleaning:

A. Pipe testing and cleaning shall be as specified in Section XXX - Stormwater Utiliities.

END OF SECTION

Section 306

Storm Inlet Drains

306.1. General

306.1.1 Description

A. This section covers storm inlets, including ring and covers, frames, grates, steps, grade rings, fittings, and other appurtenances.

306.1.2 Quality Assurance:

A. Inlet inverts shall not deviate from elevations shown on the Drawings by more than ± 0.03 ft.

306.1.3 Delivery, Storage, and Handling

A. Do not deliver precast concrete sections to job until concrete has attained at least eighty percent (80%) of specified strength.

306.1.4 Alternatives.

A. Inlets may be either monolithically precast or cast-in-place. See Section XXX – Cast-In-Place Concrete for concrete specifications.

306.2. Products

306.2.1 Concrete

A. Cast-In-Place.

1. Meet the Requirements of Section XXX - Cast-In-Place Concrete.
2. Strength: Three thousand (3000) psi at twenty-eight (28) days.
3. Cement: Type II or Type I/II.
4. Slump: Two inches (2").
5. Air Entrapment: Three to five percent (3%-5%).

B. Mortar.

1. One (1) part Portland Cement, ASTM C150, Type II.
2. Three (3) parts sand, ASTM C144.
3. One-half (1/2) part hydrated lime, ASTM C207, Type S.

C. Grout (non-shrink).

1. Pre-mixed: Master Builders "Set Grout," Sonneborn "Ferrolith G-D.S. Redi-Mixed," or equal.
2. Job Mixed:
    a. One part Portland Cement, ASTM C150, Type II.
    b. One part sand, ASTM C144.
    c. One part shrinkage correcting aggregate, Master Builders "Embco Aggregate," "Sonneborn "Ferrolith G-D.S.," or equal.

306.2.2 Precast Concrete.

A. Bases, sections, and tops.

1. Cast base and first barrel section monolithic.
2. Meet Requirements of: ASTM C478.
3. Cement: Type II or Type I/II.
4. Invert: Cast-in-place concrete as specified in paragraph 400.2.1.A above.
5. Provide horseshoe shaped openings for inlets to be installed in existing lines.

306.2.3 Section Gaskets.

A. Meet Requirements of: F.S. SS-S-00210, Type I, Rope Form.

B. Approved Manufacturers.

1. K.T. Snyder Co., "Ram-Nek" or "Rubr'-Nek."
2. Hamilton-Kent Mfg. Co., "Kent Seal."
3. Or equal.

306.2.4 Pipe Penetration Gaskets.

A. Approved Manufacturers.

1. Dukor Co., “Ko-N-Seal”.
2. A-lok Corp., “A-lok”.
3. Or equal.

306.2.5 Ring and Cover.

A. Material: Gray Iron meeting requirements of ASTM A48.

B. Construction.

1. Size: Min. Clear opening twenty-four inch (24") diameter.
2. Weight: Heavy duty four hundred (400) pounds minimum.
3. Bearing surfaces: machined.
4. Lid pattern: checkered top or indented top.
5. Pick hole: concealed.
6. Utility type (STORMWATER) shall be cast into the cover, see Standard Detail.

306.2.6 Frame and grate.

A. Material: Gray Iron meeting requirements of ASTM A48.

B. Construction.

1. Size: Each individual grate section shall be installed in two equal pieces.
2. Weight: Heavy duty four hundred (400) pounds minimum.
3. Bearing surfaces: machined.
4. Pattern: Type A, Type B, or Type L.

306.2.7 Steps.

A. Materials: Polypropylene plastic coated steel. See Standard Detail.

B. Construction.

1. Reinforcing rod: On-half inch (1/2") diameter Grade 60 steel.
2. Length: Nine and three-quarters inches (9 ¾"), designed for six and three-eighths inch (6-3/8") protrusion from manhole wall.
3. Width: Fourteen inches (14") clear.
4. Tread: notched ridge with retainer lugs on each end.

C. Spacing.

1. Eight inches (8") above bench.
2. Twenty inch (20") maximum below rim.
3. Twelve inch (12") vertical spacing between steps.

306.2.8 Pre-cast Manufacturing.

A. Forms must be rigid, adequately braced, free from dents, gouges or other irregularities which would impair quality, appearance, or performance of members.

B. Holes and Openings. Incorporate into design and fabrication, openings indicated on the approved plans.

C. Surface Finish and Formed Surfaces. Provide a smooth, transverse broom finish at top surface of flat-top slabs. Provide smooth, uniform texture and color for formed surfaces. Remove fins and other projections.

D. Shop Marking. Label or paint, on each section, a shop marking to indicate location and position of each member.

E. Curing. Cure precast sections in accordance with ACI 308 to attain specific design strength.

306.3. Execution

306.2.9 Inspection.

A. Perform Examine each precast section, frame and grate and appurtenance for cracks and other defects. Remove all defective materials from the site.

306.2.10 Installation of Precast Sections.

A. Connect all pipes to precast sections using pipe penetration gaskets.

B. If inverts are not constructed by precaster and wherever grade and alignment permit, lay the main sewer continuously through the inlet and split the pipe after construction of the invert. Where this is not possible, terminate pipe flush with interior inlet wall and construct transition smooth and of proper radius for uninterrupted flow. In no case shall the invert flow section through the inlet be greater than that of the outgoing pipe. Finish invert with a steel trowel prior to adding riser section to the base.

C. Set each riser section plumb. Join multiple sections using mortar or pre-formed flexible plastic gaskets. The last section prior to placement of the top slab shall be the manufacturer's shortest, but in no case greater than twenty-four inches (24") in height. All joint surfaces shall be clean, dry and warm during installation. Where mortar joints are used, set each section in a one inch (1") minimum full bed of mortar. If flexible gaskets are used, prime entire joint on both sections prior to placement of gasket material.

D. Fill all lifting holes and other imperfections with mortar. Neatly point inside of joints no matter what joint material is used.

306.2.11 Construction of Cast-in-Place Inlets.

A. Set stubs and mains before concrete is placed and recheck for alignment and grade before concrete has set. Where grade and

alignment permit, lay the main sewer continuously through inlets and split the pipe after construction of the base. Where this is not possible, terminate the pipe flush with the interior inlet wall and construct transitions smooth and of proper radius for uninterrupted flow. In no case shall the invert flow section be larger than that of the outgoing pipe. Shape the base with a wood float and finish with a steel trowel. Allow the base to set a minimum of twenty-four (24) hours before continuing construction.

B. When thermoplastic pipe is used, connections to the inlet base shall be made using approved couplings cast into the base or a minimum of three (3) pipe gaskets spaced two inches (2") apart on the end of each pipe and cast into the base.

C. If the pipe connection is to a precast section, use pipe penetration gaskets as specified above.

D. Install precast sections and slab tops as specified in section 400.2.10 above.

306.2.12 Field Quality Control.

A. Inspect each inlet for and repair all visible leaks and damp spots.

END OF SECTION

Section 307
Manholes

307.1. General

307.1.1 Description

A. This section covers manholes, including ring and covers, steps, grade rings, fittings, and other appurtenances.

B. This section also covers the rehabilitation of existing manholes.

307.1.2 Related Sections

A. Sections 100-110 for general specifications.

307.1.3 Quality Assurance

A. Manhole inverts shall not deviate from elevations shown on the Drawings by more than ± 0.03 ft.

307.1.4 Product Delivery, Storage and Handling

A. Do not deliver precast concrete sections to job until concrete has attained at least eighty percent (80%) of specified strength.

307.1.5 Alternatives

A. Manhole bases may be either monolithically precast or cast-in-place. Reference Section xxx for concrete specifications.

307.2. Products

307.2.1 Concrete

A. Cast-In-Place.

1. Meet the Requirements of Section xxx - Cast-in-Place Concrete.
2. CDOT Class D
3. Strength: Four thousand five hundred (4500) psi at twenty-eight (28) days
4. Cement: Type II or Type I/II
5. Slump: Two inches (2").
6. Air Entrapment: Five to Eight percent (5%-8%).

B. Mortar.

1. One (1) part Portland Cement, ASTM C150, Type II.
2. Three (3) parts sand, ASTM C144.
3. One-half (1/2) part hydrated lime, ASTM C207, Type S.

C. Grout (non-shrink).

1. Pre-mixed: Quickrete "Non-Shrink Precision Grout", or equal.
2. Job Mixed:
   a. One)1) part Portland Cement, ASTM C150, Type II.
   b. One (1) part sand, ASTM C144.
   c. One (1) part Quickrete Non-Shrink Precision grout, or equal.

307.2.2 Precast Concrete

A. Bases, barrels, cones and flat tops.

1. Cast base at first barrel section monolithic.
2. Meet Requirements of: ASTM C478.
3. Cement: Type II or Type I/II
4. Invert: Cast-in-place concrete as specified in paragraph 401.2.1 above.
5. Provide horseshoe shaped openings for manholes to be installed in existing lines.

307.2.3 Manhole Gaskets.

A. Meet Requirements of: SS-S-210 A, AASHTO M-198 75 1, and ASTM C990-91

B. Diameter:

1. 48-inch manholes: One and one-half inch (1½").
2. 60-inch manholes: One and three-quarters inch (1 ¾").
3. 72-inch manholes: Two inch (2").

C. Approved Manufacturers.

1. K.T. Snyder Co., "Ram-Nek" or "Rubr'-Nek."
2. Hamilton-Kent Mfg. Co., "Kent Seal."
3. ConSeal, "CS-231 Controlled Expansion Waterstop Sealant."
4. Or equal.

307.2.4 Pipe Penetration Gaskets.

A. Approved Manufacturers.

1. Dukor Co., "Ko-N-Seal".
2. A-lok Corp., "A-lok".
3. Or equal.

307.2.5 Ring and Cover.

A. Material: Gray Iron meeting requirements of ASTM A48.

B. Construction.

1. Size: Min. Clear opening twenty-four-inch (24") diameter.
2. Weight: Heavy duty four hundred (400) pounds minimum.
3. Bearing surfaces: machined.
4. Lid pattern: checkered top or indented top.
5. Pick hole: concealed.
6. Utility type (SANITARY SEWER) and Town Logo shall be cast into the cover, see Standard Details.

307.2.6 Steps.

A. Materials: Polypropylene plastic-coated steel. See Standard Detail.

B. Construction.

1. Reinforcing rod: One-half inch (1/2") diameter, Grade 60 steel.
2. Length: Nine and three-quarter inches (9¾"), designed for six and three-eighths inch (6 3/8") protrusion from manhole wall.
3. Width: Fourteen inches (14") clear.
4. Tread: notched ridge with retainer lugs on each end.

C. Spacing.

1. Eight inches (8") above bench.
2. Twenty inches (20") maximum below rim.
3. Twelve inches (12") vertical spacing between steps.

307.2.7 Pre-cast Manufacturing.

A. Forms must be rigid, adequately braced, free from dents, gouges or other irregularities which would impair quality, appearance, or performance of members.

B. Holes and Openings. Incorporate into design and fabrication, openings indicated on the approved plans.

C. Surface Finish and Formed Surfaces. Provide a smooth, transverse broom finish at top surface of flat-top slabs. Provide smooth, uniform texture and color for formed surfaces. Remove fins and other projections.

D. Shop Marking. Label or paint, on each section, a shop marking to indicate location and position of each member.

E. Curing. Cure precast sections in accordance with ACI 308 to attain specific design strength.

307.2.8 Renovating Manholes

A. The materials to be utilized in the lining of manholes shall be designed and manufactured to withstand the severe effects of hydrogen sulfide in a wastewater environment.

B. Equipment for installation of lining materials shall be high quality grade and be as recommended by the manufacturer.

C. The lining system to be utilized for manhole structures shall be multi-component stress skin panel liner system as described below:

1. Liner

Installation	Liner
Moisture Barrier	Modified Polymer
Surfacer	Polyurethan/Polymeric blend foam
Final Corrosion Barrier	Modified Polymer

2. Modified polymer shall be sprayable, solvent free, two-component polymeric, moisture/chemical barrier specifically developed for the corrosive wastewater environment.

307.2.9 Approved Manufacturers.

A. SpectraShield

B. Poly-Triplex Technologies

C. Or equal.

307.3. Execution

307.3.1 Inspection

A. Examine each precast section, ring and cover and appurtenance for cracks and other defects. Remove all defective materials from the site.

B. Reference: ASHTO R-73

307.3.2 Manhole Size.

A. Unless directed otherwise on the Drawings use forty-eight (48) inch diameter manholes on sewers eight (8) inch through eighteen (18) inch in diameter, sixty (60) inch manholes on sewers twenty-one (21) inches through thirty (30) inches in diameter, and seventy-two (72) inch manholes on sewers thirty-three (33) inches through forty-two (42) inches in diameter.

B. Use eccentric cones where manhole depth is sixty (60) inches or greater on forty-eight-inch (48") manholes and seventy-two inches (72") or greater on sixty-inch (60") manholes. Use flat top manholes when manhole depth is less than the above and on all seventy-two-inch (72") manholes.

C. Manholes installed at depths greater than twenty feet (20') measured from finished grade to invert shall have an intermediate platform as shown on the Towns Standard Detail.

307.3.3 Installation of Precast Manhole Sections.

A. Connect all pipes to precast manhole sections using pipe penetration gaskets.

B. If inverts are not constructed by precaster and wherever grade and alignment permit, lay the main sewer continuously through the manhole and split the pipe after construction of the invert. Where this is not possible, terminate pipe flush with interior manhole wall and construct transition smooth and of proper radius for uninterrupted flow. In no case shall the invert flow section through the manhole be greater than that of the outgoing pipe. Finish invert with a steel trowel prior to adding riser section to the base.

C. Set each manhole riser section plumb. Use sections of various heights to bring ring and cover to grade. Join manhole sections or pre-formed flexible plastic gaskets. The last barrel section prior to placement of the eccentric cone or the flat top slab shall be the manufacturer's shortest, but in no case greater than twenty-four (24) inches in height. All joint surfaces shall be clean, dry and warm during installation.

D. Install ring and covers on one or a maximum of two (2) pre-cast adjusting rings of varying heights, not to exceed six (6) inches in height each. On buried manholes the total allowable height of adjusting rings and the ring and cover shall be one inch less than the manufacturer's shortest precast barrel section. Set rings in a full bed of mortar and encase in mortar around the entire perimeter. Unless otherwise indicated, set the top of the rings twenty-four (24) inches below finished grade in farmed fields, six (6) inches below finish grade in gravel roadways and such that no part of the ring or cover will project above a point one-quarter (1/4) inch below the finish surface of pavement in paved areas subject to cleaning by snowplows.

E. Fill all lifting holes and other imperfections with mortar. Neatly point inside of joints no matter what joint material is used.

307.3.4 Construction of Cast-in-Place Bases.

A. Set stubs and mains before concrete is placed and recheck for alignment and grade before concrete has set. Where grade and alignment permit, lay the main sewer continuously through manholes and split the pipe after construction of the base. Where this is not possible, terminate the pipe flush with the interior manhole wall and construct transitions smooth and of proper radius for uninterrupted flow. In no case shall the invert flow section be larger than that of the outgoing pipe. Shape the base with a wood float and finish with a steel trowel. Allow the base to set a minimum of forty-eight (48) hours before continuing construction. Twenty-four (24) hour set time allowable with high early as approved by the Town.

B. When thermoplastic pipe is used, connections to the manhole base shall be made using approved manhole couplings cast into the base or a minimum of three (3) pipe gaskets spaced two inches (2") apart on the end of each pipe and cast into the base.

C. If the pipe connection is to a precast section, use pipe penetration gaskets as specified above.

D. Install precast manholes risers, cones, and tops and the ring and covers as specified in paragraphs 401.3.3.C through 401.3.3.E above.

307.3.5 Drop Manholes.

A. Requirements: Drop manhole bases shall be constructed large enough to form a base for the concrete encasing the sewer drop entering the bottom of the manhole. The drop entering the manhole shall be completely encased in concrete up to the spring line of the main sewer line as shown on the Standard Details(s) for sewer line up to fifteen

inches (15") and twelve inches (12") above the pipe as shown on the Standard Detail(s) for sewer line eighteen inches (18") and larger.

B. Drop Distance. All drop manholes must be constructed with an outside drop. The maximum vertical drop shall be ten feet (10').

C. Cleanout. Install a cleanout in the manhole at the level of the main sewer line, as shown in the Standard Details.

D. Lining. All drop manholes must be completely lined as shown in the Standard Details.

307.3.6 Underdrain.

A. The use of all sanitary sewer trench for either a pipe or gravel underdrain is prohibited.

B. Foundation perimeter pipe or gravel are prohibited from connecting to a service or main line trench, and a positive method shall be used to prevent water collected in the foundation perimeter drain from flowing through the service line trench to the main line trench.

C. Sump pumps and foundation perimeter drains are prohibited from connecting directly, or indirectly as through a floor drain, to the sanitary sewer line.

307.3.7 Field Quality Control.

A. Inspect each manhole for and repair all visible leaks and damp spots.

307.3.8 Vacuum Testing.

A. All manholes must pass vacuum testing per ASTM C1244-11. Vacuum testing shall be performed after backfilling. Vacuum testing must be observed by the Town.

B. Typical Field Test Procedure:

1. Plug and brace all penetrations.
2. Install 5 psig rated plugs beyond boot seals on influent and effluent pipes.
3. Secure vacuum apparatus.
4. Start vacuum.
5. Attain a vacuum of 10-inches Hg.
6. Time pressure drop to 9-inches Hg.
7. Release vacuum.
8. Compare time of pressure drop to the table below.

9. If leaks are evident excavate, seal, re-backfill, and re-test.

MINIMUM TEST TIMES FOR VARIOUS MANHOLE DIAMETERS (ASTM C1244-93)									
Depth (feet)	**Diameter (inches)**								
	30	33	36	42	48	54	60	66	72
	Time (seconds)								
5	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	25	27	32	38	45	52	59	65	73
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	15
28	39	42	49	59	69	81	91	101	113
30	42	45	53	65	74	87	98	108	121

END OF SECTION

Section 308
Underdrain Systems

308.1. General

308.1.1 Description

A. CONTRACTOR shall furnish all labor, tools, and equipment and perform all Work necessary for, or incidental to, the supply and installation of pipe underdrains as shown in the DRAWINGS and specified herein. This WORK includes trenching, placement of a geotextile fabric, rock, HDPE pipe, PVC pipe, and clean-outs to drain water from structure foundations. The WORK shall be coordinated with the work of all other trades and activities on the PROJECT.

B. CONTRACTOR shall furnish and install all supplementary and miscellaneous items, appurtenances and devices incidental to or necessary for a complete installation.

308.1.2 Related Sections

A. Sections 100-110 for general specifications.

308.1.3 Quality Control

A. American Association of State Highway and Transportation Officials (AASHTO):

1. M252, Standard Specification for Corrugated Polyethylene Drainage Pipe.
2. M294, Standard Specification for Corrugated Polyethylene Pipe, 300-mm to 1500-mm Diameter.

B. ASTM International (ASTM):

1. C33, Standard Specification for Concrete Aggregates.
2. D737, Standard Test Method for Air Permeability of Textile Fabrics.
3. D1784, Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
4. D3034, Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
5. D3212, Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.

6. D3776, Standard Test Method for Mass per Unit Area (Weight) of Fabric.
7. D3786, Standard Test Method for Bursting Strength of Textile Fabrics—Diaphragm Bursting Strength Tester Method.
8. D3887, Standard Specification for Tolerances for Knitted Fabrics
9. D4491, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
10. D4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
11. D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
12. D4751, Standard Test Method for Determining the Apparent Opening Size of a Geotextile.
13. D4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
14. D6241, Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products using a 50-mm Probe.
15. D6707, Standard Specification for Circular-Knit Geotextile for Use in Subsurface Drainage Applications
16. F405, Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings.
17. F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

308.1.4 Submittals

A. Submittals shall include as a minimum the following:

1. Geotextile fabric.
2. Rock gradation results.
3. Polyethylene pipe and fittings (including slot perforation pattern).
4. PVC pipe and fittings (including perforation pattern).
5. Meter vault sections and lid (where required for clean-outs).

308.1.5 Delivery, Storage and Handling

A. Geotextile: During shipment and storage, the rolls of fabric shall be protected against deterioration from the sun, mud, dirt, dust, and other deleterious conditions at all times.

B. Keep Pipe shaded from direct sunlight prior to installation in the trench.

308.2. Products

308.2.1 Geotextile Fabric

A. The fabric shall have complete resistance to deterioration from ambient temperatures, acid, and alkaline conditions, and shall be indestructible to microorganisms and insects. The material shall be resistant to short-term (until placement) deterioration by ultraviolet light or protected until placement, as recommended by the manufacturer, such that no deterioration occurs.

B. Fibers used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long chain synthetic polymers composed of at least eighty five percent (85%) by weight polyolefins, polyesters, or polyamides. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvedges.

C. The property values shown below are not design values but represent the minimum accepted physical characteristics of the geotextile required. The number represents a value to be confirmed by the manufacturer. These values represent minimum average roll values (for example, any roll tested shall meet or exceed the minimum values in the table).

Property	Value	Test Method
Grab Strength	120 lbs.	ASTM D4632
Grab Tensile Elongation	55%	ASTM D4632
Burst Strength	225 psi	ASTM D3786
Puncture Resistance	65 lbs.	ASTM D4833
Trapezoid Tear Strength	50 lbs.	ASTM D4533
Apparent Opening Size	70, U.S. Standard Sieve	ASTM D4751
Permittivity	1.7 $sec.^{-1}$	ASTM D4491
Water Flow Rate	140 $gal./min./ft^2$	ASTM D4491

D. Geotextile fabric for pipe underdrains shall be Mirafi 140N or equivalent.

308.2.2 Drain Sleeve

Property	Value	Test Method
Weight	3.5-3.9 $oz./yd.^2$	ASTM D3776
Thickness	0.040 in.	-
Burst Strengths (min)	120 psi	ASTM D3887
Puncture Resistance (min)	180 bs.	ASTM D6241
Air Permeability	700 $ft.^3/ft.^2/min.$	ASTM D737
Apparent Opening Size	30, U.S. Standard Sieve	ASTM D4751
Permittivity (min)	2.4 $sec.^{-1}$	ASTM D4491

Water Flow Rate	300 gal./min./ft^2 (2" Constant Head)	ASTM D4491

308.2.3 Rock Bedding

A. Unless otherwise shown in the DRAWINGS, rock shall consist of dense, clean, uniformly graded material with a maximum size of two (2) inches and less than five percent (5%) passing the three-eighths inch (3/8") sieve. Coarse concrete aggregate meeting the requirements of ASTM C33 No. 4 may be used.

308.2.4 HDPE Pipe and Fittings

A. ADS Heavy Duty Pipe meeting ASTM F405 with slotted or circular perforations providing a minimum inlet area as required by AASHTO M252 or AASTO M294 Class 2 perforations. The slotted perforation pattern shall be in accordance with AASHTO M252 or AASHTO M294 Class 2 perforations providing a flow rate for six-inch (6") diameter pipe of ninety-four hundredths (0.94) GPM at a one foot (1') pressure head. The pipe is available in ten-foot (10') joints, one hundred (100), and one thousand five hundred (1,500) linear foot rolls. The pipe shall include a factory installed drain sleeve that meets the requirements of ASTM D6707 (ADS Drain Sleeve or approved equal).

B. HDPE pipe and fittings shall be made in accordance with ASTM F405.

C. HDPE pipe shall be Type S or approved equal.

308.2.5 PVC Pipe and Fittings

A. Specifications and Dimensions:

1. PVC pipe and fittings shall be made in accordance with ASTM D1784.

2. The pipe shall be designed, manufactured, tested, inspected and marked in accordance with the provisions of this SPECIFICATION and ASTM D3034. The minimum wall thickness shall be SDR 35.

3. Nominal pipe lengths of pipe shall be twenty (20) feet, with shorter lengths provided as required by DRAWINGS, alignment, and grade.

B. Joint Type

1. Pipe joints shall be made using an integral bell with an elastomeric gasket pushon type joint. The joint shall comply with the requirements of ASTM D3212.

2. Gaskets shall meet the requirements of ASTM F477.

3. Solvent-cement joints are strictly prohibited.

C. Perforations:

1. PVC piping shown on the DRAWINGS to be perforated shall be perforated to the pattern shown on the DRAWINGS. If no pattern is shown on the DRAWINGS, four (4) one-quarter inch (1/4") diameter holes shall be provided at six-inch (6") centers at the quarter points of the pipe. No perforation shall be made within six (6) inches from either end of the pipe.

2. Laterals, drain lines away from the structure, and the top ten (10) feet of cleanout risers shall have a solid wall.

308.2.6 Meter Vault

A. The precast concrete meter vault sections and lid shall be to the dimensions shown on the DRAWINGS. The vault shall be furnished by Amcor or equivalent. The lid shall be blank and not be labeled "water."

308.3. Execution

308.3.1 Trenching

A. The underdrain shall be trenched into the native soil a maximum of six (6) inches if so shown on the DRAWINGS to the grades shown on the DRAWINGS. The trenches shall slope uniformly at the grade shown on the DRAWINGS.

308.3.2 Geotextile Fabric

A. All perforated pipe shall be wrapped with geotextile fabric.

B. Perforated pipe in cleanout risers shall be wrapped in geotextile fabric. Suitable means shall be found to seal the seam and maintain the position of the fabric during backfilling.

C. Care shall be taken not to tear any geotextile fabric during backfilling.

308.3.3 Rock

A. Rock shall be placed on the geotextile fabric to the depth shown prior to placement of the underdrain pipe. After the pipe is in place, rock shall be placed along and over the top of the pipe in a manner that shall not damage the pipe.

308.3.4 HDPE Pipe and Fittings

A. The pipe shall be installed in accordance with the manufacturer's written instructions, a copy of which shall be maintained on site during pipe installation.

308.3.5 PVC Pipe and Fittings

A. General: When laying PVC pipe out on a curve, the joints may be deflected up to seventy five percent (75%) of the maximum value

permitted by the manufacturer of the pipe. Tighter curves shall be made by either using shorter lengths of pipe or by using manufactured bends.

B. Perforated Pipe: Perforated pipe shall be placed in the rock bedding as shown on the DRAWINGS.

C. Solid Pipe: Solid PVC pipe shall be placed on six (6) inches of sand bedding, unless the native soil is capable of providing uniform support as approved by ENGINEER or shown on the DRAWINGS.

308.3.6 Clean-outs

A. The clean-out risers shall be protected from damage during the backfilling operations.

B. The ring and cap shall be secured in place with a reinforced concrete collar as shown on the DRAWINGS.

END OF SECTION

Section 309

Precast Reinforced Concrete Box Culverts

309.1. General

309.1.1 Description

A. This work shall consist of furnishing and placing Precast Reinforced Concrete Box (RCB) Culvert of the size and dimensions and at locations shown on the plans.

B. The precast RCB culvert shall be constructed to the lines and grades given by the Engineer and in accordance with the design shown on the plans.

C. Precast RCB culvert sections shall be monolithic.

D. Square or rectangular precast RCB sections shall be designed and constructed conforming to ASTM C1577, as controlled by the height of cover shown on the plans and specified herein. The design cover and loading calculations shall be included in the working drawing submittal.

E. Design calculations and working drawings shall be submitted for precast RCB sections for review and approval. Working drawings shall include the contract number, the jobsite name of the structure as shown on the plans, bridge number (if applicable), material designations, bill of materials, complete fabrication details, and guidelines for handling and assembly. Calculations and working drawings shall be prepared and stamped by a Colorado Registered Professional Civil Engineer.

309.1.2 Related Sections

A. Sections 100-110 for general specifications.

309.2. Materials

309.2.1 General

A. Manufacturer Certification and Qualification. The manufacturer of the precast RCB shall submit for approval, substantial evidence of qualification to produce the product. Such evidence of qualification shall include the following:

1. Plant produced concrete products proposed for use will require either National Precast Concrete Association (NPCA) or American Concrete Pipe Association (ACPA) certification.

2. Written evidence of successful completion of at least three (3) projects of size and scope similar to the project for which the manufacturer wishes to be pre-qualified. The projects shall have been performed within the previous three (3) years. Such evidence shall include references for said work.

3. A written document detailing the manufacturer's Quality Control Program that demonstrates conformance to the requirements of these specifications.

B. Concrete. Concrete shall be as specified in Section XXX - Structural Concrete. A copy of the concrete mix design which will be used in the manufacture of the precast RCB shall be submitted for review and approval. The mix design shall identify the type of casting process (wet or dry casting), in addition to the requirements of Section XXX - Structural Concrete.

1. When a wet cast manufacturing process is used, concrete shall be Class A Modified or Class AA Modified. A wet cast manufacturing process is defined as one in which forms are removed after 6 hours or more.

2. When a dry cast manufacturing process is used, concrete shall be Class A Modified. A dry cast manufacturing process is defined as one in which the concrete is densified by continuous vibration, and forms are removed immediately. If approved, alternative aggregate gradations from those specified in Section XXX - Structural Concrete may be allowed.

C. Product Certification. A certificate of compliance issued by the manufacturer of the precast RCB shall be submitted at the time of shipment. The certificate shall include the following:

1. The specification under which the box sections were manufactured.

2. All project identification information as noted for working drawings above.

3. The number of box sections of each size which are being shipped.

4. A statement that the construction of the box sections, and all materials used therein, are in compliance with the requirements of the applicable ASTM or AASHTO specifications.

5. Copies of the Quality Control test results, and compressive strength for that lot shall be kept at the plant and available for review.

D. The Engineer may, at their option, inspect the precast facility operations including, but not limited to, the reinforcing assembly, forming equipment, concrete batching equipment; placement, curing, and

handling equipment; and testing and inspection equipment and procedures.

E. The manufacturer of the precast RCB shall maintain, for a period of seven (7) years following shipment, a copy of the appropriate test reports and other documentation, including compressive strength tests, necessary to support the certificates of compliance.

F. If the RCB culverts have not been cast prior to the notice to proceed date, written notification shall be given two (2) weeks in advance of performing casting operations for the project.

G. All materials will be subject to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials in the work.

H. Reinforcement shall conform to the requirements of Section XXX - Reinforcing Steel unless otherwise noted.

I. All joints of the precast boxes shall be sealed with a flexible, butyl-blend, watertight, preformed joint material with a minimum cross-section width of 1 ¼ square inches, installed according to the manufacturer's recommendations. Joint material shall conform to ASTM C990.

1. Joint surfaces of the precast box shall be clean, dry and free of any foreign material, including mud, aggregate base, and leveling course. Apply primer in accordance with manufacturer's recommendations. Install sealant to form a continuous seal around the perimeter of the joint. The sealant may be placed on the lower portion of the groove of the downstream box and upper portion of the tongue of the upstream box, provided there are three (3) inches of overlap of the sealant on each side of the box.

309.3. Execution

309.3.1 Earthwork

A. Excavation and backfill shall conform to the requirements of Section XXX – Excavation and Embankment, and Section XXX – Trenching, Bedding, and Backfill when the precast RCB is constructed in a trench.

1. The precast RCB shall be bedded as shown in the plans or as specified in the Special Provisions.

2. When no bedding class is specified, the requirements for normal bedding as shown in Section XXX – Trenching, Bedding, and Backfill shall apply.

3. The lines and grades shall be established by the Engineer or as designated in the contract documents.

B. Where precast RCB sections are to be installed in new embankments on a steep slope or in a difficult location, the height of new embankments may be varied as directed by the Engineer.

C. When headwalls are not required and granular materials are used for backfilling, the fill at the ends of the structure shall be sealed against the infiltration of water by bedding the ends of the structure using Class II CLSM or concrete.

D. Subgrade preparation shall conform to the requirements of Section XXX – Trenching, Bedding, and Backfill.

309.3.2 Headwalls

A. Where shown on the plans, inlet and outlet headwalls shall be constructed or installed in connection with precast box sections.

B. Where headwalls are constructed or installed, the ends of precast RCB sections shall be placed flush or cut off flush with the headwall face, unless otherwise permitted by the Engineer.

C. Headwalls shall be constructed to conform to Section XXX - Structural Concrete.

309.3.3 Laying Precast Reinforced Concrete Box Culverts

A. Construction installation shall comply with AASHTO LRFD Bridge Design Specifications, most current edition, Section XXX - Trench Excavation and Backfill, and these specifications.

B. Inspection of precast RCBs prior to laying:

1. Written notification shall be given twenty-eight (28) days in advance of performing casting operations.

2. No precast box shall be laid which is excessively cracked per Subsection 125.3.4, (i.e., cracked, spalled, or damaged) and shall be removed from the work. Precast RCB culverts which show defects due to handling will be rejected at the site of installation regardless of prior acceptance.

3. Fine cracks and checks on the surface of the member which do not extend to the plane of the nearest reinforcement will not be cause for rejection unless they are numerous and extensive. Cracks which extend into the plane of the reinforcing steel shall be repaired in an approved manner.

4. Small damaged or honeycombed areas which are purely surface defects in nature shall be repaired in an approved manner. Excessive damage, honeycomb, or cracking will be subject to structural review at the Contractor's expense. All repairs shall be made sound, properly finished, and cured according to the pertinent specifications. When fine cracks or hair checks on the surface indicate poor curing practices, the production of precast boxes shall be discontinued until corrections are made and proper curing is provided.

C. All precast boxes shall be carefully handled during loading, unloading, transporting, and laying.

D. Precast box laying shall begin at the downstream end of the box except for extensions of existing boxes. Place the bottom of the box in contact with the bedding throughout its full length. The first section of box to be laid shall be firmly placed to the designated line and grade at the outlet end with the groove end pointing upstream. Construction loads shall be considered by the design engineer. Design loads shall not be exceeded at any time. Boxes shall be inspected before any backfill is placed. Contractor shall ensure that no rocks greater than three (3) inches or other rigid or jagged material is present in the bedding material where box will be laid directly on the material.

E. The box segments shall be joined in such a manner that the ends are fully entered and the inner surfaces are flush and even. The maximum tolerable nominal horizonal gap between joints is 0.75 inch, or the manufacturer's maximum joint gap tolerance, whichever is less. This gap shall be checked immediately after laying each section. Any annular space existing in the interior portion of the joint shall be filled with an approved mortar and finished flush with the interior surfaces of the box units. If the inner surfaces are not flush or there is an adverse slope, a procedure to repair the vertical gap must be submitted to the Engineer for approval.

F. After laying, the box culvert segments shall be checked for alignment and grade. The culvert shall be installed within the tolerances for horizontal and vertical location and gradient as follows:

1. Horizontal location within 0.05 feet of location shown on plans.
2. Vertical location within 0.05 feet of elevation shown on plans.
3. Gradient shall not vary by more than ten percent (10%) of slope shown on plans.

G. The Contractor shall remove and relay or replace box that is out of alignment, damaged, or has unduly settled at no cost to the Town.

H. The interior of the precast box sections shall be kept free of dirt and other foreign material as the box laying progresses and be left clean at the completion of the work. Boxes which are not in true alignment, which show any undue settlement, or are damaged shall be taken up and re-laid at the Contractor's expense. The bottom of the trench shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of the box for the leveling course to be placed on. Blocking shall not be used to bring the box to grade. Box sections shall be checked for alignment and grade at the time of joining the sections.

I. The box culverts shall be laid with nominal three (3) inch space between multiple box culverts. The annular space shall be grouted. The grout shall be a workable mix suitable for pumping without segregation and shall conform to the requirements of Section XXX – Grout. The grout shall be placed by pumping or an approved alternate method and consolidated by mechanical vibration or rodding during placement. The grouting shall be performed by a continuous placement in lifts not exceeding six (6) feet. Vertical grout barriers may be used to control the flow of grout horizontally. The grout shall attain a minimum compressive strength of 2,500 psi in 28 days when tested according to ASTM C39.

J. The backfill material shall comply with the requirements of Section XXX – Trenching, Bedding, and Backfill. If the Contractor cannot fit compaction equipment between the box and the trench wall, or the conditions are unsafe for compaction and/or testing, CLSM must be used.

K. The Contractor shall provide box culverts with beveled ends where the radius of the center line alignment exceeds the manufacturer's minimum radius of curvature allowed using pulled joints. The maximum bevel angle shall not exceed 5 degrees. The Contractor may provide elbows, with a maximum deflection angle of 22 ½ degrees, where the radius of the center line alignments is less than the manufacturer's minimum radius of curvature for a 5-degree bevel.

309.3.4 Inspection

A. All precast RCB joints and lengths shall be 100 percent inspected.

B. Inspection and Testing shall be performed by the contractor during and after installation to ensure proper performance.

C. Installation of bedding and backfill materials, as well as their placement and compaction, shall adhere to the requirements of this section and other applicable sections.

D. Errors in line and grade, as well as any improper placement or backfill techniques, shall be corrected prior to placing significant backfill or trench fill.

E. Joints shall be properly assembled to prevent the infiltration of soil fines. Flexible joint material shall be properly placed to prevent groundwater infiltration and shall be uniformly oriented around the precast RCB.

F. Shallow cover installations shall be checked to ensure the minimum cover level is provided.

G. The Contractor shall complete an internal quality inspection a minimum of thirty (30) days after final backfill has been placed and prior to final acceptance by the Town. The culvert shall be cleaned and inspected for cracks and joint gaps using visual physical measurement or other devices, including but not limited to calibrated television or video cameras, subject to approval by the Engineer.

H. Cracks in precast RCB culverts (both longitudinal and circumferential) that are less than 0.10 inch in width are generally considered non-structural flaws and need not be repaired. Cracks that are equal to or exceed 0.10 inch in width shall require an evaluation by a Colorado licensed professional engineer. The Contractor's engineer shall provide a recommendation regarding removal or repair in accordance with ASTM C1577 standards and subject to approval by the Town.

I. Precast RCB joints and lengths that do not meet the specification shall be repaired or replaced at the Contractor's expense. Any replacement precast RCB shall also be subject to the same testing.

J. All inspection and testing results shall be submitted and approved by the Town before final payment. The Town Engineer shall be allowed access to randomly inspect at least 10 percent of the total number of precast RCB runs.

309.3.5 Backfill

A. Precast RCB culvert section backfill shall conform to the requirements of Section XXX – Trenching, Bedding, and Backfill, unless otherwise noted.

B. Prior to placing backfill material, all handing holes in RCB culverts shall be completely filled with grout or other acceptable methods.

309.3.6 Extending Existing Culverts

A. Where shown on the plans or directed by the Engineer, existing culverts shall be extended in accordance with the provisions for installing new culverts and the following additional provisions.

B. Existing headwalls shall be demolished, removed, and disposed, or moved to the extended location as indicated on the plans or ordered by the Engineer.

C. A headwall that is not to be reset shall be demolished without injury to the existing culvert and removed and disposed of. If shown on the plans or ordered by the Engineer, a new concrete headwall shall be constructed in accordance with the provisions of Section XXX - Structural Concrete, of these specifications or a flared end section shall be attached thereto.

END OF SECTION

Section 310
Pipe Culverts

310.1. General

310.1.1 Description

A. This section includes general requirements that are applicable to all types of culvert pipes regardless of the material or culvert use with the following exceptions:

1. Structural plate pipe,
2. Water distribution systems and sanitary sewer system specifications will specify the pipe to be used in their respective installations.

B. This work shall consist of furnishing and installing pipe culverts, siphons, end sections, end walls, and so forth, as may be required to complete the work shown on the plans or established by the Engineer.

C. The pipe shall comply with AASHTO Design and Construction LRFD Specifications most current edition and these specifications. The more stringent requirements shall apply.

310.1.2 Related Sections

A. Sections 100-110 for general specifications.

B. Section XXX - Reinforced Concrete Pipe

C. Section XXX – Waterstop?

310.2. Materials

310.2.1 General

A. When the location of manufacturing plants allows, the plants will be inspected periodically for compliance with specified manufacturing methods.

1. Material samples will be obtained for laboratory testing for compliance with materials quality requirements as specified in the referenced specifications.
2. This can be the basis for acceptance of manufacturing lots.

B. All materials will be subject to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials in the work.

C. The lengths shown on the plans are approximate.

D. For structural plate pipe and arches, comply with Section XXX - Structural Plate Pipe and Pipe Arch Culverts.

310.3. Execution

310.3.1 Earthwork

A. Excavation and backfill shall conform to the requirements Section XXX - Trench Excavation and Backfill, when the culvert is placed in a trench.

1. The pipe shall be bedded as shown in the plans and/or drawings appended to the plans or as specified in the Special Provisions.
2. When no bedding class is specified, the requirements for normal bedding as shown in the Uniform Standard Drawings shall apply.
3. The lines and grades will be established by the Engineer or as designated in the contract documents.

B. Where pipes are to be installed in new embankments on a steep slope or in a difficult location, the height of new embankments may be varied as directed by the Engineer before installing pipes.

C. When headwalls are not required and granular materials are used for backfilling, the fill at the ends of the structure shall be sealed against the infiltration of water by bedding the ends of the structure using Class II CLSM or concrete.

310.3.2 Headwalls

A. Where shown on the plans, inlet and outlet headwalls shall be constructed or installed in connection with culvert pipes.

B. Where headwalls are constructed or installed, the ends of pipes shall be placed flush or cut off flush with the headwall face, unless otherwise permitted by the Engineer.

C. Headwalls shall be constructed to conform to Section XXX – Structural Concrete.

310.3.3 End Sections

A. The bed for the end section shall be excavated to the required width and grade.

B. For metal end sections with toe plates, a trench shall be excavated for the toe plate in a manner to permit the toe plate from being against the inner face of the trench when the end section is in its final position.

After end sections have been properly secured to the pipe, this trench shall be backfilled and firmly compacted.

C. Precast concrete end section shall be placed with its tongue (or groove) fully entered in the groove (or tongue) of the pipe.

D. Thermoplastic pipe greater than 30 inches shall not be used at the open-end sections.

310.3.4 Jacked Pipes

A. Culvert pipe to be jacked in place between the limits shown on the plans shall conform to the requirements of the respective section of pipe culverts.

B. The strength of pipe or gauge of pipe will be determined for vertical load only in embankment conditions. Any additional reinforcement or strength required to withstand jacking pressure shall be determined and furnished by the Contractor at no additional cost to the Town.

C. Variation from theoretical alignment and grade at the time of completion of placing shall not exceed 0.2 foot for each 20 feet of pipe placed.

D. The diameter of the excavated hole shall not be more than 0.1 foot greater than the outside diameter of the pipe.

1. Sluicing and jetting with water will not be permitted.

2. When the material tends to cave in from outside these limits, a shield shall be used ahead of the first section of pipe or the face of excavation shall not extend beyond the end of the pipe greater than 1 1/2 feet unless permitted by the Engineer.

E. Areas resulting from caving or excavating outside the above limits shall be backfilled with sand or grout by a method that will fill the voids.

310.3.5 Laying Culvert Pipe

A. Laying of culvert pipe shall conform to the requirements of the respective sections of culvert pipe.

310.3.6 Extending Existing Culverts

A. Where shown on the plans or directed by the Engineer, existing culverts shall be extended in accordance with the provisions for installing new culverts and the following additional provisions.

B. Existing headwalls shall be demolished, removed, and disposed, or moved to the extended location as indicated on the plans or ordered by the Engineer.

C. A headwall that is not to be reset shall be demolished without injury to the existing culvert and removed and disposed of. If shown on the plans or ordered by the Engineer, a new concrete headwall shall be constructed in accordance with the provisions of Section XXX - Structural Concrete, of these specifications or a flared end section shall be attached thereto.

310.3.7 Video Inspection

A. Unless otherwise approved by the Town, all video inspection shall be completed by a National Association of Sewer Service Companies (NASSCO) certified operator, certified at the user level minimum.

1. The user shall have completed the Pipeline Assessment and Certificate Program (PACP).

2. Video inspection reports must follow the NASSCO format and use standard sewer defect codes.

END OF SECTION

Section 311

Structural Plate Pipe and Pipe Arch Culverts

311.1. General

311.1.1 Description

A. This work shall consist of furnishing and installing structural plate pipe and pipe arch culverts conforming to these specifications and consisting of the sizes and dimensions required in the plans and installing the structures at locations designated in the plans or established by the Engineer, and in conformity with the lines and grades established by the Engineer.

B. The work shall also include the reinstallation of salvaged structural plate pipe and pipe arch culverts.

C. Plates for a pipe arch shall form a cross section made up of 4 circular arcs tangent to each other at their junctions and symmetrical about the vertical axis.

1. The top shall be an arc of not more than 180 degrees nor less than 155 degrees.
2. The bottom shall be an arc of not more than 50 degrees nor less than 10 degrees.
3. The top shall be joined at each end to the bottom by an arc having a radius between 16 inches and 21 inches and of not more than 87-1/2 degrees nor less than 75 degrees.

311.1.2 Related Sections

A. Sections 100-110 for general specifications.

311.2. Materials

311.2.1 General

A. Materials shall meet the requirements of AASHTO M167, "Structural Plate Pipe and Pipe Arches."

B. If called for in the bid schedule, plates for pipes and pipe arches shall be bituminous coated in accordance with AASHTO M190, Type A, B or C.

1. When bituminous coating is applied to plates for structural steel plate pipe, arches, and pipe arches, each plate shall have the thickness

painted on the inner surface so that the plate thickness can be readily identified.

2. The portion of nuts and bolts used for assembly of bituminous coated structural steel plate pipes, arches, and pipe arches outside the pipe shall be bituminous coated after installation. The portion of the nuts and bolts inside the pipe need not be bituminous coated.

3. Damaged bituminous coating shall be repaired by the Contractor by applying bituminous material conforming to AASHTO M190 or other approved material.

C. The bottom plates of structural plate pipes and arches shall be 1 gauge heavier than the gauge specified in the bid schedule, which will apply to top and side plates. When 1 gauge is specified, the bottom plates shall also be 1 gauge.

D. Plates shall be shipped and handled in a manner to prevent bruising, scaling, or breaking of the spelter coating.

1. Damaged spelter coating in lieu of the requirements of AASHTO M36 may be repaired by thoroughly wire brushing the damaged area and removing all loose and cracked spelter coating, after which the cleaned area shall be painted with 2 coats of zinc oxide-zinc dust paint conforming to Federal Specification MIL-P-15145.

2. The paint shall be properly compounded in a suitable vehicle in the ratio of 1 part zinc oxide to 4 parts zinc dust by weight.

E. Planned lengths and sizes are approximate. The Contractor shall not order and deliver the plates until a list of sizes and lengths is furnished to the Contractor by the Engineer.

311.3. Execution

311.3.1 Plate Description

A. Plates shall consist of structural units of galvanized corrugated metal.

1. Single plates shall be furnished in standard sizes to permit structure length increments of 2 feet.

2. Plates have approximately a 2-inch lip beyond each end crest, which results in the actual length of a given structure being approximately 4 inches longer than the nominal length, except when skewed or beveled.

B. The plates at longitudinal and circumferential seams shall be connected by bolts.

1. Joints shall be staggered so that not more than 3 plates come together at any 1 point.

2. Each plate shall be curved to 1 or more circular arcs.

311.3.2 Fabrication

A. Plates shall be formed to provide lap joints.

1. The bolt holes shall be so punched that all plates having like dimensions, curvature, and the same number of bolts per foot of seam shall be interchangeable.

2. Each plate shall be curved to the proper radius so that the cross-sectional dimensions of the finished structure will be as specified.

B. Bolt Hole Configuration:

1. Unless otherwise specified, bolt holes along those edges of the plates that will form longitudinal seams in the finished structure shall be staggered in rows 2 inches apart, with 1 row in the valley and 1 in the crest of the corrugations.

2. Bolt holes along those edges of the plates that will form circumferential seams in the finished structure shall provide for a bolt spacing of not more than 12 inches.

3. The minimum distance from the center of hole to edge of the plate shall be not less than 1-3/4 times the diameter of the bolt.

4. The diameter of the bolt holes in the longitudinal seams shall not exceed the diameter of the bolt by more than 1/8 inch.

C. Burnt edges shall be free from oxide and burrs and shall present a workmanlike finish.

1. Damaged spelter on the surface of the plates and the edges of cuts shall be repaired as set forth in Subsection 311.2.1 within 24 hours after the cuts are made.

2. Each cut plate shall be legibly identified to designate its proper position in the finished structure.

311.3.3 Field Inspection

A. The Engineer shall be furnished with an itemized statement of the number and length of the plates in each shipment by the manufacturer.

B. Each plate included in a shipment shall conform to these specifications.

C. If 25 percent or more of the plates in any shipment fail to conform to the specifications, the entire shipment may be rejected.

311.3.4 Earthwork

A. Excavation and backfill shall conform to Section XXX - Trench Excavation and Backfill when the culvert is placed in a trench.

B. The pipe shall be laid in a trench excavated to the lines and grades established by the Engineer.

C. The bottom of the trench shall be graded and prepared to provide full contact with the pipe throughout its entire length.

D. Where pipes are to be installed in new embankments on a steep slope or in a difficult location, the height of new embankments may be varied when permitted by the Engineer before installing pipes.

E. When headwalls are not required and granular materials are used for backfilling, the fill at the ends of the structure shall be sealed against the infiltration of water by bedding the ends of the structure in well-tamped clay as shown on the plans.

F. When the pipe is laid in hard material, a space below the pipe shall be excavated and replaced with a bed of compacted sand or compacted earth fill. In no place shall the pipe be laid directly on the hard material.

G. When sand or compacted fill is used, the depth of the sand or compacted fill below the pipe shall not be less than 1/3 the inside diameter of the pipe with a minimum of 4 inches and a maximum of 12 inches with the exception that an extra 1/2 inch shall be added for every foot the trench exceeds 16 feet in depth. This bed shall extend at the sides of the pipe at least a distance of 1/4 the outside diameter of the pipe.

H. When no bedding is specified, the requirements for Normal bedding as shown in the Standard Details shall apply.

311.3.5 Assembling

A. The structural plate structures shall be assembled in accordance with the manufacturer's assembly instructions.

1. The unsupported edges of all plates shall be held in position by temporary props.

2. Each row of side plates shall extend far enough to support the plate above until the first complete ring has been assembled.

3. A sufficient number of bolts shall be progressively installed to hold the plates in position.

4. Bolts shall not be tightened until tightening will not interfere with the adjustment and matching of additional plates and sections.

5. Special care shall be exercised in the use of drift pins or pry bars to prevent chipping or injury to the galvanized or other protective coating, and such injury shall be repaired as set forth in Subsection 311.2.1 at no additional cost to the Contracting Agency.

6. After all plates are in place, the bolts shall be progressively and uniformly tightened from 1 end of the structure, and the tightening operation repeated to be sure that all bolts are tight.

7. Bolts shall be tightened to a minimum of (a) 100 foot-pounds of torque for plates of 7 gauge and lighter, and (b) 150 foot-pounds of torque for plates of 5 gauge and heavier and shall be rechecked and retightened as necessary just prior to backfilling.

B. The elliptical-shaped pipes shall be installed with their long diameter vertical.

C. Pipe arches shall be installed with their span width horizontal.

311.3.6 Strutting

A. When specified, structural plate pipes that are not fabricated out-of-round before erection shall be timber strutted vertically 3 percent out-of-round before placement of the embankment.

B. The pipe shall be deformed to the required degree by means of suitable jacks.

1. The method of jacking shall be approved by the Engineer.

2. A tolerance of 25 percent above or below the specified deformation will be permitted.

C. Strutting shall be carried uniformly from end to end of the pipe.

D. The struts shall be left in place until the embankment is complete and compacted, unless otherwise ordered by the Engineer.

E. In lieu of strutting structural plate pipe, the Contractor may furnish structural plate pipe with the vertical axis fabricated out-of-round 5 percent of the nominal diameter from end to end of the pipe.

1. A tolerance of 25 percent above or below the specified deformation will be permitted.

2. The deformation shall be made by approved shop methods, and any coating damaged or destroyed shall be repaired or replaced satisfactorily.

311.3.7 Workmanship

A. In addition to compliance with the details for construction, the completed pipe shall show careful, finished workmanship in all particulars.

B. Structural plates on which the spelter coating has been bruised or broken or which show defective workmanship shall be rejected, except as otherwise specified.

1. The requirement applies not only to the individual plates, but to the shipment on any project as a whole.

2. Among others, the following defects are specified as constituting poor workmanship and the presence of any or all of them in any individual culvert plate, or in general in any shipment, shall constitute sufficient cause for rejection:

a. Uneven laps.

b. Variation from a straight center line.

c. Ragged edges.

d. Loose, unevenly lined or spaced bolts.

e. Bruised, scaled, or broken spelter coating. (See Subsection 311.2.1 for exception)

f. Dents or bends in the metal itself.

311.3.8 Headwalls

A. Where shown on the plans, inlet and outlet headwalls shall be constructed or installed in connection with culvert pipes.

B. Where headwalls are constructed or installed, the ends of pipes shall be placed flush or cut off flush with the headwall face, unless otherwise permitted by the Engineer.

C. Headwalls shall be constructed to conform to Section XXX – Structural Concrete.

311.3.9 Extending Existing Structural Plate Pipe and Pipe Arch Culverts

A. In case the plans provide for the extension of any old or existing structural plate pipe or pipe arch culverts, the connection of the old and new sections shall be made by:

1. Punching any necessary bolt holes.

2. Furnishing bolts, nuts, and washers.

3. Changing location of individual plates on pipe arches.

4. Providing any other work required in the completion of the connection in a workmanlike manner.

B. In all cases where an existing headwall is in place, the concrete shall be completely removed.

END OF SECTION

Section 312
Stormwater Rundowns

312.1. General

312.1.1 Description

A. This work shall consist of furnishing and installing embankment protectors, flume rundowns, anchor assemblies, slip joints, and bituminous concrete rundowns to collect and carry surface drainage down the roadway slopes.

312.1.2 Related Sections

A. Sections 100-110 for general specifications.

312.2. Materials

312.2.1 General

A. Pipe for crossbars shall be unpainted standard weight black pipe conforming to ASTM A53 or ASTM A120.

B. Rundowns metal products shall be fabricated in accordance with the details and dimensions shown on the plans, except that minor variations may be accepted at the discretion of the Engineer to permit the use of manufacturer's standard jigs and templates in the fabrication. Metal shall not be less than the gauge shown on the plans.

312.3. Execution

312.3.1 Metal Rundowns

A. The embankment protector outlet pipe shall be connected to a rundown pipe of the dimensions shown on the plans by means of a band coupler or a slip joint.

B. Embankment protectors shall be installed at an outside edge of the embankment gutters or in the shoulder dikes to carry drainage from the roadbed down the embankment slopes to protect the slopes and shoulders from erosion.

1. The entrance device shall be installed to prevent water from percolating around the structure and care shall be taken to prevent the structure from being undermined.

2. The seal between the structure and the surrounding earth shall be made watertight.

3. The embankment protectors shall be placed so that the lower edge of the opening will be from 3 inches to 6 inches below the bottom of the gutter flow lines.

312.3.2 Bituminous Mixtures and Grouted Riprap

A. Bituminous mixture and grouted riprap rundowns, when called for, shall be placed in accordance with the provisions in Section X – Grouted Riprap.

END OF SECTION

Section 313
Concrete Slope Paving

313.1. General

313.1.1 Description

A. This work shall consist of constructing concrete slope paving and concrete mortar slope paving including aprons and cutoff walls in connection therewith, to the lines and grades established by the Engineer and in accordance with the design shown on the plans.

313.1.2 Related Sections

A. Sections 100-110 for general specifications.

313.2. Materials

313.2.1 General

A. Concrete mortar slope paving shall consist of a mixture of 1 part Portland cement to 4 parts sand, thoroughly mixed in a dry state prior to mixing with water.

1. Measurement may be either by volume or weight.
2. Before placing, all lumps 3/8 inch and over shall be removed by screening.
3. An air-entraining admixture shall be added to the concrete mortar at a rate of 4 percent to 7 percent.

B. Mesh reinforcing for ditch lining and slope paving reinforcement shall be of the sizes shown on the plans, shall be fabricated of cold drawn steel wire, and need not be galvanized. Mesh reinforcing shall conform to ASTM A185.

C. Header boards consisting of 2-inch by 4-inch redwood lumber furnished and placed in the concrete or mortar slope paving shall be as shown on the plans. Lumber used in the construction of header boards shall be commercial grade heart redwood, S4S.

D. Nails used in construction of header boards shall be commercial quality galvanized nails.

313.3. Execution

313.3.1 Earthwork

A. The subgrade for paved ditches and slope paving shall be formed by excavating to the required depth below the prepared finish surface grade in accordance with dimensions and design indicated on the plans or as directed by the Engineer.

B. The subgrade shall be thoroughly compacted.

1. Any soft, spongy, or other unsuitable material shall be removed to the depth directed by the Engineer, backfilled with suitable material, and thoroughly compacted.

2. Water shall be sprinkled on the subgrade during compaction.

3. The subgrade shall be sufficiently moist prior to placing concrete or mortar to prevent absorption.

313.3.2 General

A. Concrete, after placing, shall be tamped until it is thoroughly consolidated and mortar flushes to the surface.

1. If the slope is too steep to permit the use of concrete sufficiently wet to flush with tamping, the concrete may be tamped until consolidated and a mortar surface 1/4-inch thick troweled on immediately.

2. The mortar shall consist of 1 part Portland cement and 3 parts clean, sharp sand.

3. The mortar surface shall be considered as a part of the concrete and no additional allowance will be made therefor.

B. After striking off to grade, the concrete shall be hand floated with wooden floats not less than 4 inches in width and not less than 30 inches in length.

1. Care shall be taken to prevent rotary marks of the hand floats.

2. The entire surface shall be broomed with a fine texture hair push broom to produce a uniform surface and eliminate float marks.

3. Brooming shall be done when the surface is sufficiently set to prevent deep scarring and shall be accomplished by drawing the broom down the slope leaving the marks parallel to the edges of the panel.

4. Joints shall be edged with a 1/4-inch radius edger prior to the brooming.

C. Materials for mortar that have been mixed for more than 45 minutes and have not been incorporated in the work shall not be used unless otherwise permitted by the Engineer.

D. Concrete or mortar shall not be placed against frosted or frozen surface. If concrete or mortar is placed during cold weather, it shall be heated and protected during placing and curing as set forth in Section XXX – Structural Concrete, except concrete or mortar shall be maintained at a temperature of not less than 50 degrees F for 72 hours after placing and at not less than 40 degrees F for an additional 4 days.

E. The slope paving shall be constructed without expansion joints.

F. The mesh reinforcing shall be placed in the approximate center of the concrete mortar.

G. All joints shall be lapped 6 inches and run continuously throughout paving or between headers.

H. Concrete slope paving, aprons, and cutoff walls shall be cured as specified in Section XXX – Concrete Curing.

END OF SECTION

Section 314

Slope and Channel Protection

314.1. General

314.1.1 Description

A. This work shall consist of constructing slope and channel protection structures to the lines and grades established by the Engineer using riprap or wire mesh gabions in accordance with the design shown on the plans and these specifications.

B. Riprap construction shall consist of furnishing and placing riprap (with or without grout) or sacked Portland cement concrete riprap.

C. Wire mesh gabion construction shall consist of furnishing, assembling, tying, and filling open mesh wire baskets with stone.

314.1.2 Related Sections

A. Sections 100-110 for general specifications.

314.2. Materials

314.2.1 General

A. When so provided and with prior approval of the Engineer, crushed concrete may be substituted for the above designated stone. In such a case, the concrete shall be sound and meet all requirements as specified for stone.

314.2.2 Grout

A. Grout shall be composed of 1 part by volume of Portland cement and 3 parts by volume of sand and shall be of such consistency that it will fill all voids in the riprap.

314.2.3 Sacked Concrete

A. Sacked concrete shall be composed of sacks filled with Portland cement concrete.

1. The mixed concrete shall contain a minimum of 376 pounds (4 sacks) of Portland cement per cubic yard.

2. The amount of water added at the time of mixing shall be such as will produce a mixture with a slump of from 3 inches to 5 inches.

B. Unless otherwise provided in the Special Provisions, aggregate for use in sacked concrete riprap shall consist of river run material of a sandy, gravelly nature, clean and free from roots, vegetable matter, and other deleterious substances. When tested on laboratory sieves, river run material shall conform to the following gradation requirements.

1. Passing a 2-inch sieve: 80 to 100 percent.
2. Passing a No. 200 sieve: 0 to 4 percent

C. Sacks for concrete riprap shall be made of at least 10 ounce burlap and shall be approximately 19-1/2 inches by 36 inches measured inside the seams when the sack is laid flat.

1. The capacity of each sack shall be approximately 1.25 cubic feet.
2. Sound reclaimed sacks may be used.

314.2.4 Stones for Riprap

A. Stones used for riprap shall be hard, durable, angular in shape, resistant to weathering and erosion, and free from spoils, cracks, and organic matter.

1. The stone for non-grouted riprap shall have a minimum of 2 fractured faces with neither width nor thickness of a single stone less than 1/3 its length.
2. The specific gravity of the riprap shall not be less than 2.45.
3. The nominal stone size shall be as follows:

Percent Passing by Mass	Riprap D50=12" (inches)	Heavy Riprap D50=18" (inches)
100	20	30
70-85	18	27
35-50	12	18
5-15	5	7
0	2	3

B. This stone shall conform to the following requirements:

Source Requirement Test	Test Method	Requirements
Percent of Water (500 Rev.)	ASTM C131	45% Maximum
Bulk Specific Gravity	ASTM C127	2.5 Maximum

C. Control of gradation will be by visual inspection.

1. Upon request by the Engineer, the Contractor shall provide a sample of stone of at least 5 tons meeting the gradation for each location riprap is indicated.
2. Each sample shall be located at the construction site near the location where the riprap is to be placed.
3. The sample shall be used as a frequent reference for judging the gradation of the riprap supplied.
4. The sample riprap shall be in place and acceptable to the Engineer before riprap placing work begins.
5. The Contractor shall maintain the placed riprap until the project is completed and any material displaced by any cause shall be repaired to the lines and grades indicated on the plans.

D. Caliche stone or cementitious materials meeting the requirements of this section may be used as riprap with prior approval of the Engineer.

1. The riprap shall be fully cemented material. Only materials designated as hard (scratches leave only dust, requires many hammer blows to break) or very hard (difficult to scratch or break) shall be utilized.
2. Moderately hard (crumbles with several hammer blows) or partially cemented materials are not acceptable.

E. The Contractor may be required to provide riprap test results from an approved testing laboratory.

314.2.5 Stones for Gabions

A. Stones for filling the gabions shall be well graded, hard stones, conforming to the testing requirements specified in Subsection 314.2.4 Stones for Riprap.

B. Size and gradation shall be such that the predominant size is between 4 inches and 8 inches, 85 percent by weight.

1. Minimum stone dimensions shall be 3 inches and maximum stone dimension shall be 8 inches.
2. For gabion baskets less than 1 foot in height, the maximum stone dimension shall be 6 inches.

314.2.6 Filter Material

A. When filter material is specified or shown on the plans, the material shall consist of mineral aggregate that is clean, hard, durable, and free of any deleterious matter or harmful adherent coatings.

B. Gradation of the filter material shall conform to the requirements specified by the Engineer or as shown in the Special Provisions.

314.2.7 Filter Fabric

A. When filter fabric is specified or shown on the plans, the fabric shall consist of a geotextile that is made from synthetic fibers.

B. The filter fabric shall be in accordance with AASHTO M288, Section A4, and shall conform to the requirements specified by the Engineer.

314.2.8 Wire Mesh Gabions and Gabion Mattresses

A. Wire mesh gabions and gabion mattresses shall be fabricated from either twisted wire mesh or welded wire mesh.

1. All wires shall be galvanized prior to fabricating the mesh and in compliance with ASTM A90.

2. Only 1 type of wire mesh may be used in any 1 structure.

B. Gabion and gabion mattress dimensions of width, height, and length shall be as shown on the plans.

1. Each gabion unit shall not vary more than 5 percent from the dimensions shown on the plans.

2. Gabions come 1 foot or greater in height, 3 feet in width, and are compartmentalized into cells not larger than 3 feet by 3 feet by attaching to the base single diaphragm panels made of the same type and size mesh as the gabion panels.

3. Gabion mattresses come 9 inches or less in height, 6 feet in width, and are compartmentalized into cells not larger than 6 feet by 3 feet by attaching to the base single diaphragm panels made of the same type and size mesh as the gabion mattress panels.

C. The baskets shall be assembled with the necessary panels and diaphragms secured to the base in accordance with ASTM A975-97, Table 2 requirements. Pleating the base panel to obtain the diaphragms is prohibited.

D. Fabrication of the wire mesh gabions and gabion mattresses shall be as follows:

1. Twisted Wire Mesh Gabions and Gabion Mattresses:

a. Gabion panels for the twisted mesh style shall be manufactured from galvanized steel wire, Class 3, soft temper, conforming to ASTM A641, or from aluminized steel wire, soft temper, conforming to ASTM A809.

i. The wire shall have a minimum tensile strength of 60,000 psi when tested in accordance with ASTM A370.

ii. Twisted wire mesh gabions and gabion mattresses shall comply with ASTM A975-97 standards.

b. The mesh shall be formed with non-raveling double twists by twisting each pair of wires through two 360-degree turns. The mesh openings shall be hexagonal in shape and uniform in size and shall comply with the mesh dimensions and requirements shown on Table 1 and Table 2 below.

c. All perimeter edges of the mesh panels forming the gabion basket shall be securely tied to a selvedge wire so that the selvedge-to-mesh connection has at least the same strength as the body of the mesh. Selvedge wire shall be the same kind and type of material used for the mesh, except that wire diameters shall be as shown on the tables below.

d. When specified by the Engineer, the galvanized or aluminized wire shall be coated with a polyvinyl chloride (PVC) material. The coating shall be accomplished by using either extruded or extruded and bonded PVC material and shall be applied before twisting the wire into mesh panels.

e. All wire used for twisted mesh gabions and gabion mattresses shall meet the following nominal requirements:

Nominal Requirements for Twisted Wire Mesh Gabions			
Type of Basket	**Mesh Size**	**Mesh Wire**	**Selvedge Wire**
Baskets 1 foot or greater in height	3.25-inch by 4.5-inch	0.120 inch	0.148 inch
Baskets 1 foot or greater in height with PVC coating	3.25-inch by 4.5-inch	0.106 inch, plus the PVC coating	0.134 inch, plus the PVC coating

Nominal Requirements for Twisted Wire Mesh Gabions Mattresses			
Type of Basket	**Mesh Size**	**Mesh Wire**	**Selvedge Wire**
Baskets 9 inches or less in height	2.5-inch by 3.25-inch	0.120 inch	0.106 inch
Baskets 9 inches or less in height with PVC coating	2.5-inch by 4352-inch	0.106 inch, plus the PVC coating	0.106 inch, plus the PVC coating

2. Welded Wire Mesh Gabions and Gabion Mattresses:

a. Gabion panels for the welded mesh style shall be manufactured from welded wire fabric conforming to ASTM A185 and ASTM A974-97, Type 1.

b. Galvanized wire shall have a Class 3 coating as indicated in ASTM A641.

c. Aluminized wire shall have a minimum coating as indicated in ASTM A809.

d. The wire shall be soft tempered with a minimum tensile strength of 60,000 psi when tested in accordance with ASTM A370.

e. Welded wire mesh gabions and gabion mattresses shall comply with ASTM A974-97 standards.

f. The mesh shall form a square or rectangular grid pattern with the maximum diagonal dimension of any grid opening not to exceed 4.5 inches.

g. The welded wire mesh shall be galvanized or aluminized prior to welding into mesh and shall comply with the dimensions and requirements shown on Table 3 and Table 4 below.

h. When specified by the Engineer, the welded wire mesh shall be coated with a polyvinyl chloride material. The PVC coating shall be fusion bonded to the galvanized or aluminized wire after fabrication of the gabion mesh panels.

i. All wire used for welded mesh gabions and gabion mattresses shall meet the following nominal requirements:

j. For polyvinyl chloride coated either twisted or welded mesh gabions and gabion mattresses, the PVC coating shall have a nominal thickness of 0.020 inch and a minimum thickness of 0.015 inch. The coating shall be grey, silver, green, or black and conform to the following:

Nominal Requirements for Welded Wire Mesh Gabions		
Type of Basket	**Mesh Size**	**Mesh Wire**
Baskets 1 foot or greater in height	3-inch by 3-inch	0.120 inch
Baskets 1 foot or greater in height with PVC coating	3-inch by 3-inch	0.106 inch, plus the PVC coating

Nominal Requirements for Welded Wire Mesh Gabions		
Type of Basket	**Mesh Size**	**Mesh Wire**
Baskets 9 inches or less in height	1.5-inch by 3-inch	0.087 inch
Baskets 9 inches or less in height with PVC coating	1.5-inch by 3-inch, plus PVC coating	0.087 inch, plus the PVC coating

k. Specific Gravity: In the range of 1.20 to 1.40, ASTM D792.

l. Abrasion Resistance: The percentage of weight loss shall be less than 12 percent, when tested according to ASTM D1242, Method B at 200 cycles, CSI-A Abrader Tape, 80 Grit.

m. Brittleness Temperature: Not higher than 15 degrees F, ASTM D746.

n. Tensile Strength: Extruded Coating - Not less than 2,980 psi, ASTM D412. Fusion Bonded Coating - Not less than 2,275 psi, ASTM D638.

o. Modulus of Elasticity: Extruded Coating - Not less than 2,700 psi, at 100 percent strain, ASTM D412. Fusion Bonded Coating - Not less than 1,980 psi. at 100 percent strain, ASTM D638.

p. Ultraviolet Light Exposure: A test period of not less than 3,000 hours, using apparatus Type E at 145.4 degrees F, ASTM G23.

q. Salt Spray Test: A test period of not less than 3,000 hours, ASTM B117.

314.2.9 Internal Connecting Wires

A. Internal connecting wires to reinforce the side panels of individual gabion baskets shall meet the same specifications as the wire used in the gabion body, except wire nominal diameter shall be 0.087 inches or larger. Alternate preformed stiffeners acceptable to the gabion manufacturer and the Engineer may also be used.

314.2.10 Lacing Wire

A. Lacing wire to assemble, interconnect, and close the gabion baskets shall meet the same specifications, as the wire used in the gabion body except its nominal diameter shall be 0.087 inches.

314.2.11 Wire Fasteners

A. Machine formed spiral wire binders with a 3-inch pitch and 2.5-inch inside diameter maximum are the standard fastener for welded wire mesh gabions and gabion mattresses and shall be formed from wire meeting the same quality and coating thickness requirements as specified above for the gabions and gabion mattresses.

B. As an alternative to lacing wire and spiral binders, wire fasteners including interim fasteners, interlocking ring fasteners, overlapping (hog) ring fasteners, and twist ties may be used, subject to the approval of the Engineer.

C. The Contractor shall demonstrate that:

1. The proposed fastener can consistently resist an opposed tension force of at least 600 pounds without pulling apart.
2. The proposed fastener system can consistently produce a joint with strength of at least 1,400 pounds per linear foot while encompassing the number of wires as intended for its use. When PVC coated wire is used, the joint strength shall be at least 1,200 pounds per linear foot.
3. The proposed fastener system does not cause damage to the protective coating on the wire.
4. The Contractor has the proper equipment and trained employees to correctly install the fasteners.
5. Proper installation can be readily verified by visual inspection.

D. The Contractor shall provide a complete description of the fastener system, including the number of fasteners required, the number and size of wires that the fastener is capable of properly joining, and a description of a properly installed fastener, including drawings or photographs, if necessary.

E. Properly formed fasteners shall meet the following requirements:

1. Each interlocking fastener shall be locked and closed.
2. Each overlapping ring fastener shall be closed and the free ends shall overlap a minimum of 1 inch.
3. Spiral binders shall be crimped to secure the spiral in place.
4. Twist ties shall have a minimum of 2 complete revolutions.

F. If gauges or other aids are needed to verify the proper installation of the fasteners, the Contractor shall furnish the Engineer the gauges or aids in numbers as may reasonably be required.

1. If more than 1 wire fastener is proposed, e.g. different gauge or length of wire, for different joints, the fasteners shall be readily distinguishable.
2. Wire fasteners shall not be used to join more wires, or larger wires, than for which they were tested and approved.
3. As a minimum, a fastener shall be installed at intervals of 4 inches to 6 inches at the location where mesh wire meets selvedge or edge wire.

G. Fastener Materials:

1. Galvanized wire fasteners shall be used with galvanized gabions.

2. Aluminized wire fasteners shall be used with aluminized gabions.
3. Stainless steel overlapping rings or interlocking rings shall be used for stainless steel gabions.
4. PVC coated wire spiral binders shall be used for PVC coated gabions.

H. Fastener Properties:

1. Galvanized wire fasteners shall conform to ASTM A764 with Type III coating.
2. Aluminized wire fasteners shall conform to ASTM A809 for wire diameter and coating, with tensile strength equal to ASTM A764, Table 2.
3. Stainless steel wire fasteners shall conform to ASTM A313, Grade 302.
4. Spiral binder fasteners shall be formed with wire having at least the same thickness and coating as the basket mesh wire.
5. Twist tie fasteners shall meet the requirements of lacing wire, as specified in Subsection 314.13 Lacing Wire.

314.3. Execution

314.3.1 Earthwork

A. The areas where riprap or wire mesh gabions are to be placed shall be graded to the required lines and grades as shown on the plans or as directed by the Engineer.

B. Any excavations or backfill required to achieve such grade shall conform to the provisions of Section XXX – Trenching, Excavation, and Backfill.

314.3.2 Filter Placement

A. Filter material shall be spread uniformly on the prepared foundation surface in a manner satisfactory to the Engineer, and to the slopes, lines, and grades as shown on the plans or as specified by the Engineer.

1. Placing of a filter material by methods that will segregate particle sizes will not be permitted.
2. Any damage to the foundation surface during filter placement shall be repaired before proceeding with the work.
3. The filter materials shall be placed and placement shall be approved and accepted before proceeding with the work.

4. The filter materials shall be placed and finished to present a reasonably even surface free from mounds or windrows.

5. Compaction of the filter materials shall conform to the requirements shown on the plans or as outlined in the Special Provisions.

B. Filter fabric shall be installed in accordance with the manufacturer's recommendations and in manner that will not tear, puncture, or shift the fabric.

C. Joining edges of the filter fabric shall be overlapped a minimum of 18 inches.

D. Filter fabric placed behind and/or beneath gabion or gabion mattress structures shall have a minimum permeability of 0.15 inch/second and shall be designed to retain the fine particles of the subsoil while releasing any hydrostatic pressure buildup.

314.3.3 Riprap

A. Stone for riprap shall be placed in a manner that will produce a well-graded mass of stone with a minimum percentage of voids.

1. The entire mass of stone shall be placed in conformance with the lines, grades, and thicknesses shown on the plans.

2. Riprap shall be placed to its course thickness in 1 operation and in such a manner as to avoid displacing underlying material.

3. When filter fabric is used under the riprap, the height from which the stone is dropped shall be minimized to avoid fabric damage.

4. Placement of stones shall begin at the bottom of the slope and proceed upward to the top.

B. The large stones shall be well distributed and the entire mass of stone shall conform to the gradation specified.

1. All material placed as riprap protection shall be so placed and distributed that there is no large accumulation of either the larger or smaller sizes of stone.

2. Placing of riprap in layers, or by dumping into chutes, or by similar methods likely to cause segregation will not be permitted.

314.3.4 Grouted Riprap

A. When grouted riprap is specified, the stone shall be laid as set forth above for riprap.

B. The spaces between the stones shall then be filled with grout as directed.

C. Sufficient grout shall be used to completely fill all voids, except that the face surface of the stone shall be left exposed.

D. After grouting is completed, the surface shall be cured as specified in Section XXX – Concrete Curing for a period of at least 3 days.

314.3.5 Slacked Concrete Riprap

A. The sacks shall be filled with concrete, loosely placed, with enough room left at the top to fold to retain the concrete at the time of placing.

1. Not more than 1 cubic foot of concrete shall be placed in each sack.
2. Immediately after being filled with concrete, the sacks shall be placed and lightly trampled to cause them to conform with the earth face and to adjacent sacks in place.

B. The slopes on which the sacked concrete riprap is to be placed shall be finished true to line and grade.

1. The first course shall consist of a double row of stretchers laid in a neatly trimmed trench.
2. The second course shall consist of a single row of headers.
3. The third and remaining courses shall consist of stretchers.
4. Courses shall be placed in such a manner that joints in succeeding courses are staggered.
5. All dirt and debris shall be removed from the top of the sacks before the next course is laid thereon.
6. Stretchers shall be placed so that the folded ends will not be adjacent.
7. Headers shall be placed with the folds toward the earth face.
8. Not more than 4 vertical courses of sacks shall be placed in any tier until initial set has taken place in the first course of any such tier.

C. When, in the opinion of the Engineer, there will not be proper bearing or bond for the concrete due to delays for any cause, a small trench shall be excavated back of the row of sacks already in place. The trench shall be filled with fresh concrete before the next layer of sacks is laid.

D. Sacked concrete riprap shall be cured in accordance with Section XXX – Concrete Curing.

314.3.6 Wire Mesh Gabions and Gabion Mattresses

A. Prior to the assembly and placement of the wire mesh gabions, a representative of the gabion manufacturer shall be present at the

construction site for 1 day of placement or construction to demonstrate the method of assembling, interconnecting, stone filling, and closing the gabion, unless otherwise specified in the Special Provisions.

B. Construction of the gabion structure shall not proceed until the Engineer approves the Contractor's assembly and placement methods.

C. Gabion baskets shall first be assembled as empty units.

1. The panels and diaphragms shall be connected to the base panel, rotated into position, and joined along the edges with lacing wire, spiral binders, or approved wire fasteners.

2. When joined with lacing wire, the lacing wire shall be tightly looped at intervals of not more than 6 inches along the seams so that single and double loops are alternated.

3. When joined with preformed spiral binders, thread the spirals along the panels' edges through every mesh and crimp the spirals ends to secure them in place.

4. When joined with alternate fasteners, the fasteners shall be properly installed as specified in Subsection 314.2.11 Wire Fasteners.

5. For either method, there shall not be any opening greater than 2 inches (maximum line dimension) along the joined edges or at the corner of the gabion basket.

D. Empty gabion baskets shall be placed into position, over the filter fabric when required, on the prepared foundation.

1. Empty gabion baskets shall be joined successively to the next empty gabion basket before filling with stone.

2. Each row, tier, and layer of baskets shall be reasonably straight and shall conform to the line and grade shown on the plans or established by the Engineer.

3. The empty gabion baskets shall be fastened to the adjacent baskets along the top and vertical edges.

4. Each layer shall be fastened to the underlying layer along the front, back, and ends.

5. Unless otherwise shown on the plans, the vertical joints between basket units of adjacent tiers or layers shall be staggered by at least one cell along the length of the structure.

E. All fastening of adjacent baskets shall be done with lacing wire, spiral binders, or approved wire fasteners in order to obtain a monolithic

structure. The method of fastening shall meet the same requirements as that specified for assembling individual gabion baskets.

F. Fastening shall be made through selvedge-to-selvedge or selvedge-to-edge wire connection. Mesh-to-mesh or selvedge-to-mesh wire connection is allowed along vertical edges or in the case where baskets are offset or stacked, and selvedge-to-mesh or mesh to-mesh wire connection would be necessary.

G. Before filling each gabion basket with stone, tension may be applied to the empty baskets to achieve a uniform alignment and shall be accomplished to prevent any possible unraveling.

    1. Welded wire mesh gabions do not require stretching.

    2. The finished gabion structure shall have no gaps along the perimeter of the contact surfaces between adjoining gabion basket units.

H. The gabion cells shall be carefully filled with stone placed by hand and/or machine so that the alignment of the structure will be maintained to avoid bulges and minimize voids.

    1. All exposed stone surfaces shall have a reasonable smooth and neat appearance.

    2. No sharp stone edges shall project through the wire mesh.

I. The gabion baskets stone-fill may be either cobbles or crushed stone.

    1. The stone shall be clean, hard, durable, and of suitable quality to ensure suitable performance in the gabions or gabion mattresses.

    2. The stone shall be free from cracks, seams, and other defects that would tend to increase its deterioration in the gabion baskets.

    3. The inclusion of dirt, sand, clay, debris, and rock fines will not be permitted.

    4. Stone-fill used in the gabions and gabion mattresses shall be a well-graded mixture with sizes ranging between 4 inches and 8 inches in diameter for gabions 1 foot or greater in height, and between 3 inches and 6 inches in diameter for gabion mattresses 9 inches or less in height.

J. The gabion cells in any row or layer shall be filled in stages so that local deformations may be avoided.

    1. At no time shall any cell be filled to a depth exceeding 12 inches more than any adjacent cell.

2. The maximum height from which the stone may be dropped into the basket units shall be 3 feet.

K. During filling operations, internal connecting wires shall be placed in all exposed front and side gabion units in the following manner:

1. For gabion cells with a 36-inch height:

a. Stone shall be placed to a depth of 1/3, 12 inches, after which a minimum of 2 equally spaced internal connecting wires shall be placed in each cell, connecting the front and back faces of the compartment.

b. For corner units, internal connecting wires shall be placed in both directions.

c. The connecting wires shall be looped around 2 twisted wire mesh openings, or a welded wire joint, at each basket face, and the wire terminals shall be securely wrapped to prevent their loosening.

i. This operation shall be repeated when the cell is 2/3 full.

ii. In welded mesh gabions, these cross-ties or stiffeners are made from lacing wire and placed across the comers of the gabion cells at 12 inches from the comers, thus providing a diagonal bracing. Lacing wire or preformed hooked wire stiffeners may be used.

2. For thinner gabion cells:

a. Internal connecting wires are not required except when 18-inch baskets are used to build exposed vertical surfaces.

b. In this case, the procedures under Subparagraph 1. above shall be followed, except that the internal connecting wires shall be placed at 9 inches from the base.

END OF SECTION