

2026 Edition Revisions to the SUDAS Design Manual

To update your printed manual, print this packet. Then remove the old sheets and place the revised sheets in your manual. Some pages are completely new and do not replace an existing sheet. Also, some pages do not contain revisions, but are included due to changes on the other side or a change in the page number. **PLEASE READ CAREFULLY - PAY ATTENTION TO THE SECTION NUMBER!** Included shading to help distinguish between chapters. Questions can be directed to Beth Richards - brich@iastate.edu. The current edition of the manual, with the latest revisions incorporated, can be found at www.iowasudas.org.

Chapter	Section	pg #	Summary of Revision(s)
1	Manual introductory info		Updated the Contributors and Acknowledgments page. <i>Note - if you want to replace the small business card for the spine of your manual, you can print a copy from our website.</i>
	1D-2	2; 18	Revised some “items to be specified” based on corrections and SUDAS Specifications revisions.
	1D-3 1D-4	ALL ALL	Updated the “incidental or included items” list based on corrections and SUDAS Specifications revisions. Updated the “bid item” list based on corrections and SUDAS Specifications revisions.
2	Table of Contents	ii	Updated Table of Contents based on revisions made in Chapter 2.
	2A-2, B, 1, b	1	Deleted incorrect Iowa DNR URLs from the text and included hyperlinks instead.
	2C-3, F & G	8-21	Corrected conflicting size requirements for the minimum concrete leg between openings, which lead to other updates and added pages to the section; noted and fixed other minor errors.
	2E-2, C	6	Deleted URLs from text and included hyperlinks instead.
3	Table of Contents	i	Updated Table of Contents based on revisions made in Chapter 3.
	3C-1, L, 10	7-8	Deleted duplicated language; REMOVE pages 9-10.
4	Table of Contents	i	Updated Table of Contents based on revisions made in Chapter 4.
	4C-1, K	7-11	Revised to address questions regarding restrained joints and thrust blocks. Change added a new page.
5	Table of Contents	i-v	Updated Table of Contents based on revisions made in Chapter 5.
	5D-1	5-9	Deleted mixture design criteria table to reference table in specs. Updated references throughout section.
	5G-2	9-19	Removed duplicated spec figure and included reference/hyperlink. Updated figure numbers accordingly. REMOVE pages 21-22.
	5G-3	5-15	Removed duplicated spec figure and updated figure numbers accordingly. REMOVE pages 17-19.
	5J-1, D	12	Updated reference to Concrete Pavement Preservation Guide.
6	5O-1	2	Removed duplicated spec figure and included reference/hyperlink. REMOVE pages 3-4.
	Table of Contents	ii	Updated Table of Contents based on revisions made in Chapter 6.
	6G-1	4-10	Removed duplicated spec figure and included reference/hyperlink. REMOVE page 11.

7	Table of Contents	iii	Updated Table of Contents based on revisions made in Chapter 7.
	7E-9	ALL	Removed duplicated spec figure and included reference/hyperlink.
	7E-10	ALL	Removed duplicated spec figure and included reference/hyperlink. Updated figure numbers accordingly. REMOVE pages 7-8.
	7E-11	ALL	Removed duplicated spec figure and included reference/hyperlink.
9	7E-16, B, 4	3	Corrected terminology error - "entrance" changed to "exit."
	9D-1, B	1	Deleted URLs from text and corrected hyperlinks.

Contributors and Acknowledgments

In 2025, SUDAS staff held many meetings to accomplish the various revisions reflected in the 2026 versions of the SUDAS manuals. These revisions would not have been possible without the efforts of the SUDAS technical committee members. The SUDAS program's success is also due to the dedication of the district committees and Board of Directors. Keeping the SUDAS manuals current is an ongoing, cooperative effort, involving hundreds of people who volunteer their time and expertise. It is not possible to acknowledge each of these volunteers individually, but we appreciate them all.

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Items to be Specified on Plans or in Contract Documents

The SUDAS Specifications specify many items and methods that can be used for the construction of improvements. Following is a list of items in the SUDAS Specifications that are to be noted on the construction drawings and/or in the special provisions whenever there is to be a deviation from the standard requirements of the specifications. This information may include specifying pipe sizes and materials, who is responsible for providing compaction testing, as well as many others.

The project engineer should review the following list and the SUDAS Specifications to make sure all items that are necessary to construct the project are specified on the plans and/or in the special provisions. Please note - this list is not all-inclusive.

Section 2010 - Earthwork, Subgrade, and Subbase

- [2010, 1.08, D](#) Specify whenever the depth of cut for stripping and salvaging topsoil is other than 8 inches.
- [2010, 1.08, E](#) Specify the class of excavation as Class 10, Class 12, or Class 13.
- [2010, 1.08, E, 1, b, 2\)](#) When the truck count method is to be used for measuring Class 10 or Class 13 excavation, specify if the shrinkage factor is other than 1.35.
- [2010, 1.08, E, 4](#) Specify whenever stripping, salvaging, and spreading 8 inches of topsoil is NOT a pay item and is included in the payment of Class 10, Class 12, or Class 13 Excavation.
- [2010, 1.08, F, 1](#) Specify whenever below grade excavation (core out) will NOT be measured and paid as extra work.
- [2010, 1.08, K, 3](#) Specify whenever removal of pipe and conduits will include plugging.
- [2010, 1.08, M](#) Specify when the Contractor is responsible for compaction testing.
- [2010, 2.01](#) Specify use of compost-amended or off-site topsoil if on-site topsoil is NOT to be used.
- [2010, 2.02, C, 3](#) Specify the limits of Class 13 excavation.
- [2010, 2.04, C, 5](#) Specify whenever Type 2 geogrid is to be used in lieu of Type 1.
- [2010, 3.02, C](#) Specify if 8 inches of off-site topsoil is not to be used.
- [2010, 3.03, B, 2, a](#) Specify if the removed pavement materials should be processed for re-use.
- [2010, 3.03, B, 2, b, 2\)](#) Specify if the removed pavement should be delivered and stockpiled.

2010, 3.03, F, 1	Specify the desired depth for removal of unsuitable or unstable materials.
2010, 3.04, D	Specify whenever Type A compaction is to be used in lieu of compaction with moisture and density control.
2010, 3.05	Specify whenever and where unsuitable soils will be allowed in the right-of-way.
2010, 3.06, A	Specify if granular stabilization materials or subgrade treatment is to be used in lieu of select subgrade materials.
2010, 3.07	Specify the type of subgrade treatment (lime, cement, fly ash, asphalt, geogrid, or geotextiles) to be used.
2010, 3.07, A, 1	Specify the depth and rate of incorporation of the subgrade treatment material (lime, cement, fly ash, or asphalt).
2010, 3.07, A, 2	Specify the areas requiring subgrade treatment.
2010, 3.08, B	Specify the type and depth of subbase.
2010, 3.09, A	Specify when the Contractor is responsible for compaction testing.
Figure 2010.102	Specify whenever Type A compaction is desired in lieu of compaction with moisture and density control.

Section 3010 - Trench Excavation and Backfill

3010, 1.08, F	Specify when the Contractor is responsible for trench compaction testing.
3010, 2.04, A, 2	Specify whenever Class V material can be used as other than topsoil.
3010, 2.06, D, 1	Specify if foamed cellular concrete may be substituted for flowable mortar.
3010, 3.05, A, 6, a	Specify if concrete, flowable mortar, CLSM, or foamed cellular concrete is to be used in lieu of other bedding materials.
3010, 3.05, B, 1, a	Specify if granular bedding material is to be used for pressure pipes.
Figure 3010.101	Specify when over-excavation and foundation stone will be required.
Figure 3010.105	Specify when and where to install a waterstop.

Section 3020 - Trenchless Construction

3020, 2.02, A	Specify the wall thickness of casing pipe. See Section 9C-1.
3020, 2.02, C	Specify inside diameter of casing pipe.
3020, 2.05, B	Specify where special fill materials will be used.
3020, 3.04, A, 2, b	Specify the installation deviation tolerances of casing pipe if different than those included.

- [Figure 8030.117](#) Specify the use of auxiliary lighting or audible information devices.
- [Figure 8030.118](#) Specify the use of a crash cushion to separate the temporary sidewalk from vehicular traffic.
- [Figure 8030.119](#) Specify the use of auxiliary lighting or audible information devices.

Section 8040 - Traffic Signs and Posts

- [8040, 2.02, C](#) Specify when to use Type IV high intensity retroreflective sheeting instead of Type XI diamond grade.

Section 9010 - Seeding

- [9010, 2.01, B](#) Specify PLS, which shall not be less than the accumulated total.
- [9010, 2.02](#) Specify seed mixture in the contract documents.
- [9010, 2.03, A, 2](#) Specify if fertilizer is not to be applied for temporary conventional seeding.
- [9010, 3.01, A](#) Specify when aerial application of seed and fertilizer is desired.
- [9010, 3.01, N](#) Specify the use of a no-till attachment if desired.
- [9010, 3.04, E, 4, a](#) Specify if winter dormant seeding is required.
- [9010, 3.10, B](#) Specify when a warranty for seeding is required.

Section 9020 - Sodding

- [9020, 2.04](#) Specify when contractor is not to provide water and watering equipment.

Section 9030 - Plant Material and Planting

- [9030, 1.03, E](#) Specify when the contractor is to submit a schedule of unit prices for each size and variety of tree, shrub, and ground cover plant.
- [9030, 1.08, A-D](#) Specify the use of pre-emergent herbicide.
- [9030, 2.01, A, 4](#) Specify whenever plants in rows do not need to be matched in form or size.
- [9030, 2.01, E, 1](#) Specify where to use bare root plants.
- [9030, 3.05](#) Specify when tree drainage wells are needed.
- [9030, 3.09, A](#) Specify when tree wrapping is required.
- [9030, 3.13, B](#) Specify when a warranty for plants is required.
- [Figure 9030.102](#) Specify when tree wrapping is required.

Section 9040 - Erosion and Sediment Control

9040, 1.08, A, 1	Specify if the Contractor will be responsible for the SWPPP preparation.
9040, 1.08, A, 2	Specify if the Contractor will be responsible for the SWPPP management.
9040, 1.08, C, 3	Specify if vegetation should be included with the filter berm.
9040, 1.08, E, 1	Specify the width of temporary RECP.
9040, 1.08, I	Specify if level spreaders are <u>not</u> to be removed.
9040, 1.08, L, 1, c	Specify the use of anti-seep collars.
9040, 1.08, Q, 2, c	Specify the area to hydromulch.
9040, 1.08, W	Specify when to use linear erosion control.
9040, 2.02, B	Specify the use of tackifiers in compost blankets.
9040, 2.03	Specify the use of filter material in areas other than filter socks.
9040, 2.04	Specify the use of slash mulch in areas other than filter berms.
9040, 2.07, A	Specify diameter for open weave, degradable netting if other than 9 inches is required.
9040, 2.08, A, 2	Specify if using RECP for permeable check dam.
9040, 2.09, A	Specify length of pressure-treated timber for level spreaders.
9040, 2.12, A	Specify class of concrete if <u>not</u> Class C.
9040, 2.12, B	Specify riser diameter for sediment basin outlet structures.
9040, 2.12, C, 1	Specify the number, diameter, and elevation of the holes in the riser of the dewatering device in sediment basin outlet structures.
9040, 2.12, D	Specify barrel diameter of the sediment basin outlet structures.
9040, 2.12, E	Specify riser diameter for anti-vortex device.
9040, 2.21, C, 3	Specify if additional or alternate underlayment materials are required.
9040, 3.02, D	Specify if weekly erosion and sediment control site inspections are <u>not</u> required as a part of SWPPP management.
9040, 3.05, B	Specify depth of compost blankets.
9040, 3.06, A	Specify when the filter berm is <u>not</u> to be installed along the contour.
9040, 3.07, A, 1	Specify the size and length of filter sock.

Incidental or Included Items

Items that are necessary to properly complete construction, including work and materials, and are not pay items. The following is a list of items in the SUDAS Specifications that are considered incidental to other work unless specified as a pay item on the plans or in the contract documents. Please note - this list is not all-inclusive.

Section 2010 - Earthwork, Subgrade, and Subbase

- 2010, 1.08, A, 3 Clearing and Grubbing (by units)
Placement of backfill in area where roots have been removed, and removal and disposal of all materials.
- 2010, 1.08, B, 3 Clearing and Grubbing (by area)
Removal and disposal of all materials and placement of backfill in area where roots have been removed.
- 2010, 1.08, C, 3 Clearing and Grubbing (by lump sum)
Removing and disposing all materials and furnishing and placing backfill material in area where roots have been removed.
- 2010, 1.08, D, 1, c Topsoil, On-site
Stripping and stockpiling topsoil; preparing the topsoil placement area by tillage or ripping; re-spreading the topsoil; additional tillage to address compaction during placement; and removal of clods, roots, stones, and other undesirable materials.
- 2010, 1.08, D, 2, c Topsoil, Compost-amended
Preparing the placement area by tillage or ripping and furnishing, transporting, placing, and incorporating compost.
- 2010, 1.08, D, 3, c Topsoil, Off-site
Preparing the placement area by tillage or ripping; furnishing, transporting, and spreading the off-site topsoil; completing tillage to address compaction during placement; and removal of clods, roots, stones, and other undesirable materials.
- 2010, 1.08, E, 3 Excavation, Class 10, Class 12, or Class 13
a. Site preparation for, and the construction of, embankment, fills, shoulder backfill, and backfill behind curbs.
b. Overhaul.
c. Finishing the soil surface, including roadways, shoulders, behind curbs, side ditches, slopes, and borrow pits.
d. Repair or replacement of any fences that have been unnecessarily damaged or removed.

2010, 1.08, F, 3	<p><u>Below Grade Excavation (Core Out)</u> Equipment, tools, labor, disposal of unsuitable materials, dewatering, drying, furnishing, and placement of foundation materials as required by the Engineer, compaction and finishing of the excavated area, and all incidental work as may be required.</p>
2010, 1.08, G, 3	<p><u>Subgrade Preparation</u> Excavating, manipulating, replacing, compacting, and trimming to the proper grade.</p>
2.01, 1.08, H, 3	<p><u>Granular Stabilization</u> Removal and disposal of unstable material and furnishing, hauling, placing, and compacting granular stabilization material.</p>
2010, 1.08, I, 3	<p><u>Subgrade Treatment</u> Furnishing, placing, and incorporating the subgrade treatment material (cement, asphalt, fly ash, lime, geogrid, or geotextiles).</p>
2010, 1.08, J, 3	<p><u>Subbase</u> Furnishing, placing, compacting, and trimming to the proper grade.</p>
2010, 1.08, K, 1, c	<p><u>Removal of Structures</u> Removal and disposal of structures.</p>
2010, 1.08, K, 2, a, 3)	<p><u>Removal of Known Box Culverts</u> Removal and disposal of known box culverts.</p>
2010, 1.08, K, 2, c, 3)	<p><u>Removal of Known Pipe Culverts</u> Removal and disposal of known pipe culverts.</p>
2010, 1.08, K, 3, a, 3)	<p><u>Removal of Known Pipes and Conduits</u> Removal, disposal, and plugging, if specified, of pipes and conduits.</p>
2010, 1.08, L, 1, c	<p><u>Filling and Plugging of Known Pipe Culverts, Pipes, and Conduits</u> Furnishing and installing the plug and the flowable mortar as designated by the Engineer.</p>

Section 3010 - Trench Excavation and Backfill

3010, 1.08, A	<p><u>General</u></p> <ol style="list-style-type: none"> 1. Standard trench excavation. 2. Removal and disposal of excess backfill material resulting from pipe installation. 3. Removal of abandoned private utilities encountered during trench excavation. 4. Furnishing and placing granular bedding material. 5. Placing and compacting backfill material. 6. Dewatering including, but not limited to, all equipment such as generators, pumps, rock for sump pits, discharge piping, and any extra excavation needed to facilitate dewatering according to stormwater regulations, as applicable. 7. Sheet piling, shoring, and bracing. 8. Adjusting the moisture content of excavated backfill material to the range specified for placement and compaction.
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- 3010, 1.08, B, 3 Rock Excavation
Furnishing the equipment and labor to break up, remove, and properly dispose of rock encountered in the trench.
- 3010, 1.08, C, 3 Trench Foundation
Removal and disposal of over-excavated material required to stabilize trench foundation; and furnishing, hauling, and placing stabilization material.
- 3010, 1.08, D, 3 Removal, Disposal, and Replacement of Unsuitable Backfill Material
Removal, hauling, and disposal costs of the unsuitable material and the furnishing, hauling, and placing of the suitable replacement backfill material. Unit price does not include landfill costs for contaminated materials.
- 3010, 1.08, E, 3 Special Pipe Embedment or Encasement
Furnishing and placing all required special pipe embedment or encasement materials.
- 3010, 1.08, F, 3 PCC Pipe Support Over Existing Utility
Furnishing and placing PCC pipe supports and associated materials.
- 3010, 1.08, G, 3 Reinforced PCC Beam Utility Line Support
Furnishing and placing the reinforced PCC beam utility line support and associated materials
- 3010, 1.08, H, 3 Trench Compaction Testing
All payments associated with retesting resulting from failure of initial tests.

Section 3020 - Trenchless Construction

- 3020, 1.08 All items of work contained in this section are incidental to the underground utility pipe being installed and will not be paid for separately.

Section 4010 - Sanitary Sewers

- 4010, 1.08, A, 1, c Sanitary Sewer Gravity Main, Trenched
Trench excavation; dewatering; furnishing and installing pipe; pipe lining (if specified); furnishing, placing, and compacting bedding and backfill material; wyes and other fittings; pipe joints; pipe connections; testing; and inspection.
- 4010, 1.08, A, 2, c Sanitary Sewer Gravity Main, Trenchless
Furnishing and installing pipe; pipe lining (if specified); trenchless installation materials and equipment; pit excavation; dewatering; placing and compacting backfill material; pipe connections; testing; and inspection.
- 4010, 1.08, B, 1, c Sanitary Sewer Gravity Main with Casing Pipe, Trenched
Furnishing and installing both carrier pipe and casing pipe, pipe lining (if specified); trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, furnishing and installing annular space fill material, casing spacers, pipe connections, testing, and inspection.

- 4010, 1.08, B, 2, c Sanitary Sewer Gravity Main with Casing Pipe, Trenchless
Furnishing and installing both carrier pipe and casing pipe; pipe lining (if specified); trenchless installation materials and equipment; pit excavation; dewatering; and placing and compacting backfill material; casing spacers; furnishing and installing annular space fill material; pipe connections; testing; and inspection.
- 4010, 1.08, C, 1, c Sanitary Sewer Force Main, Trenched
Trench excavation; dewatering; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill; wyes and other fittings; pipe joints; testing; and inspection.
- 4010, 1.08, C, 2, c Sanitary Sewer Force Main, Trenchless
Furnishing and installing pipe; trenchless installation materials and equipment; pit excavation; dewatering; placing and compacting backfill material; pipe connections; testing; and inspection.
- 4010, 1.08, D, 1, c Sanitary Sewer Force Main with Casing Pipe, Trenched
Furnishing and installing both carrier pipe and casing pipe; trench excavation; dewatering; furnishing, placing, and compacting bedding and backfill material; furnishing and installing annular space fill material; casing spacers; pipe connections; testing; and inspection.
- 4010, 1.08, D, 2, c Sanitary Sewer Force Main with Casing Pipe, Trenchless
Furnishing and installing both carrier pipe and casing pipe; trenchless installation materials and equipment; pit excavation; dewatering; placing and compacting backfill material; casing spacers; furnishing and installing annular space fill material; pipe connections; testing; and inspection.
- 4010, 1.08, E, 3 Sanitary Sewer Service Stub
Trench excavation; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill material; tap; fittings; testing; and inspection.
- 4010, 1.08, F, 3 Sanitary Sewer Service Relocation
Removal of existing pipe, trench excavation, furnishing new pipe and bedding material, placing and compacting bedding and backfill material, connection back to existing service, compaction, testing, and inspection.
- 4010, 1.08, G, 3 Sewage Air Release Valve and Pit
Excavation; furnishing, placing, and compacting bedding and backfill material; and testing.
- 4010, 1.08, H, 3 Removal of Sanitary Sewer
Removal, disposal, and capping (if specified) of pipe; and furnishing, placing, and compacting backfill material.
- 4010, 1.08, I, 3 Sanitary Sewer Cleanout
Plug at the end of the main, fittings, riser pipe, cap with screw plug, casting, and concrete casting encasement.
- 4010, 1.08, K, 3 Sanitary Sewer Abandonment, Plug
Trench excavation (if necessary), cutting pipe (if required), furnishing and placing plug materials, and placing and compacting backfill material.

4010, 1.08, L, 3 Sanitary Sewer Abandonment, Fill and Plug
Trench excavation (if necessary), cutting pipe (if required), furnishing and placing pipe fill material, furnishing and placing plug materials, and placing and compacting backfill material.

Section 4020 - Storm Sewers

4020, 1.08, A, 1, c Storm Sewer, Trenched
Trench excavation; dewatering; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill material; joint wrapping; wyes and other fittings; pipe joints; pipe connections; testing; and inspection.

4020, 1.08, A, 2, c Storm Sewer, Trenchless
Furnishing and installing pipe; trenchless installation materials and equipment; pit excavation; dewatering; placing and compacting backfill material; pipe connections; testing; and inspection.

4020, 1.08, B, 1, c Storm Sewer with Casing Pipe, Trenched
Furnishing and installing both carrier pipe and casing pipe; trench excavation; dewatering; furnishing, placing, and compacting bedding and backfill material; furnishing and installing annular space fill material; casing spacers; pipe connections; testing; and inspection.

4020, 1.08, B, 2, c Storm Sewer with Casing Pipe, Trenchless
Furnishing and installing both carrier pipe and casing pipe; trenchless installation materials and equipment; pit excavation; dewatering; placing and compacting backfill material; casing spacers; furnishing and installing annular space fill material; pipe connections; testing; and inspection.

4020, 1.08, C, 3 Linear Trench Drain
Furnishing and installing the linear trench drain including all appurtenances; furnishing and placement of PCC transition; furnishing, excavation, and backfill of discharge pipe; connection to manhole or intake, if required; installation of apron, if required.

4020, 1.08, D, 3 Removal of Storm Sewer
Removal, disposal, and capping (if specified) of pipe; and furnishing, placing, and compacting backfill material.

4020, 1.08, F, 3 Storm Sewer Abandonment, Plug
Trench excavation (if necessary), cutting pipe (if required), furnishing and placing plug materials, and placing and compacting backfill material.

4020, 1.08, G, 3 Storm Sewer Abandonment, Fill and Plug
Trench excavation (if necessary), cutting pipe (if required), furnishing and placing pipe fill material, furnishing and placing plug materials, and placing and compacting backfill material.

Section 4030 - Pipe Culverts

- 4030, 1.08, A, 1, c Pipe Culvert, Trenched
Trench excavation; dewatering; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill material; connectors; testing; and inspection.
- 4030, 1.08, A, 2, c Pipe Culvert, Trenchless
Furnishing and installing pipe; trenchless installation materials and equipment; pit excavation, dewatering, and placing and compacting backfill material; pipe connections; testing; and inspection.
- 4030, 1.08, B, 3 Pipe Apron
Trench excavation; dewatering; furnishing and installing the apron; furnishing, placing, and compacting bedding and backfill material; connectors; and other appurtenances.
- 4030, 1.08, C, 3 Footing for Concrete Pipe Apron
Excavation; dewatering; reinforcing steel; concrete; furnishing, placing and compacting bedding and backfill material.
- 4030, 1.08, D, 3 Pipe Apron Guard
Furnishing and installing the apron guard and repairing any damage to the apron from the installation process.

Section 4040 - Subdrains and Footing Drain Collectors

- 4040, 1.08, A, 3 Subdrain
Trench excavation, furnishing and placing bedding and backfill material, engineering fabric (when specified), connectors, and elbows and tees. The length of elbows and tees of the pipes installed will be included in the length of pipe measured.
- 4040, 1.08, B, 3 Footing Drain Collector
Trench excavation, pipe, wyes, tap, fittings, and furnishing and placing bedding and backfill material.
- 4040, 1.08, C, 1, c Subdrain Cleanout
Trench excavation; furnishing cleanout and lid; and furnishing, placing, and compacting bedding and backfill material.
- 4040, 1.08, C, 2, c Footing Drain Cleanout
Trench excavation; furnishing cleanout and lid; and furnishing, placing, and compacting bedding and backfill material.
- 4040, 1.08, D, 1, c Subdrain Drain Outlets and Connections
Pipe, non-shrink grout, coupling bands, and rodent guards for pipes 6 inches or smaller.
- 4040, 1.08, D, 2, c Footing Drain Outlets and Connections
Pipe, non-shrink grout, coupling bands, and rodent guards for pipes 6 inches or smaller.

4040, 1.08, E, 3 Storm Sewer Service Stub
Trench excavation, furnishing bedding material, placing bedding and backfill material, tap, fittings, and plugs.

Section 4050 - Pipe Cleaning and Rehabilitation

4050, 1.08, A, 1, c Mainline Cleaning
Sewer cleaning, debris removal and transport, post CCTV inspection for Engineer review, and logging of active service taps (if specified). Unit price also includes disposal and associated costs for all debris removed from sewer.

4050, 1.08, A, 2, c Pre-Rehabilitation Cleaning and Inspection
Pre-cleaning CCTV inspection, light sewer cleaning, debris removal and transport, post cleaning CCTV inspection for Engineer review, and identification and logging of active service taps. Unit price also includes disposal and associated costs for all debris removed from sewer.

4050, 1.08, A, 3, c Additional Sewer Cleaning
Heavy sewer cleaning, root cutting, deposit cutting, and post cleaning CCTV inspection for Engineer review.

4050, 1.08, A, 4, c Debris Removal, Transportation, and Disposal
Removing, decanting, transporting, disposing, and paying associated costs for all debris removed from sewer as a part of additional cleaning.

4050, 1.08, B, 3 Remove Protruding Service Connections
Removal of protruding service connections and debris removal.

4050, 1.08, C, 1, c CIPP Main Lining
Furnishing and installing the liner and appurtenances, CCTV inspection immediately prior to lining, bypass pumping unless otherwise specified, sliding foil, post-lining CCTV inspection, and all costs associated with the public information and notification program.

4050, 1.08, C, 2, c Building Sanitary Sewer Service Reinstatement
Reinstating sanitary sewer service connections, removal of debris, and coordination with service owners.

4050, 1.08, C, 3, c CIPP End Seal
End seal and installation.

4050, 1.08, D, 3 CIPP Point Repair
Furnishing and placing point repair liner, bypass pumping unless otherwise specified, sewer cleaning, removal of obstructions, debris removal, pipe preparation, and pre and post repair CCTV inspection.

4050, 1.08, E, 1, c CIPP Service Pipe, Connection
Furnishing and placing service connection liner, bypass pumping unless otherwise specified, documentation, and all costs associated with the public information and notification program.

- 4050, 1.08, E, 2, c CIPP Service Repair, Partial Pipe
Furnishing and installing service repair liner, bypass pumping unless otherwise specified, documentation, and all costs associated with the public information and notification program.
- 4050, 1.08, F, 1, c Pressure Testing of Mainline Sewer Joints
Bypass pumping unless otherwise specified, control testing, and documentation.
- 4050, 1.08, F, 2, c Injection Grouting of Mainline Sewer Joints
Bypass pumping unless otherwise specified, material testing, pressure testing after grouting, re-grouting of failed joints, and documentation. Unit price does not include the quantity of chemical grout used.
- 4050, 1.08, F, 3, c Pressure Testing of Service Connections
Bypass pumping unless otherwise specified, and documentation.
- 4050, 1.08, F, 4, c Injection Grouting of Service Connections
Bypass pumping unless otherwise specified, material testing, pressure testing after grouting, and documentation. Unit price does not include the quantity of chemical grout used.
- 4050, 1.08, F, 5, c Chemical Grout
Grout additives; root inhibitor; and supplying, mixing, and measurement of chemical grout.
- 4050, 1.08, G, 3 Bypass Pumping
Development and submittal of the bypassing plan, all staffing, equipment, and appurtenances necessary to accomplish the approved bypassing plan, including reserve equipment.
- 4050, 1.08, H, 1, c Spot Repairs by Pipe Replacement (by count)
Uncovering and removing existing pipe and furnishing and placing bedding and backfill material for replacement pipe.
- 4050, 1.08, H, 2, c Spot Repairs by Pipe Replacement (by linear foot)
Furnishing and installing replacement pipe and connections.

Section 4060 - Cleaning, Inspection, and Testing of Sewers

- 4060, 1.08 Cleaning, inspecting, and testing sanitary sewers, storm sewers, pipe culverts, and rehabilitated pipes (including video inspection) are incidental to other project costs and will not be paid for separately.

Section 5010 - Pipe and Fittings

- 5010, 1.08, A, 1, c Water Main, Trenched
Trench excavation; dewatering; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill material; tracer system; testing; disinfection; and polyethylene wrap for ductile iron pipe and for fittings.

- 5010, 1.08, A, 2, c Water Main, Trenchless
Furnishing and installing pipe; trenchless installation materials and equipment; pit excavation; dewatering; placing and compacting backfill material; tracer system; testing; and disinfection.
- 5010, 1.08, B, 1, c Water Main with Casing Pipe, Trenched
Furnishing and installing both carrier pipe and casing pipe; trench excavation; dewatering; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill material; casing spacers; furnishing and installing annular space fill material; tracer system; testing; and disinfection.
- 5010, 1.08, B, 2, c Water Main with Casing Pipe, Trenchless
Furnishing and installing both carrier pipe and casing pipe; trenchless installation materials and equipment; pit excavation; dewatering; placing and compacting backfill material; casing spacers; furnishing and installing annular space fill material; tracer system; testing; and disinfection.
- 5010, 1.08, C, 1, c Fitting (by count)
Furnishing and installing fittings, restrained joints, anchor blocks, and thrust blocks.
- 5010, 1.08, C, 2, c Fitting (by weight)
Furnishing and installing fittings, restrained joints, anchor blocks, and thrust blocks.
- 5010, 1.08, D, 3 Water Service Stub (by each)
Water service corporation; service pipe; curb stop; stop box; trench excavation; dewatering; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill material; and installation of tracer wire system for non-metallic service pipe.
- 5010, 1.08, E, 1, c Water Service Pipe
Trench excavation; dewatering; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill material; and installation of tracer wire system for non-metallic service pipe.
- 5010, 1.08, E, 2, c Water Service Corporation
Trench excavation (if necessary); furnishing and installing the water service corporation; and furnishing, placing, and compacting bedding and backfill material.
- 5010, 1.08, E, 3, c Water Service Curb Stop and Box
Trench excavation (if necessary); furnishing and installing the curb stop and box; and furnishing, placing, and compacting bedding and backfill material.
- 5010, 1.08, F, 3 Water Main Abandonment, Cap
Trench excavation (if necessary); closing valves; removing valve boxes; installing thrust blocks; cutting pipe; installing MJ caps; and furnishing, placing, and compacting backfill material.

- 5010, 1.08, G, 3 Water Main Abandonment, Fill and Plug
Trench excavation (if necessary); closing valves; removing valve boxes; installing thrust blocks; cutting and removing the specified section of pipe; furnishing and pumping flowable material to fill the pipe to be abandoned; installing MJ caps; and furnishing, placing, and compacting backfill material.
- 5010, 1.08, H, 3 Water Main Removal
Trench excavation (if necessary); closing valves; installing thrust blocks; cutting pipe; installing MJ caps; removal and disposal of all valves and pipe specified for removal; furnishing, placing, and compacting backfill material.

Section 5011 - Fusible PVC and HDPE Pipe

- 5011, 1.08, A, 1, c Fusible Water Main, Trenched
Trench excavation, dewatering, furnishing bedding material, performing fusion jointing, placing bedding and backfill material, tracer system, testing, and disinfection.
- 5011, 1.08, A, 2, c Fusible Water Main, Trenchless
Furnishing and installing pipe; performing fusion jointing, trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill material; tracer system; testing; and disinfection.
- 5011, 1.08, B, 1, c Water Main with Casing Pipe, Trenched
Furnishing and installing both fusible carrier pipe and casing pipe, performing fusion jointing, trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, casing spacers, furnishing and installing annular space fill material, tracer system, testing, and disinfection.
- 5011, 1.08, B, 2, c Water Main with Casing Pipe, Trenchless
Furnishing and installing both fusible carrier pipe and casing pipe; performing fusion jointing, trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill material; casing spacers; furnishing and installing annular space fill material; tracer system; testing; and disinfection.

Section 5020 - Valves, Fire Hydrants, and Appurtenances

- 5020, 1.08, A, 3 Valve
All components attached to the valve or required for its complete installation, including underground or above ground operator, square valve operating nut, valve box and cover, valve box extension, and valve stem extension.
- 5020, 1.08, B, 3 Tapping Valve Assembly
Tapping sleeve, tapping valve, the tap, valve box and cover, valve box extension, and valve stem extension.
- 5020, 1.08, C, 3 Fire Hydrant Assembly
The fire hydrant, barrel extensions sufficient to achieve proper bury depth of anchoring pipe and height of fire hydrant above finished grade, and components to connect the fire hydrant to the water main, including anchoring pipe, fittings, thrust blocks, pea gravel or porous backfill material, and fire hydrant gate valve and appurtenances, except tapping valve assembly if used.

- 5020, 1.08, D, 3 Alternate Fire Hydrant Assembly
The fire hydrant, barrel extensions sufficient to achieve proper bury depth of anchoring pipe and height of fire hydrant above finished grade, and components to connect the fire hydrant to the water main, including anchoring pipes, 90 degree bend; fittings, thrust blocks, pea gravel or porous backfill material, and fire hydrant gate valve and appurtenances, except tapping valve assembly if used.
- 5010, 1.08, E, 3 Flushing Device (Blowoff)
Trench excavation; furnishing, installing, and removing the flushing device (if designated by the Engineer); and furnishing, placing, and compacting bedding and backfill material.
- 5020, 1.08, F Measurement and payment for minor adjustment of an existing valve box by raising or lowering the adjustable valve box is incidental.
- 5020, 1.08, G, 3 Valve Box Extension
Furnishing and installing the valve box extension and replacing the valve box lid.
- 5020, 1.08, H, 3 Valve Box Replacement
Removal of existing valve box; excavation; furnishing and installing new valve box; backfill; compaction; and all other necessary appurtenances.
- 5020, 1.08, I, 3 Fire Hydrant Adjustment
Removal and reinstallation of the existing fire hydrant; furnishing and installing the extension barrel section and stem; and all other necessary appurtenances.
- 5020, 1.08, J, 3 Fire Hydrant Assembly Removal
Excavation, removal of the fire hydrant, hydrant valve, thrust block, delivery of the fire hydrant assembly to the Contracting Authority (if specified), capping of the pipe, backfill, compaction, and surface restoration to match the surrounding area.
- 5020, 1.08, K, 3 Valve Removal
Excavation, removal of each valve, replacing the removed valve with pipe and connections if required or capping the former valve connection, delivery of the valve to the Contracting Authority (if specified), backfill, compaction, and surface restoration to match the surrounding area.
- 5020, 1.08, L, 3 Valve Box Removal
Excavation, removal of each valve box, delivery of the valve box to the Contracting Authority (if specified), backfill, compaction, and surface restoration to match the surrounding area.

Section 5030 - Testing and Disinfection

- 5030, 1.08 Testing and disinfection of water systems is incidental to the construction of pipe and fittings.

Section 6010 - Structures for Sanitary and Storm Sewers

- 6010, 1.08, A, 3 Manhole
Excavation; furnishing and installing pipe; lining (if specified); furnishing, placing, and compacting bedding and backfill material; base; structural concrete; reinforcing steel; precast units (if used); concrete fillets; pipe connections; infiltration barriers (sanitary sewer manholes only); castings; and adjustment rings.
- 6010, 1.08, B, 3 Intake
Excavation; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill material; base; structural concrete; reinforcing steel; precast units (if used); concrete fillets; pipe connections; castings; adjustment rings; and the insert/boxout.
- 6010, 1.08, C, 1, c Internal Drop Connection
Cutting the hole and installing a flexible watertight connector, providing and installing the receiving bowl, flexible coupler between the bowl and the drop pipe, the PVC drop pipe, pipe brackets and bolts, the bottom elbow, repair of fillet if required, and a splash guard if required.
- 6010, 1.08, C, 2, c External Drop Connection
The connection to the manhole and all pipe; fittings; concrete encasement; and furnishing, placing, and compacting bedding and backfill material.
- 6010, 1.08, D, 3 Casting Extension Rings
Furnishing and installing each casting extension ring and reinstalling the casting lid.
- 6010, 1.08, E, 1, c Manhole Adjustment, Minor
Removing existing casting and existing adjustment rings, furnishing and installing adjustment rings, furnishing and installing new casting, and installing new infiltration barrier (sanitary sewer manholes only).
- 6010, 1.08, E, 2, c Intake Adjustment, Minor
Removing existing casting and existing adjustment rings, furnishing and installing adjustment rings, and furnishing and installing new casting.
- 6010, 1.08, F, 1, c Manhole Adjustment, Major
Removal of existing casting, adjustment rings, top sections, and risers; excavation; concrete and reinforcing steel or precast sections; furnishing and installing new casting; installing new infiltration barrier (sanitary sewer manholes only); placing backfill material; and compaction.
- 6010, 1.08, F, 2, c Intake Adjustment, Major
Removal of existing casting, adjustment rings, top sections, and risers; excavation; concrete and reinforcing steel or precast sections; furnishing and installing new casting; placing backfill material; and compaction.
- 6010, 1.08, G, 1, c Connection to Existing Manhole
Coring or cutting into the existing manhole, removal of existing fillet, pipe connections, replacement of fillet, grout, and waterstop (when required).

- 6010, 1.08, G, 2, c Connection to Existing Intake
Coring or cutting into the existing intake, removal of existing fillet, pipe connections, replacement of fillet, grout, and waterstop (when required).
- 6010, 1.08, H, 1, c Remove Manhole
Removal of casting, concrete, and reinforcement; plugging pipes; filling remaining structure with flowable mortar; and placing compacted fill over structure to finished grade.
- 6010, 1.08, H, 2, c Remove Intake
Removal of casting, concrete, and reinforcement; plugging pipes; filling remaining structure with flowable mortar; and placing compacted fill over structure to finished grade.

Section 6020 - Rehabilitation of Existing Manholes

- 6020, 1.08, A, 1, c Rubber Chimney Seal
All necessary compression or expansion bands and extension sleeves as necessary to complete chimney seal.
- 6020, 1.08, A, 2, c Molded Shield
Sealant.
- 6020, 1.08, A, 3, c Urethane Chimney Seal
Preparing the surface of the manhole and furnishing and applying primer and urethane chimney seal according to the manufacturer's requirements.
- 6020, 1.08, B, 3 In-situ Manhole Replacement, Cast-in-place Concrete
Handling of sewer flows as required to properly complete the installation, invert overlay as recommended by the manufacturer, replacement of existing casting with a new casting, and testing the manhole upon completion.
- 6020, 1.08, C, 3 In-situ Manhole Replacement, Cast-in-place Concrete with Plastic Liner
Handling of sewer flows as required to properly complete the installation, invert overlay as recommended by the manufacturer, replacement of existing casting with a new casting, sealing at the frame and cover, sealing pipe penetrations as recommended by the manufacturer, and testing the manhole upon completion.
- 6020, 1.08, D, 3 Manhole Lining with Centrifugally Cast Cementitious Mortar Liner with Epoxy Seal
Handling of sewer flows during lining operations as required to properly complete the installation, and replacement of the existing casting with a new casting.

Section 6030 - Cleaning, Inspection, and Testing of Structures

- 6030, 1.08 Cleaning, inspection, and testing of structures are incidental to construction of structures and will not be paid for separately.

Section 7010 - Portland Cement Concrete Pavement

- 7010, 1.08, A, 3 Pavement, PCC
Final trimming of subgrade or subbase, integral curb, bars and reinforcement, joints and sealing, surface curing and pavement protection (excluding cold weather protection; see Section 7010, 1.08, N), safety fencing, concrete for rigid headers, boxouts for fixtures, and pavement smoothness testing.
- 7010, 1.08, E, 3 Curb and Gutter
Final subgrade/subbase preparation, bars and reinforcement, joints and sealing, surface curing and pavement protection (excluding cold weather protection; see Section 7010, 1.08, N), and boxouts for fixtures.
- 7010, 1.08, F, 3 Beam Curb
Final subgrade/subbase preparation, bars and reinforcement, joints and sealing, surface curing and pavement protection (excluding cold weather protection; see Section 7010, 1.08, N), and boxouts for fixtures.
- 7010, 1.08, G, 3 Concrete Median
Final subgrade/subbase preparation, bars and reinforcement, joints and sealing, surface curing and pavement protection (excluding cold weather protection; see Section 7010, 1.08, N), and boxouts for fixtures.
- 7010, 1.08, H, 3 PCC Railroad Crossing Approach
Excavation for modified subbase and subdrain, furnishing and installing subdrain, furnishing and installing subdrain outlet or connection to storm sewer, furnishing and installing porous backfill material, furnishing and placing modified subbase material, furnishing and installing reinforcing steel and tie bars, furnishing and placing concrete, furnishing, placing, and compacting asphalt.
- 7010, 1.08, I, 3 PCC Pavement Samples and Testing
Certified plant inspection, pavement thickness cores, pavement smoothness measurement (when required by the contract documents), and maturity testing.
- 7010, 1.08, K, 3 PCC Pavement Widening
Final subgrade/subbase preparation, integral curb, bars and reinforcement, joints and sealing, surface curing and pavement protection (excluding cold weather protection; see Section 7010, 1.08, N), safety fencing, concrete for rigid headers, boxouts for fixtures, and pavement smoothness.
- 7010, 1.08, N, 3 PCC Cold Weather Protection
Payment will be limited to protection necessary only within the contract period and with prior authorization of the work by the Engineer. No price modifications will be made for quantity underruns or overruns for this item. Cold weather protection necessary after the completion date, after all calendar days have passed, or after all working days have been used is incidental to the work regardless if a quantity was included in the contract.

Section 7011 - Portland Cement Concrete Overlays

- 7011, 1.08, A, 1, c PCC Overlay, Furnish Only
Furnishing the concrete mixture and delivery to the project site.
- 7011, 1.08, A, 2, c PCC Overlay, Place Only
Integral curb, bars and reinforcement, joints and sealing, finishing and texturing, surface curing and pavement protection, safety fencing, concrete for rigid headers, boxouts for fixtures, and pavement smoothness testing.
- 7011, 1.08, A, 3, c Surface Preparation for Bonded PCC Overlay
Sandblasting, shot blasting, scarification, and surface cleaning.
- 7011, 1.08, A, 4, c Surface Preparation for Unbonded PCC Overlay
Scarification and surface cleaning.
- 7011, 1.08, A, 5, c Asphalt Separation Layer for Unbonded PCC Overlay
Asphalt mix, including asphalt binder.
- 7011, 1.08, A, 6, c Geotextile Fabric Separation Layer for Unbonded PCC Overlay
Cleaning surface and furnishing, placing, and securing the geotextile fabric separation layer.
- 7011, 1.08, A, 7, c Liquid Curing Compound Separation Layer on PCC Surface Patches for Unbonded PCC Overlay
Cleaning PCC surface patches and furnishing and placing the liquid curing compound.

Section 7020 - Asphalt Pavement

- 7020, 1.08, A, 3 Pavement, Asphalt (by ton)
Asphalt mix with asphalt binder, tack coats between layers, construction zone protection, and quality control.
- 7020, 1.08, B, 3 Pavement, Asphalt (by square yard)
Asphalt mix with asphalt binder, tack coats between layers, construction zone protection, and quality control.
- 7020, 1.08, C, 3 Asphalt Base Widening (by ton)
Asphalt mix with asphalt binder, tack coats between layers, construction zone protection, and quality control.
- 7020, 1.08, D, 3 Asphalt Base Widening (by square yard)
Asphalt mix with asphalt binder, tack coats between layers, construction zone protection, and quality control.
- 7020, 1.08, E, 3 Asphalt Railroad Crossing Approach
Excavation for modified subbase and subdrain, furnishing and installing subdrain, furnishing and installing subdrain outlet, furnishing and installing porous backfill material, furnishing and placing modified subbase material, furnishing and applying tack coat, furnishing, placing, and compacting asphalt.

- 7020, 1.08, I, 3 Asphalt Pavement Samples and Testing
Certified plant inspection, pavement thickness cores, density analysis, pavement smoothness measurement (when required by the contract documents), and air void testing.
- 7020, 1.08, M, 3 Asphalt Cold Weather Paving
All additional labor, materials, and equipment to supply and place the flexible pavement under the approved cold weather paving plan.

Section 7021 - Asphalt Overlays

- 7021, 1.08, A, 3 Asphalt Overlay (by ton)
Asphalt mix with asphalt binder, tack coats between layers, construction zone protection, and quality control.
- 7021, 1.08, B, 3 Asphalt Overlay (by square yard)
Asphalt mix with asphalt binder, tack coat, construction zone protection, and quality control.

Section 7030 - Sidewalks, Shared Use Paths, and Driveways

- 7030, 1.08, A, 1, c Removal of Sidewalk
Sawing, hauling, and disposal of materials removed.
- 7030, 1.08, A, 2, c Removal of Shared Use Path
Sawing, hauling, and disposal of materials removed.
- 7030, 1.08, A, 3, c Removal of Driveway
Sawing, hauling, and disposal of materials removed.
- 7030, 1.08, B, 3 Removal of Curb
Hauling and disposal of materials removed.
- 7030, 1.08, C, 3 Shared Use Path
Subgrade preparation, jointing, sampling, smoothness testing and correction, and testing.
- 7030, 1.08, D, 3 Special Subgrade Preparation for Shared Use Path
Water required to bring subgrade moisture content to within the required limits.
- 7030, 1.08, E, 3 Sidewalk, PCC
Minor grade adjustments at driveways and other intersections, subgrade preparation, formwork, additional thickness at thickened edges, jointing, sampling, smoothness testing and correction, and testing.
- 7030, 1.08, F, 3 Brick/Paver Sidewalk with Pavement Base
Subgrade preparation, pavement base, setting bed, neoprene asphalt adhesive for asphalt setting bed, setting the bricks/pavers, installing weep holes and associated materials, and sand/cement joint filler.
- 7030, 1.08, G, 3 Detectable Warning
Steel bar supports and manufactured detectable warning panels.

- 7030, 1.08, H, 1, c Driveway, Paved
Excavation, subgrade preparation, jointing, sampling, and testing.
- 7030, 1.08, H, 2, c Driveway, Granular (by square yards)
Excavation and preparation of subgrade.
- 7030, 1.08, H, 3, c Driveway, Granular (by tons)
Excavation and preparation of subgrade.

Section 7040 - Pavement Rehabilitation

- 7040, 1.08, A, 3 Full Depth Patches
Sawing, removing, and disposing of existing pavement and reinforcing; restoring the subgrade; furnishing and installing tie bars and dowel bars; furnishing and placing the patch material, including the asphalt binder and tack coat; forming and constructing integral curb; surface curing and pavement protection; joint sawing and filling; and placing backfill and restoring disturbed surfaces.
- 7040, 1.08, B, 3 Subbase Over-excavation
Removal of existing subbase or subgrade, disposal of materials removed, furnishing and placing subbase material, and any additional excavation required for subbase placement.
- 7040, 1.08, C, 3 Partial Depth Patches
Sawing, removing, and disposing of existing pavement; furnishing tack coat or bonding agent; furnishing and placing the patch material; curing; joint filling (PCC patches only); placing backfill; and restoring disturbed surfaces.
- 7040, 1.08, D, 3 Crack and Joint Cleaning and Filling, Hot Pour
Furnishing crack and joint filler material and routing, sawing, cleaning, and filling joints or cracks.
- 7040, 1.08, E, 1, c Crack Cleaning and Filling, Emulsion
Furnishing emulsified crack filler material, cleaning cracks, placing soil sterilant, and filling cracks.
- 7040, 1.08, E, 2, c Asphalt for Crack Filling
Cleaning, applying tack coat, and furnishing and placing asphalt for crack filling.
- 7040, 1.08, F, 3 Diamond Grinding
Diamond grinding pavement, testing for smoothness according to the contract documents, and removal of slurry and residue from the project site.
- 7040, 1.08, G, 3 Milling
Milling pavement; furnishing water; and salvaging, stockpiling, and removing cuttings and debris.
- 7040, 1.08, H, 3 Pavement Removal
Sawing, breaking, removing, and disposing of existing pavement and reinforcing steel.
- 7040, 1.08, I, 3 Curb and Gutter Removal
Sawing, breaking, removing, and disposing of existing curb and gutter.

- 7040, 1.08, J, 3 Dowel Bar Retrofit
Cutting the slots, preparing the slots, placing and grouting the bars, and curing the surface.
- 7040, 1.08, K Core Hole Cutting and Replacement
Cutting the core hole, vacuum excavation, furnishing and placing backfill material and pavement, or replacing the pavement core using waterproof bonding material, if specified.
- 7040, 1.08, L Required sampling and testing for pavement repair and rehabilitation work is incidental to other project costs and will not be paid for separately.

Section 7050 - Asphalt Stabilization

- 7050, 1.08, A, 3 Asphalt Stabilization
Furnishing and spreading imported material, applying and incorporating asphalt stabilization, blending of the materials, grading and compacting the blended materials, and final clean up.

Section 7060 - Bituminous Seal Coat

- 7060, 1.08, A, 3 Bituminous Seal Coat (by area)
Surface preparation including protection of street fixtures; furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts; and final clean up.
- 7060, 1.08, B, 1, c Cover Aggregate
Surface preparation including protection of street fixtures; furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts; and final clean up.
- 7060, 1.08, B, 2, c Binder Bitumen
Furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts; and final clean up.

Section 7070 - Emulsified Asphalt Slurry Seal

- 7070, 1.08, A, 3 Emulsified Asphalt Slurry Seal (by area)
Surface preparation and furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts.
- 7070, 1.08, B, 1, c Aggregate
Surface preparation and furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts.
- 7070, 1.08, B, 2, c Asphalt Emulsion
Surface preparation and furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts.

Section 7080 - Permeable Interlocking Pavers

- 7080, 1.08, B, 3 Engineering Fabric
Placing and securing filter fabric and any overlapped areas.
- 7080, 1.08, C, 3 Underdrain
Furnishing and placing pipe, cleanouts, observation wells, and pipe fittings.
- 7080, 1.08, D, 3 Storage Aggregate
Furnishing, hauling, placing, and compacting storage aggregate.
- 7080, 1.08, E, 3 Filter Aggregate
Furnishing, hauling, placing filter, and compacting aggregate.
- 7080, 1.08, F, 3 Permeable Interlocking Pavers
Testing, furnishing and placing bedding course, furnishing and installing permeable interlocking pavers, furnishing and placing joint/opening fill material, refilling joint after 6 months, and pavement protection.
- 7080, 1.08, G, 3 PCC Edge Restraint
Final trimming of subgrade or subbase, bars and reinforcement, joints and sealing, surface curing and pavement protection, safety fencing, and boxouts for fixtures.

Section 7090 - Cold-in-Place Pavement Recycling

- 7090, 1.08, A, 3 Cold-in-Place Recycling
Milling and sizing of existing asphalt layers; protecting street fixtures; development of a job mix formula; adding and mixing recycling agents and additives, if required; supplying and incorporating water; compacting the reclaimed mix; shaping of the mix; completing secondary compaction, if required; removing any loose or excess material; and final clean up.
- 7090, 1.08, B, 3 Bituminous Recycling Agents
Furnishing and placing of materials and mixing the agent into the recycled mix.
- 7090, 1.08, C, 3 Chemical Recycling Additives
Furnishing and placing of materials and mixing the agent into the recycled mix.

Section 7091 - Full Depth Reclamation

- 7091, 1.08, A, 3 Full Depth Reclamation
Pulverizing and sizing of existing asphalt layers; incorporating and mixing of existing underlying materials; protecting street fixtures; development of a job mix formula; adding and mixing stabilizing agents and additives, if required; compacting the reclaimed mix; shaping of the mix; removing any loose or excess material; curing; and final clean up.
- 7091, 1.08, B, 3 Mechanical Stabilization Agents
Furnishing and placing of aggregate and blending of the aggregates.

- 7091, 1.08, C, 3 Bituminous Stabilization Agents
Furnishing and placing of materials and mixing the agent into the reclaimed mix.
- 7091, 1.08, D, 3 Chemical Stabilization Agents
Furnishing and placing of materials and mixing the agent into the reclaimed mix.
- 7091, 1.08, E, 3 Microcracking
Furnishing equipment, protecting street fixtures, completing microcracking, and curing.
- 7091, 1.08, F, 3 Interlayer for Cement Stabilized Base
Surface cleaning, furnishing, and placing of the interlayer (if specified).

Section 7092 - Crack and Seat Existing PCC Pavement

- 7092, 1.08, A, 3 Crack and Seat of PCC Pavement
Notifying adjacent properties, providing traffic control and no parking signs; vibration monitoring if specified; cracking and seating of the designated PCC pavement to the specified pattern; watering to verify crack pattern; protecting existing fixtures; cleaning of slab prior to overlay; and final project site cleanup.
- 7092, 1.08, B, 3 Remove and Replace Curb and Gutter
Full depth sawing; removing and disposing removed materials; furnishing and compacting subgrade material to bring to the proper elevation; all form work required; concrete; placing new curb and gutter; and final cleanup and backfill placement behind the new curb.
- 7092, 1.08, C, 3 Full Depth Saw Cut
Providing a concrete saw or other cutting device that will result in a full depth vertical edge and severing all tie or reinforcing steel.
- 7092, 1.08, G, 3 Intake Adjustment, Major
Sawing all three sides of the boxout; removing and replacing the boxout; furnishing and installing a new grate assembly or, if specified, removing and re-setting the existing grate assembly; removing existing open-throat intake grate; adjusting intake walls; furnishing and installing new intake grate or, if specified, re-setting existing intake grate; and furnishing, placing, and compacting backfill.
- 7092, 1.08, H, 3 Joint Control Fabric
Cleaning and preparing the surface, furnishing, placing, and adhering joint control fabric prior to placing surface lift.
- 7092, 1.08, I, 3 Partial Depth Patch Removal
Provide equipment and removing all designated partial depth patches down to the base PCC, cleaning of the former patch area; and disposal of the patch material.
- 7092, 1.08, J, 3 Rock Interlayer
Furnishing and placing the rock interlayer to the thickness specified.

Section 8010 - Traffic Signals

- 8010, 1.08, A, 3 Traffic Signal
Furnishing and installing all pole foundations, poles, wiring, conduit, heads, signs, detection equipment, traffic signal control equipment (including pedestrian equipment), traffic signal controller and cabinet, and associated appurtenances for a complete, fully operation installation.
- 8010, 1.08, B, 3 Temporary Traffic Signal
Furnishing, installing, maintaining, and removing poles; wiring; traffic signal control equipment including pedestrian equipment if specified; implement all modifications of signal timing, signal placement and display due to Contractor initiated changes in the construction staging plan established by the Contracting Authority; relocation of trailer mounted temporary traffic signal systems; placement in another physical location to address changes in construction staging; and all appurtenances.
- 8010, 1.08, C, 3 Traffic Signal Removal
Removal of poles, concrete pads, foundations, wiring, traffic signal cabinet and equipment, pedestrian signal equipment, and handholes; delivery of removed materials to the location specified in the contract documents; furnishing, placing, and compacting backfill in all excavations; and restoring disturbed surfaces.

Section 8020 - Pavement Markings

- 8020, 1.08, B, 3 Painted Pavement Markings, Solvent/Waterborne
Reflectorizing spheres, layout, surface preparation, and application of marking paint.
- 8020, 1.08, C, 3 Painted Pavement Markings, Durable
Layout, surface preparation, and application of marking paint.
- 8020, 1.08, D, 3 Painted Pavement Markings, High-Build
Layout, surface preparation, and application of marking paint.
- 8020, 1.08, E, 3 Permanent Tape Markings
Layout, surface preparation, and application of marking tape.
- 8020, 1.08, F, 3 Wet, Retroreflective Removable Tape Markings
Layout, surface preparation, application, and removal.
- 8020, 1.08, G, 3 Painted Symbols and Legends
Layout, surface preparation, and application of each symbol and legend.
- 8020, 1.08, H, 3 Precut Symbols and Legends
Layout, surface preparation, and application of each symbol and legend.
- 8020, 1.08, I, 3 Temporary Delineators
Installation and removal of delineators.
- 8020, 1.08, J, 3 Raised Pavement Markers
Installation and removal of pavement markers.

- 8020, 1.08, K, 3 Pavement Markings Removed
Pavement marking removal and waste material collection, removal, and disposal.
- 8020, 1.08, L, 3 Symbols and Legends Removed
Symbol and legend marking removal and waste material collection, removal, and disposal.
- 8020, 1.08, M, 3 Grooves Cut for Pavement Markings
Layout, cutting grooves, collection and disposal of removed material, and additional groove width and transition length beyond the pavement marking dimensions.
- 8020, 1.08, N, 3 Grooves Cut for Symbols and Legends
Layout, cutting grooves, and collection and disposal of removed material.

Section 8030 - Temporary Traffic Control

- 8030, 1.08, A, 3 Temporary Traffic Control
Installation, maintenance, and removal of temporary traffic control; total roadway closures with installation and removal of detour signing as shown in the contract documents; removal and reinstallation or covering of permanent traffic control devices that conflict with the temporary traffic control plan; monitoring and documenting traffic control conditions; and flaggers or automated flagger assistance devices (AFAD). When required in the contract documents, the following are also included in traffic control unless a separate bid item is provided: portable dynamic message signs, temporary barrier rail, temporary flood lighting, and pilot cars.

Section 8040 - Traffic Signs and Posts

- 8040, 1.08, A, 3 Traffic Signs (by each)
The sign blank, application of reflective sheeting, application of screened message, all mounting hardware, and erecting the sign according to the traffic control technician's direction.
- 8040, 1.08, B, 3 Traffic Signs (by area)
The sign blank, application of reflective sheeting, application of screened message, all mounting hardware, and erecting the sign according to the traffic control technician's direction.
- 8040, 1.08, C, 3 Wood Posts
Furnishing and erecting the post, including treatment and other details necessary to provide a complete installation.
- 8040, 1.08, D, 3 Perforated Square Steel Tube Posts
Fabricating, furnishing, and erecting the post and other details required to provide a complete installation.
- 8040, 1.08, E, 3 U-Shaped Rail Steel Posts
Fabricating, furnishing, and erecting the post and other details required to provide a complete installation.

- 8040, 1.08, F, 3 Round Steel Posts
Fabricating, furnishing, and erecting the post and other details required to provide a complete installation.
- 8040, 1.08, G, 3 Perforated Square Steel Tube Post Anchors
Furnishing and installing the anchor, coring pavement and filling with concrete, if required, slip base hardware, and other details necessary to provide a complete installation.
- 8040, 1.08, H, 3 Round Steel Post Anchors
Furnishing and installing the anchor, coring pavement and filling with concrete, if required, slip base hardware, and other details necessary to provide a complete installation.
- 8040, 1.08, I, 3 Remove and Reinstall Traffic Signs
Removing the sign and post, filling the post hole, storing and maintaining the sign and post in good condition, and reinstalling the sign and post. Replacing signs and posts designated for reinstallation that have been damaged is the Contractor's responsibility.
- 8040, 1.08, J, 3 Remove and Salvage Traffic Sign Assembly
Removing the sign assembly, removing the post and anchor hardware, filling the post hole, and delivering the traffic sign and post to the site designated by the Contracting Authority. Replacing signs and posts designated for salvage that have been damaged is the Contractor's responsibility.

Section 9010 - Seeding

- 9010, 1.08, A, 1, c Conventional Seeding, Seeding
Removal of rock and other debris from the area; repairing rills and washes; preparing the seedbed; furnishing and placing seed, including any treatment required; furnishing and placing fertilizer and mulch; and furnishing water and other care during the care period, unless these items are bid separately.
- 9010, 1.08, A, 2, c Conventional Seeding, Fertilizing
Furnishing, applying, and incorporating fertilizer to the area to be seeded.
- 9010, 1.08, A, 3, c Conventional Seeding, Mulching
Furnishing, applying, and incorporating mulch to the area to be seeded.
- 9010, 1.08, B, 3 Hydraulic Seeding, Seeding, Fertilizing, and Mulching
Removal of rock and other debris from the area; repairing rills and washes; preparing the seedbed; furnishing and placing seed, including any treatment required; furnishing and placing fertilizer and mulch; and furnishing water and other care during the care period, unless these items are bid separately.
- 9010, 1.08, C, 3 Pneumatic Seeding, Seeding, Fertilizing, and Mulching
Removal of rock and other debris from the area; repairing rills and washes; preparing the seedbed; furnishing and placing seed, including any treatment required; furnishing and placing fertilizer and mulch; and furnishing water and other care during the care period, unless these items are bid separately.

- 9010, 1.08, D, 3 Watering
Water, pumps, meters, equipment, water tanker/container, transportation, hoses, and sprinklers.
- 9010, 1.08, E, 3 Warranty
All work required to correct any defects in the original placement of the seeding for the period of time designated.

Section 9020 - Sodding

- 9020, 1.08, A, 3 Sod
Preparation of sod and sodbed, stakes, fertilizing, watering, maintenance, and clean-up. Also includes any necessary sod replacements during maintenance period.

Section 9030 - Plant Material and Planting

- 9030, 1.08, A, 3 Plants (by count)
Delivery; excavation; installation; watering; placing backfill material; mulching; tree protection; staking or guying; pre-emergent herbicide, if specified; maintenance during the establishment period; and replacements.
- 9030, 1.08, B, 3 Plants (by count), With Warranty
Delivery; excavation; installation; watering; placing backfill material; mulching; tree protection; staking or guying; pre-emergent herbicide, if specified; maintenance during the establishment and warranty periods; and replacements.
- 9030, 1.08, C, 3 Plants (by lump sum)
Delivery, excavation, installation, watering, placing backfill material, mulching, wrapping, staking or guying, herbicide, maintenance during the establishment period, and replacements.
- 9030, 1.08, D, 3 Plants (by lump sum), With Warranty
Delivery, excavation, installation, watering, placing backfill material, mulching, wrapping, staking or guying, herbicide, maintenance during the establishment and warranty period, and replacements.
- 9030, 1.08, E, 3 Tree Drainage Wells
Excavation, furnishing and placing rock, engineering fabric, and placing backfill material.

Section 9040 - Erosion and Sediment Control

- 9040, 1.07, C When applicable, conduct all operations in compliance with the Iowa DNR NPDES General Permit No. 2. Labor, equipment, or materials not included as a bid item, but necessary to prevent stormwater contamination from construction related sources, are considered incidental. Incidental work related to compliance with the permit may include, but is not limited to: hazardous materials protection, fuel containment, waste disposal, and providing employee sanitary facilities.

- 9040, 1.08, A, 1, c SWPPP Preparation
Development of a SWPPP by the Contractor meeting local and state agency requirements, filing the required public notices, filing a Notice of Intent for coverage of the project under the Iowa DNR NPDES General Permit No. 2, and payment of associated NPDES permit fees.
- 9040, 1.08, A, 2, c SWPPP Management
All work required to comply with the administrative provisions of the Iowa DNR NPDES General Permit No. 2; including record keeping, documentation, updating the SWPPP, filing the Notice of Discontinuation, etc. Item also includes weekly inspections required to satisfy the provisions of General Permit No. 2, unless otherwise specified in the contract documents.
- 9040, 1.08, B, 3 Compost Blanket
Furnishing and spreading compost over the designated area.
- 9040, 1.08, C, 3 Filter Berm
Furnishing material and constructing the filter berm, including vegetation if specified.
- 9040, 1.08, D, 1, c Filter Sock
Anchoring stakes.
- 9040, 1.08, D, 2, c Filter Sock, Removal
Restoration of the area to finished grade and off-site disposal of filter socks and accumulated sediment.
- 9040, 1.08, E, 3 Temporary RECP
Excavation, staples, anchoring devices, and material for anchoring slots.
- 9040, 1.08, F, 1, c Wattle
Anchoring stakes.
- 9040, 1.08, F, 2, c Wattle, Removal
Restoration of the area to finished grade and off-site disposal of wattle and accumulated sediment.
- 9040, 1.08, G, 1, c Check Dam, Rock
Engineering fabric.
- 9040, 1.08, G, 2, a, 3) Check Dam, Manufactured, Installation
Anchoring stakes.
- 9040, 1.08, G, 2, b, 3) Check Dam, Manufactured, Removal
Restoration of the area to finished grade and off-site disposal of manufactured check dam and accumulated sediment.
- 9040, 1.08, H, 3 Temporary Earth Diversion Berms
Removal of the berm upon completion of the project.
- 9040, 1.08, I, 3 Level Spreader
Maintaining the spreader during the period of construction and removal upon completion of the project, unless otherwise specified in the contract documents.

9040, 1.08, J, 3	<u>Rip Rap</u> Engineering fabric.
9040, 1.08, K, 3	<u>Temporary Pipe Slope Drain</u> Excavation, furnishing and installing pipe and pipe aprons, grading, and removal of the slope drain upon completion of the project.
9040, 1.08, L, 1, c	<u>Temporary Sediment Basin, Outlet Structure</u> Concrete base, dewatering device, anti-vortex device, outlet pipe, and anti-seep collars (if specified).
9040, 1.08, L, 2, c	<u>Temporary Sediment Basin, Removal of Sediment</u> Dewatering and removal and off-site disposal of accumulated sediment.
9040, 1.08, L, 3, c	<u>Temporary Sediment Basin, Removal of Outlet Structure</u> Dewatering and off-site disposal of the outlet structure, concrete base, emergency spillway, and accumulated sediment.
9040, 1.08, M, 1, c	<u>Sediment Trap Outlet</u> Engineering fabric.
9040, 1.08, M, 2, c	<u>Sediment Trap Outlet, Removal of Sediment</u> Dewatering and removal and off-site disposal of accumulated sediment.
9040, 1.08, M, 3, c	<u>Sediment Trap Outlet, Removal of Device</u> Dewatering and off-site disposal of sediment trap outlet and accumulated sediment.
9040, 1.08, N, 1, c	<u>Silt Fence or Silt Fence Ditch Check</u> Anchoring posts.
9040, 1.08, N, 2, c	<u>Silt Fence or Silt Fence Ditch Check, Removal of Sediment</u> Anchoring posts.
9040, 1.08, N, 3, c	<u>Silt Fence or Silt Fence Ditch Check, Removal of Device</u> Restoration of the area to finished grade and off-site disposal of fence, posts, and accumulated sediment.
9040, 1.08, O, 1, c	<u>Track-out Control (by Square Yard)</u> Subgrade stabilization fabric, removal and disposal of accumulated sediment, and removal and disposal of track-out control stone and manufactured pad.
9040, 1.08, O, 2, c	<u>Track-out Control (by Ton)</u> Subgrade stabilization fabric.
9040, 1.08, P, 1, c	<u>Dust Control, Water</u> Furnishing, transporting, and distributing water to the haul road.
9040, 1.08, P, 2, c	<u>Dust Control Product</u> Furnishing and incorporating the dust control product.

- 9040, 1.08, Q, 1, c Erosion Control Mulching, Conventional
Furnishing and incorporating mulch in the area designated in the contract documents.
- 9040, 1.08, Q, 2, c Erosion Control Mulching, Hydromulching
Furnishing mulch and tackifier (if applicable), providing equipment specific to hydromulching, and applying the mulch to the specified area.
- 9040, 1.08, R, 3 Turf Reinforcement Mats
Excavation, staples, anchoring devices, and material for anchoring slots.
- 9040, 1.08, T, 1, c Inlet Protection Device
Removal of the device upon completion of the project.
- 9040, 1.08, T, 2, c Inlet Protection Device, Maintenance
Removal and off-site disposal of accumulated sediment.
- 9040, 1.08, U, 3 Flow Transition Mat
Anchoring devices.
- 9040, 1.08, V, 3 End of Season Temporary Erosion Control
Furnishing, placing, and maintaining the end of season temporary erosion control throughout the winter season.
- 9040, 1.08, W, 1, c Linear Erosion Control Installation
Anchoring posts and anchoring stakes.
- 9040, 1.08, W, 2, c Linear Erosion Control Removal
Restoration of the area to finished grade and off-site disposal of fence, filter socks, wattles, anchoring posts, anchoring stakes, and accumulated sediment.
- 9040, 1.08, X, 1, c Grid-Tied Concrete Block Mat
Anchor trenches, underlayments, ground anchors, ties, and splicing.
- 9040, 1.08, X, 2, c GRCBM Concrete Anchor Trench
Excavation, concrete, and installation.

Section 9050 - Gabions and Revet Mattresses

- 9050, 1.08, A, 3 Gabions
Furnishing and assembling wire mesh baskets, PVC coating (if specified in the contract documents), fasteners, furnishing and placing gabion stone, engineering fabric, and anchor stakes.
- 9050, 1.08, B, 3 Revet Mattresses
Furnishing and assembling wire mesh baskets, PVC coating (if specified in the contract documents), fasteners, furnishing and placing mattress stone, engineering fabric, and anchor stakes.

Section 9060 - Chain Link Fence

- 9060, 1.08, A, 1, c Chain Link Fence, Residential
Posts, fabric, rails, fitting, ties, PVC coating (if specified in the contract documents), excavation of post holes, and concrete encasement of posts.
- 9060, 1.08, A, 2, c Chain Link Fence, Commercial
Posts, fabric, rails, braces, truss rods, ties, tension wire, tension bands, tension bars, grounds, fittings, PVC coating (if specified in the contract documents), excavation of post holes, and concrete encasement of posts.
- 9060, 1.08, B, 3 Gates
Gate rails, fabric, stretcher bars, braces, vertical stay, hinges, latches, keepers, drop bar lock, center gate stop, and barbed wire (if specified).
- 9060, 1.08, C, 3 Barbed Wire
Furnishing and installing all necessary strands of barbed wire, anchors, and barbed wire supporting arms.
- 9060, 1.08, D, 3 Removal and Reinstallation of Existing Fence
Removing vegetation; removing all fence fabric, appurtenances, posts, and gates; removal of concrete encasement from posts; storage of the removed fencing materials to prevent damage; reinstallation of the posts, gates, and fabric, including all appurtenances; and replacement of any fence parts that are not able to be salvaged and reinstalled. Replace items damaged from Contractor's operations with new materials, at no additional cost to the Contracting Authority.
- 9060, 1.08, E, 3 Removal of Fence
Off-site disposal of fence (including posts, concrete encasement of posts, gates, grounds, and barbed wire) and placing and compacting backfill material in post holes.
- 9060, 1.08, F, 3 Temporary Fence
Furnishing, installing, and removing posts, fabric, ties, and fittings.

Section 9070 - Landscape Retaining Walls

- 9070, 1.08, A, 3 Modular Block Retaining Wall
Excavation, foundation preparation, furnishing and placing wall units, geogrid (if necessary), leveling pad, subdrain, porous backfill material for subdrain, engineering fabric for subdrain, granular backfill material, suitable backfill material, and shoring as necessary.
- 9070, 1.08, B, 3 Limestone Retaining Wall
Excavation, foundation preparation, furnishing and placing leveling pad, limestone, subdrain, porous backfill material for subdrain, engineering fabric for subdrain, suitable backfill material, and shoring as necessary.
- 9070, 1.08, C, 3 Landscape Timbers
Excavation, foundation preparation, furnishing and placing leveling pad, landscape timbers, spikes, reinforcing bar, subdrain, porous backfill material for subdrain, engineering fabric for subdrain, suitable backfill material, and shoring as necessary.

Section 9071 - Segmental Block Retaining Walls

- 9071, 1.08, A, 3 Segmented Block Retaining Wall
Design by a Licensed Professional Engineer in the State of Iowa, excavation, foundation preparation, furnishing and placing wall units, geogrid, leveling pad, subdrain, porous backfill material for subdrain, engineering fabric for subdrain, suitable backfill material, and shoring as necessary.
- 9071, 1.08, C, 3 Granular Backfill Material
Furnishing, transporting, placing, and compacting material.

Section 9072 - Combined Concrete Sidewalk and Retaining Walls

- 9072, 1.08, A, 3 Combined Concrete Sidewalk and Retaining Wall
Excavation; foundation preparation; furnishing and placing concrete and reinforcing steel; joint material; subdrain; porous backfill material; suitable backfill material; finishing disturbed areas; and shoring as necessary.

Section 9080 - Concrete Steps, Handrails, and Safety Rail

- 9080, 1.08, A, 3 Concrete Steps
Reinforcement, expansion joint material, and preparation of subgrade.
- 9080, 1.08, B, 3 Handrail
Posts, mounting hardware or concrete grout, and finishing (painted, galvanized, or powder coated).
- 9080, 1.08, C, 3 Safety Rail
Posts, concrete for ground mounting, pickets, mounting hardware, epoxy grout, and finishing (painted, galvanized, or powder coated).

Section 10,010 - Demolition

- 10,010, 1.08, A, 3 Demolition Work
Removal of trees, brush, vegetation, buildings, building materials, contents of buildings, appliances, trash, rubbish, basement walls, foundations, sidewalks, steps, and driveways from the site; disconnection of utilities; furnishing and compaction of backfill material; furnishing and placing topsoil; finish grading of disturbed areas; placing and removing safety fencing; removal of fuel and septic tanks and cisterns; seeding; and payment of any permit or disposal fees.
- 10,010, 1.08, B, 3 Plug or Abandon Well
Obtaining all permits; plug or abandon private wells according to local, state, and federal regulations.

Section 11,010 - Construction Survey

- 11,010, 1.08, A, 3 Construction Survey
The costs of resetting project control points, re-staking, and any additional staking requested beyond the requirements of this section.

- 11,010, 1.08, B, 3 Monument Preservation and Replacement
Property research and documentation, locating monuments prior to construction, replacement of disturbed monuments, and preparation and filing of the monument preservation certificate.

Section 11,020 - Mobilization

- 11,020, 1.07, B When the proposal form does not include a bid item for mobilization, all costs incurred by the contractor for mobilization are incidental to other work and no separate payment will be made.
- 11,020, 1.08, A, 3 Mobilization
The movement of personnel, equipment, and supplies to the project site; the establishment of offices, buildings, and other facilities necessary for the project; and bonding, permits, and other expenses incurred prior to construction.

Section 11,030 - Temporary Services During Construction

- 11,030, 1.08, A, 3 Maintenance of Postal Service
Coordinating with USPS and erecting and maintaining temporary mailboxes.
- 11,030, 1.08, B, 3 Maintenance of Solid Waste Collection
Coordinating and maintaining solid waste collection services including establishing alternate collection sites if required.

Section 11,040 - Temporary Sidewalk Access

- 11,040, 1.08, A, 3 Temporary Pedestrian Residential Access
Supplying and placing granular material, continuous maintenance of granular surface, removal of temporary granular sidewalk, and restoring disturbed surfaces to a condition equal to that which existed prior to construction.
- 11,040, 1.08, B, 3 Temporary Granular Sidewalk
Excavation, grading, timber edging, supplying and placing granular material, continuous maintenance of granular surface, removal of temporary granular sidewalk, and restoring disturbed surfaces to a condition equal to that which existed prior to construction.
- 11,040, 1.08, C, 3 Temporary Longitudinal Channelizing Device
Construction, placement, maintenance, and removal of the device.

Section 11,050 - Concrete Washout

- 11,050, 1.08, A, 3 Concrete Washout
Providing concrete washwater containment, collection, and disposal.



Bid Items

Below is a list of units of measurements/payment and the abbreviations used in the bid item list.

UNITS	Units of Measurement/Payment	UNITS	Units of Measurement/Payment
ACRE	Acres	SF	Square Feet
CY	Cubic Yards	SQ	Squares
EACH	Each	STA	Stations
LB	Pounds	SY	Square Yards
LF	Linear Feet	TON	Tons
LS	Lump Sum	UNIT	Units
MGAL	1,000 Gallons		

A. Standard Bid Items

The following is a list of suggested standard bid items based on the SUDAS Specifications. The four digits first mentioned in the item number below reference the SUDAS Specifications Section; measurement and payment descriptions are included in subsection 1.08. Please note, some of the items below require additional information, such as type, size, width, thickness, etc.

Item No.	Item Description	Unit
Section 2010 - Earthwork, Subgrade, and Subbase		
2010-A	Clearing and Grubbing	UNIT
2010-B	Clearing and Grubbing	ACRE
2010-C	Clearing and Grubbing	LS
2010-D-1	Topsoil, On-site	CY
2010-D-2	Topsoil, Compost-amended	CY
2010-D-3	Topsoil, Off-site	CY
2010-E	Excavation, Class 10, Class 12, or Class 13	CY
2010-G	Subgrade Preparation	SY
2010-H	Granular Stabilization	TON
2010-I	Subgrade Treatment, ____ (Type)	SY
2010-J	Subbase, ____ (Type), ____ (Thickness)	SY
2010-K-1	Removal of Structure, ____ (Type)	EA
2010-K-2-a	Removal of Known Box Culvert, ____ (Type), ____ (Size)	LF
2010-K-2-c	Removal of Known Pipe Culvert, ____ (Type), ____ (Size)	LF
2010-K-3-a	Removal of Known Pipe and Conduit, ____ (Type), ____ (Size)	LF
2010-L-1	Filling and Plugging of Known Pipe Culverts, Pipes, and Conduits, ____ (Type), ____ (Size)	LF
2010-M	Compaction Testing	LS

Item No.	Item Description	Unit
Section 3010 - Trench Excavation and Backfill		
3010-B	Rock Excavation	CY
3010-C	Trench Foundation	TON
3010-D	Replacement of Unsuitable Backfill Material	CY
3010-E	Special Pipe Embedment or Encasement, ____ (Type)	LF
3010-F	PCC Pipe Support Over Existing Utility	EA
3010-G	Reinforced PCC Beam Utility Line Support	EA
3010-H	Trench Compaction Testing	LS
Section 4010 - Sanitary Sewers		
4010-A-1	Sanitary Sewer Gravity Main, Trenched, ____ (Type), ____ (Size)	LF
4010-A-2	Sanitary Sewer Gravity Main, Trenchless, ____ (Type), ____ (Size)	LF
4010-B-1	Sanitary Sewer Gravity Main with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
4010-B-2	Sanitary Sewer Gravity Main with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
4010-C-1	Sanitary Sewer Force Main, Trenched, ____ (Type), ____ (Size)	LF
4010-C-2	Sanitary Sewer Force Main, Trenchless, ____ (Type), ____ (Size)	LF
4010-D-1	Sanitary Sewer Force Main with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
4010-D-2	Sanitary Sewer Force Main with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
4010-E	Sanitary Sewer Service Stub, ____ (Type), ____ (Size)	LF
4010-F	Sanitary Sewer Service Relocation	EA
4010-G	Sewage Air Release Valve and Pit	EA
4010-H	Removal of Sanitary Sewer, ____ (Type), ____ (Size)	LF
4010-I	Sanitary Sewer Cleanout, ____ (Size)	EA
4010-K	Sanitary Sewer Abandonment, Plug, ____ (Size)	EA
4010-L	Sanitary Sewer Abandonment, Fill and Plug, ____ (Size)	LF
Section 4020 - Storm Sewers		
4020-A-1	Storm Sewer, Trenched, ____ (Type), ____ (Size)	LF
4020-A-2	Storm Sewer, Trenchless, ____ (Type), ____ (Size)	LF
4020-B-1	Storm Sewer with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
4020-B-2	Storm Sewer with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
4020-C	Linear Trench Drain	LF
4020-D	Removal of Storm Sewer, ____ (Type), ____ (Size)	LF
4020-F	Storm Sewer Abandonment, Plug, ____ (Size)	EA
4020-G	Storm Sewer Abandonment, Fill and Plug, ____ (Size)	LF
Section 4030 - Pipe Culverts		
4030-A-1	Pipe Culvert, Trenched, ____ (Type), ____ (Size)	LF
4030-A-2	Pipe Culvert, Trenchless, ____ (Type), ____ (Size)	LF
4030-B	Pipe Apron, ____ (Type), ____ (Size)	EA
4030-C	Footing for Concrete Pipe Apron, ____ (Type), ____ (Size)	EA
4030-D	Pipe Apron Guard, ____ (Type), ____ (Size)	EA

Item No.	Item Description	Unit
Section 4040 - Subdrains and Footing Drain Collectors		
4040-A	Subdrain, ____ (Type), ____ (Size)	LF
4040-B	Footing Drain Collector, ____ (Type), ____ (Size)	LF
4040-C-1	Subdrain Cleanout, ____ (Type), ____ (Size)	EA
4040-C-2	Footing Drain Cleanout, ____ (Type), ____ (Size)	EA
4040-D-1	Subdrain Outlets and Connections, ____ (Type), ____ (Size)	EA
4040-D-2	Footing Drain Outlets and Connections, ____ (Type), ____ (Size)	EA
4040-E	Storm Sewer Service Stub, ____ (Type), ____ (Size)	LF
Section 4050 - Pipe Cleaning and Rehabilitation		
4050-A-1	Mainline Cleaning, ____ (Size)	LF
4050-A-2	Pre-Rehabilitation Cleaning and Inspection, ____ (Size)	LF
4050-A-3	Additional Sewer Cleaning	HOURL
4050-A-4	Debris Removal, Transportation, and Disposal	TON
4050-B	Remove Protruding Service Connections	EA
4050-C-1	CIPP Main Lining, ____ (Size)	LF
4050-C-2	Building Sanitary Sewer Service Reinstatement	EA
4050-C-3	CIPP End Seal, ____ (Size)	EA
4050-D	CIPP Point Repair, ____ (Size)	EA
4050-E-1	CIPP Service Pipe, Connection, ____ (Size)	EA
4050-E-2	CIPP Service Repair, Partial Pipe, ____ (Size)	EA
4050-F-1	Pressure Testing of Mainline Sewer Joints, ____ (Size)	EA
4050-F-2	Injection Grouting of Mainline Sewer Joints, ____ (Size)	EA
4050-F-3	Pressure Testing of Service Connections, ____ (Size)	EA
4050-F-4	Injection Grouting of Service Connections, ____ (Size)	EA
4050-F-5	Chemical Grout	GAL
4050-G-3	Bypass Pumping	LS
4050-H-1	Spot Repairs by Pipe Replacement, ____ (Type), ____ (Size)	EA
4050-H-2	Spot Repairs by Pipe Replacement, ____ (Type), ____ (Size)	LF
Section 5010 - Pipe and Fittings		
5010-A-1	Water Main, Trenched, ____ (Type), ____ (Size)	LF
5010-A-2	Water Main, Trenchless, ____ (Type), ____ (Size)	LF
5010-B-1	Water Main with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
5010-B-2	Water Main with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
5010-C-1	Fitting, ____ (Type), ____ (Size)	EA
5010-C-2	Fitting, ____ (Type), ____ (Size)	LB
5010-D	Water Service Stub, ____ (Type), ____ (Size)	EA
5010-E-1	Water Service Pipe, ____ (Type), ____ (Size)	LF
5010-E-2	Water Service Corporation, ____ (Type), ____ (Size)	EA
5010-E-3	Water Service Curb Stop and Box, ____ (Type), ____ (Size)	EA
5010-F	Water Main Abandonment, Cap, ____ (Size)	EA
5010-G	Water Main Abandonment, Fill and Plug, ____ (Size)	LF
5010-H	Water Main Removal, ____ (Size)	LF

Item No.	Item Description	Unit
Section 5011 - Fusible PVC and HDPE Pipe		
5011-A-1	Fusible Water Main, Trenched, ____ (Type), ____ (Size)	LF
5011-A-2	Fusible Water Main, Trenchless, ____ (Type), ____ (Size)	LF
5011-B-1	Water Main with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
5011-B-2	Water Main with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
Section 5020 - Valves, Fire Hydrants, and Appurtenances		
5020-A	Valve, ____ (Type), ____ (Size)	EA
5020-B	Tapping Valve Assembly, ____ (Size)	EA
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5020-D	Alternate Fire Hydrant Assembly	EA
5020-E	Flushing Device (Blowoff), ____ (Size)	EA
5020-G	Valve Box Extension	EA
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6010-A	Manhole, ____ (Type), ____ (Size)	EA
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6010-D	Casting Extension Ring	EA
6010-E-1	Manhole Adjustment, Minor	EA
6010-E-2	Intake Adjustment, Minor	EA
6010-F-1	Manhole Adjustment, Major	EA
6010-F-2	Intake Adjustment, Major	EA
6010-G-1	Connection to Existing Manhole	EA
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6020-A-1	Rubber Chimney Seal	EA
6020-A-2	Molded Shield	EA
6020-A-3	Urethane Chimney Seal	EA
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6020-D	Manhole Lining with Centrifugally Cast Cementitious Mortar Liner with Epoxy Seal	VF

Item No.	Item Description	Unit
Section 7010 - Portland Cement Concrete Pavement		
7010-A	Pavement, PCC, ____ (Thickness), ____ (Mix Type)	SY
7010-E	Curb and Gutter, ____ (Width), ____ (Thickness)	LF
7010-F	Beam Curb	LF
7010-G	Concrete Median	SY
7010-H	PCC Railroad Crossing Approach	SY
7010-I	PCC Pavement Samples and Testing	LS
7010-K	PCC Pavement Widening, ____ (Thickness)	SY
7010-N	PCC Cold Weather Protection	SY
Section 7011 - Portland Cement Concrete Overlays		
7011-A-1	PCC Overlay, Furnish Only	CY
7011-A-2	PCC Overlay, Place Only	SY
7011-A-3	Surface Preparation for Bonded PCC Overlay	SY
7011-A-4	Surface Preparation for Unbonded PCC Overlay	SY
7011-A-5	Asphalt Separation Layer for Unbonded PCC Overlay	SY
7011-A-6	Geotextile Fabric Separation Layer for Unbonded PCC Overlay	SY
7011-A-7	Liquid Curing Compound Separation Layer on PCC Surface Patches for Unbonded PCC Overlay	SY
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7020-A	Pavement, Asphalt, ____ (Mix Design Level), ____ (Layer), ____ (Aggregate Size), ____ (Binder Grade),	TON
7020-B	Pavement, Asphalt, ____ (Mix Design Level), ____ (Thickness), ____ (Layer), ____ (Aggregate Size), ____ (Binder Grade)	SY
7020-C	Asphalt Base Widening, ____ (Mix Design Level), ____ (Layer), ____ (Aggregate Size), ____ (Binder Grade)	TON
7020-D	Asphalt Base Widening, ____ (Mix Design Level), ____ (Thickness), ____ (Layer), ____ (Aggregate Size), ____ (Binder Grade),	SY
7020-E	Asphalt Railroad Crossing Approach	SY
7020-I	Asphalt Pavement Samples and Testing	LS
7020-M	Asphalt Cold Weather Paving	TON
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7021-A	Asphalt Overlay, ____ (Layer), ____ (Aggregate Size), ____ (Binder Grade), ____ (Mix Design Level)	TON
7021-B	Asphalt Overlay, ____ (Thickness), ____ (Layer), ____ (Aggregate Size), ____ (Binder Grade), ____ (Mix Design Level)	SY
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7030-A-2	Removal of Shared Use Path	SY
7030-A-3	Removal of Driveway	SY
7030-B	Removal of Curb	LF
7030-C	Shared Use Path, ____ (Type), ____ (Thickness)	SY
7030-D	Special Subgrade Preparation for Shared Use Path	SY
7030-E	Sidewalk, PCC, ____ (Thickness)	SY
7030-F	Brick/Paver Sidewalk with Pavement Base	SY
7030-G	Detectable Warnings	SF
7030-H-1	Driveway, Paved, ____ (Type), ____ (Thickness)	SY

Item No.	Item Description	Unit
7030-H-2	Driveway, Granular, ____ (Thickness)	SY
7030-H-3	Driveway, Granular, ____ (Thickness)	TON
7030-I-1	Sidewalk Assurance Testing	LS
7030-I-2	Shared Use Path Assurance Testing	LS
7030-I-3	Driveway Assurance Testing	LS
Section 7040 - Pavement Rehabilitation		
7040-A	Full Depth Patches, ____ (Type), ____ (Thickness)	SY
7040-B	Subbase Over-excavation	TON
7040-C	Partial Depth Patches, ____ (Type)	SF
7040-D	Crack and Joint Cleaning and Filling, Hot Pour	LF
7040-E-1	Crack Cleaning and Filling, Emulsion	LF
7040-E-2	Asphalt for Crack Filling	TON
7040-F	Diamond Grinding	SY
7040-G	Milling	SY
7040-H	Pavement Removal	SY
7040-I	Curb and Gutter Removal	LF
7040-J	Dowel Bar Retrofit, ____ (Size)	EA
7040-K	Core Hole Cutting and Replacement	EA
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7050-A	Asphalt Stabilization	SY
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7060-A	Bituminous Seal Coat	SY
7060-B-1	Cover Aggregate	TON
7060-B-2	Binder Bitumen	GAL
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7070-A	Emulsified Asphalt Slurry Seal	SY
7070-B-1	Aggregate	TON
7070-B-2	Asphalt Emulsion	GAL
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7080-B	Engineering Fabric	SY
7080-C	Underdrain, ____ (Type), ____ (Size)	LF
7080-D	Storage Aggregate	TON
7080-E	Filter Aggregate	TON
7080-F	Permeable Interlocking Pavers, ____ (Type)	SY
7080-G	PCC Edge Restraint, ____ (Type), ____ (Size)	LF
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7090-A	Cold-in-Place Recycling	SY
7090-B	Bituminous Recycling Agents	GAL
7090-C	Chemical Recycling Additives	TON
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7091-A	Full Depth Reclamation	SY
7091-B	Mechanical Stabilization Agents	TON
7091-C	Bituminous Stabilization Agents	GAL

Item No.	Item Description	Unit
7091-D	Chemical Stabilization Agents	TON
7091-E	Microcracking	SY
7091-F	Interlayer for Cement Stabilized Base, ____ (Type), ____ (Thickness)	SY
Section 7092 - Crack and Seat Existing PCC Pavement		
7092-A	Crack and Seat of PCC Pavement	SY
7092-B	Remove and Replace Curb and Gutter, ____ (Type), ____ (Size)	LF
7092-C	Full Depth Saw Cut	LF
7092-G	Intake Adjustment, Major	EA
7092-H	Joint Control Fabric	LF
7092-I	Partial Depth Patch Removal	SF
7092-J	Rock Interlayer	TON
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8010-A	Traffic Signal	LS
8010-B	Temporary Traffic Signal	LS
8010-C	Traffic Signal Removal	LS
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8020-B	Painted Pavement Markings, Solvent/Waterborne	STA
8020-C	Painted Pavement Markings, Durable	STA
8020-D	Painted Pavement Markings, High-Build	STA
8020-E	Permanent Tape Markings	STA
8020-F	Wet, Retroreflective Removable Tape Markings	STA
8020-G	Painted Symbols and Legends, ____ (Type)	EA
8020-H	Precut Symbols and Legends, ____ (Type)	EA
8020-I	Temporary Delineators	EA
8020-J	Raised Pavement Markers	EA
8020-K	Pavement Markings Removed	STA
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8020-M	Grooves Cut for Pavement Markings	STA
8020-N	Grooves Cut for Symbols and Legends	EA
Section 8030 - Temporary Traffic Control		
8030-A	Temporary Traffic Control	LS
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8040-A	Traffic Signs, ____ (Type), ____ (Size)	EA
8040-B	Traffic Signs	SF
8040-C	Wood Posts	LF
8040-D	Perforated Square Steel Tube Posts	LF
8040-E	U-Shaped Rail Steel Posts	LF
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8040-G	Perforated Square Steel Tube Post Anchors, ____ (Type), ____ (Size)	EA
8040-H	Round Steel Post Anchors, ____ (Type), ____ (Size)	EA
8040-I	Remove and Reinstall Traffic Signs	EA
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Item No.	Item Description	Unit
Section 9010 - Seeding		
9010-A	Conventional Seeding, Seeding, Fertilizing, and Mulching, ____ (Type)	AC
9010-B	Hydraulic Seeding, Seeding, Fertilizing, and Mulching, ____ (Type)	AC
9010-C	Pneumatic Seeding, Seeding, Fertilizing, and Mulching, ____ (Type)	AC
9010-D	Watering	MGAL
9010-E	Warranty	LS
Section 9020 - Sodding		
9020-A	Sod	SY
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9030-A	Plants, ____ (Type), ____ (Size)	EA
9030-B	Plants with Warranty, ____ (Type), ____ (Size)	EA
9030-C	Plants	LS
9030-D	Plants with Warranty	LS
9030-E	Tree Drainage Wells	EA
Section 9040 - Erosion and Sediment Control		
9040-A-1	SWPPP Preparation	LS
9040-A-2	SWPPP Management	LS
9040-B	Compost Blanket, ____ (Thickness)	SF
9040-C	Filter Berm, ____ (Size)	LF
9040-D-1	Filter Sock, ____ (Size)	LF
9040-D-2	Filter Sock, Removal	LF
9040-E	Temporary RECP, ____ (Type)	SY
9040-F-1	Wattle, ____ (Type), ____ (Size)	LF
9040-F-2	Wattle, Removal	LF
9040-G-1	Check Dam, Rock	TON
9040-G-2-a	Check Dam, Manufactured, ____ (Type), ____ (Size)	LF
9040-G-2-b	Check Dam, Manufactured, Removal, ____ (Type)	LF
9040-H	Temporary Earth Diversion Berm, ____ (Type), ____ (Size)	LF
9040-I	Level Spreader	LF
9040-J	Rip Rap, ____ (Type)	TON
9040-K	Temporary Pipe Slope Drain, ____ (Type), ____ (Size)	LF
9040-L-1	Temporary Sediment Basin, Outlet Structure, ____ (Size)	EA
9040-L-2	Temporary Sediment Basin, Removal of Sediment	EA
9040-L-3	Temporary Sediment Basin, Removal of Outlet Structure	EA
9040-M-1	Sediment Trap Outlet	TON
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9040-N-2	Silt Fence or Silt Fence Ditch Check, Removal of Sediment	EA
9040-N-3	Silt Fence or Silt Fence Ditch Check, Removal of Device	LF
9040-O-1	Track-out Control	SY
9040-O-2	Track-out Control	TON

Item No.	Item Description	Unit
9040-P-1	Dust Control, Water	MGAL
9040-P-2	Dust Control, Product	SY
9040-Q-1	Erosion Control Mulching, Conventional	AC
9040-Q-2	Erosion Control Mulching, Hydromulching, ____ (Type)	AC
9040-R	Turf Reinforcement Mats, ____ (Type)	SY
9040-S	<i>Not currently used - intentionally left blank</i>	
9040-T-1	Inlet Protection Device, ____ (Type)	EA
9040-T-2	Inlet Protection Device, Maintenance	EA
9040-U	Flow Transition Mat	SF
9040-V	End of Season Temporary Erosion Control	AC
9040-W-1	Linear Erosion Control Installation	LF
9040-W-2	Linear Erosion Control Removal	LF
9040-X-1	Grid-Tied Concrete Block Mat	SY
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9050-B	Revet Mattresses, ____ (Type)	CY
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9060-B	Gates, ____ (Type), ____ (Size)	EA
9060-C	Barbed Wire, ____ (Type of Supporting Arm)	LF
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9060-F	Temporary Fence, ____ (Type), ____ (Size)	LF
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9070-B	Limestone Retaining Wall	SF
9070-C	Landscape Timbers	SF
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9071-A	Segmental Block Retaining Wall	SF
9071-C	Granular Backfill Material	TON
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11,040-C	Temporary Longitudinal Channelizing Device	LF
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11,050-A	Concrete Washout	LS

B. Supplemental Bid Items

When a new bid item needs to be created, the following format is suggested:

1. If the bid item falls within a SUDAS Specifications Section, but is not identified in SUDAS, use the four digit section number, followed by 999, then a letter. For example, if you want to add a new bid item for sanitary sewers, use 4010-999-A.
2. If the bid item generally falls within a SUDAS Specifications Division (broader category), but is not identified as a particular SUDAS Specifications Section, use the division number, followed by 999, then a letter. For example, if you add pipe bursting and want the bid items organized with the other pipe items, use 4999-A. Or if a supplemental specifications section has been created, the first four digits should match the numbers used in the supplemental. In that instance, it is suggested to use the division number as the first digit, followed by a 9, and then the next numbers as you see fit.
3. If the bid item does not fall within a SUDAS Specifications Division or Section, use 0000, followed by 999, then a letter. For example, 0000-999-A.
4. When making modifications to a standard SUDAS bid item, be sure to address such modifications in the estimate reference notes.

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Stormwater Regulations and Permitting

A. Iowa Drainage Law and Resources

Chapter 468 of the Iowa Code covers a majority of Iowa’s drainage law with respect to landowner rights and responsibilities. This chapter covers the establishment and operation of drainage districts as well as laws governing modifying, diverting, or blocking existing drainage ways.

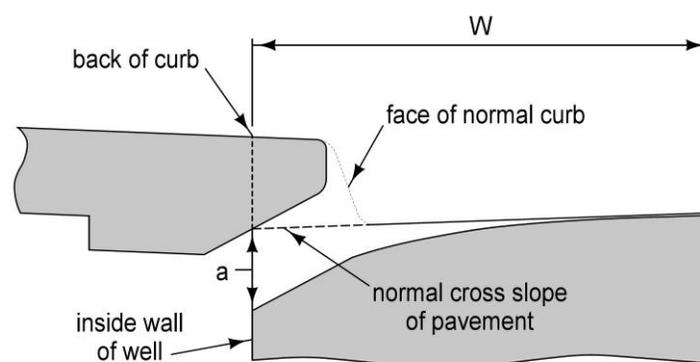
B. Regulated Activities

In Iowa, two agencies administer permit programs for protecting the state’s water resources and ensuring their wise use. Some local government agencies have also established permit programs related to land subdivision and land disturbing activities. The primary agencies are:

1. **The Iowa DNR:** Iowa DNR administers permit programs for conserving and protecting Iowa’s water, recreational, and environmental resources, and for the prevention of damage resulting from unwise floodplain development. In addition, Iowa DNR has jurisdiction over sovereign lands and waters, and certain fee title lands of the state, and land below the ordinary high water mark on meandered streams and lakes.
 - a. **General Permit No. 2:** For "stormwater associated with industrial activity for construction activities" (land disturbing 1 acre or more). Construction activities that result in the disturbance of 1 acre or more of ground cover are required to obtain an NPDES general permit normally associated with earthwork, grading, or any other non-agricultural land-disturbing activity. The goal of the permit is to reduce the amount of sediment being transported from construction site by stormwater runoff.
 - b. **Other Iowa DNR Permits:** (relating to protection of water and recreational sources or adjacent lands):
 - 1) **Floodplain Construction Permits:** Iowa DNR has authority to regulate construction on all floodplains and floodways in the state. Local governments may have obtained transfer of this jurisdiction from Iowa DNR.
 - 2) **Construction Permits:** Pursuant to the Iowa Code, no person, association, or corporation can build or erect a pier, wharf, sluice, piling, wall, fence, obstruction, building, or erection of any kind, upon or over any state-owned land or water under the jurisdiction of Iowa DNR, without first obtaining a permit from Iowa DNR.
 - 3) **Special Permits:** Projects involving a standard recreational boat dock require authorization by Iowa DNR. Permits are also required by commercial operations removing sand or aggregate from meandered streams.

2. **The US Army Corps of Engineers (USACE):** The USACE has authority over public waterways. This includes intrastate lakes, rivers, streams, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, all impoundments of waters and tributaries of waters identified above.
 - a. **Clean Water Act Section 404 Permit Program:** Prior to conducting work on or in a regulated water of the U.S., a Section 404 permit must first be obtained from the USACE. Additional information on the 404 program may be found in the Iowa DOT Local Systems [I.M. No. 4.130](#).
 - b. **Wetlands:** Wetlands are defined as “those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.” Wetlands have three essential characteristics, all of which must be present for an area to be identified as a wetland. This includes hydrophytic (water-loving) vegetation, hydric soils, and wetland hydrology
 - 1) **Wetland Delineation:** Identification of Section 404-regulated wetlands requires wetland delineation by the USACE, the EPA, or by submission of a wetland delineation report to the USACE by a qualified wetland specialist. Wetland delineation is often requested or contracted by a property owner who needs to know restrictions on the development or use of the land. In particular, a property owner may need wetland delineation when seeking an individual or general permit.
 - 2) **Wetland Mitigation:** Every effort should be made at the beginning of a project to avoid or minimize impacts. Any project that does not meet the conditions of any one of the Nationwide Permits must be sent to the USACE and probably will require satisfactory mitigation for the loss of wetlands. Mitigation is defined as wetland restoration, creation, enhancement, or preservation for the purpose of compensating for unavoidable wetland losses in advance of development actions, when such compensation cannot be achieved at the development site or would not be as environmentally beneficial.
3. **Joint Application:** Given the regulatory relationship between the Iowa DNR and the USACE, certain projects require authorization from both agencies before work can commence. Construction, excavation, or filling in streams, lakes, wetlands, or floodplains may require permits from both agencies. Specifically, State Section 401 water quality certification is mandatory for all projects requiring a Federal Section 404 permit. In order to simplify this process, a joint application form has been developed for the permit process for any of the following activities:
 - Cutting the bank of a river or stream
 - Any excavation or dredging in a stream or channel
 - Channel changes or relocations (including stream straightening)
 - Construction of any permanent dock, pier, wharf, seawall, boat ramp, beach, intake, or outfall structure on a stream, river, or lake
 - Placement of any fill, rip rap, or similar material in a stream, river channel, or lake
 - Construction of a dam across any waterway
 - Placement of fill, construction of levees, roadways, and bridges; and similar activities on a floodplain
 - Construction of buildings on a floodplain

The joint application form and instructions are available on the Iowa DNR website (www.iowadnr.gov); search for “Sovereign Lands Construction Permit.”

Figure 2C-3.01: Open-throat Intake Depression - On-grade

4. **Combination Intakes (On-grade):** The interception capacity of a combination intake with the open throat segment immediately behind the grate is determined by neglecting the open-throat portion and treating the intake as a grate.

F. Design of Intakes in Sag Locations

Intakes in sag locations operate as weirs under low-head conditions and orifices at greater depths. When grate head is developed they function as an orifice. Flow may fluctuate between weir and orifice control depending on the grate size, grate configuration, or the curb-opening height. At depths between those at which weir flow definitely prevails and those at which orifice flow definitely prevails, flow is in a transition stage. At these depths, control is ill-defined and flow may fluctuate between weir and orifice control. Design procedures presented here are based on a conservative approach to estimating the capacity of intakes in sump locations.

The efficiency of intakes in passing debris is critical in sag locations because all runoff that enters the sag must be passed through the intake. Total or partial clogging of intakes in these locations can result in hazardous ponded conditions. Grate intakes alone are not recommended for use in sag locations because of the tendencies of grates to become clogged. Combination intakes or open-throat intakes are recommended for use in these locations.

1. **Grate Intakes in Sags:** A grate inlet in a sag location operates as a weir to depth dependent on the size of the grate and as an orifice at greater depths. Grates of larger dimension will operate as weirs to greater depths than smaller grates.

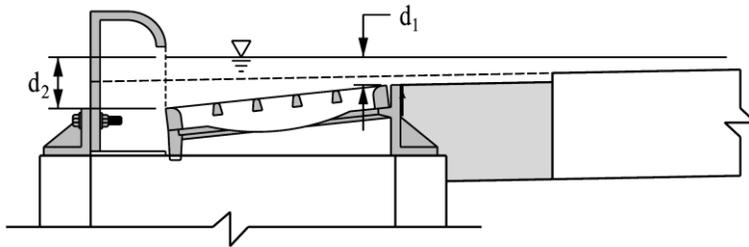
The capacity of a grate intake operating as a weir is:

$$Q_i = 3.0Pd^{1.5} \quad \text{Equation 2C-3.11}$$

where:

- Q_i = Grate intake capacity, cfs
- P = Perimeter of the grate disregarding the side against the curb, ft
- d = average depth across the grate, ft (see Figure 2C-3.02 below)

Figure 2C-3.02: Average Depth for Gate Intakes



Average depth (d) is determined as follows:

$$d = \frac{d_1 + d_2}{2}$$

The capacity of a grate intake operating as an orifice is:

$$Q_i = 0.67A_g(2gd)^{0.5} \tag{Equation 2C-3.12}$$

where:

- A_g = Clear opening of the grate, ft^2
- g = gravitational constant = 32.16 ft/s^2

In order to determine if an intake is operating under weir flow or orifice flow, both equations should be solved for a given depth. The equation resulting in the lowest calculated flow determines the control type.

Table 2C-3.03: Factors for Weir and Orifice Calculations

Figure No. ¹	Grate Type	Description	Perimeter ^{2,4} P (ft)	Open Area ⁴ A_g , (sq-ft)	Weir to Orifice ³ Transition (ft)
6010.603	Type Q	Driveway	9.91	2.62	0.4
6010.603	Type R	Curb Inlet with Vane	5.86	1.95	0.5
6010.603	Type S	Median Barrier	7.52	2.3	0.4
6010.604	Type 3A	Beehive for 18" RCP	5.2	1.2	0.4
6010.604	Type 3B	Beehive for 24" RCP	6.77	1.64	0.5
6010.604	Type 4A	Flat Round for 18" RCP	5.2	0.8	0.3
6010.604	Type 4B	Flat Round for 24" RCP	6.82	1.29	0.3
6010.604	Type 4C	Flat Round for 30" RCP	8.41	2.2	0.5
6010.604	Type 4D	Flat Round for 36" RCP	9.99	2.93	0.5
6010.604	Type 5	Stool Type for 24" to 30" RCP	6	3.06	0.9
6010.604	Type 6	30" x 42" Rectangular	10.54	2.91	0.5

¹ The figure numbers listed in this table refer to figures from the SUDAS Specifications.
² Perimeter length disregards side against curb for curb inlets.
³ This is the approximate depth at which the intake transitions from weir flow to orifice flow and should be verified by the designer.
⁴ Average of Neenah Foundry and East Jordan Iron Works values.

2. Open-throat Intakes in Sags: The capacity of an open-throat intake in a sag depends on the water depth at the curb, the length of the throat opening, and the height of the throat opening. The intake operates as a weir to depths equal to the curb opening height and as an orifice at depths greater than 1.4 times the opening height. At depths between 1.0 and 1.4 times the opening height, flow is in a transition stage.

The equation for the interception capacity of a depressed open-throat intake operating as a weir is:

$$Q_i = 2.30(L + 1.8W)d^{1.5} \quad \text{Equation 2C-3.13}$$

where:

L = Length of curb opening, ft

W = Lateral width of depression, ft

d = depth at curb measured from the normal cross slope (i.e. $d = T \times S_x$)

The weir equation is applicable to depths at the curb approximately equal to the height of the opening plus the depth of the depression. Thus, the limitation on the use of Equation 2C-3.13 for a depressed open-throat intake is:

$$d \leq h + a/12 \quad \text{Equation 2C-3.14}$$

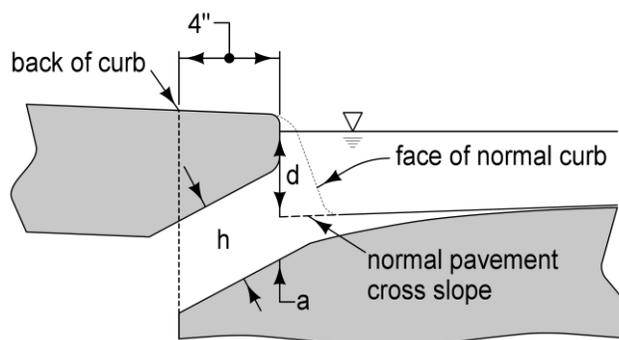
where:

h = height of curb opening, ft

a = depth of depression, in

for standard SUDAS/Iowa DOT open-throat intakes, $a = 4''$

Figure 2C-3.03: Open-throat Intake Depression - in Sag



The weir equation for open-throat intakes without depression is:

$$Q_i = 3.0Ld^{1.5} \quad \text{Equation 2C-3.15}$$

Open-throat intakes operate as orifices at depths greater than approximately 1.4 times the opening height. The interception capacity can be computed by Equations 2C-3.16 or 2C-3.17. These equations are applicable to both depressed and undepressed open-throat intakes. The depth at the intake includes any gutter depression.

$$Q_i = 0.67hL(2gd_0)^{0.5} \quad \text{Equation 2C-3.16}$$

or

$$Q_i = 0.67A_g \left[2g \left(d_i - \left(\frac{h}{2} \right) \right) \sin\theta \right]^{0.5} \quad \text{Equation 2C-3.17}$$

where:

d_0 = Effective head on the center of the orifice throat, ft - (see note below)

d_i = Depth at the lip of the curb opening, ft (see Figure 2C-3.04)

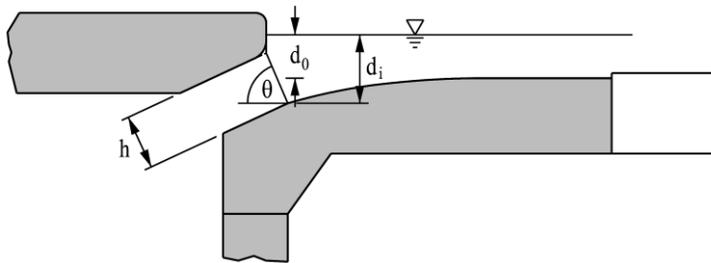
L = Length of the open-throat section, ft

A_g = Clear area of opening, ft²

h = Height of open-throat orifice, ft

Note: the configuration of the SUDAS/Iowa DOT style intakes is an “inclined throat” according to HEC-22. Based upon this configuration HEC-22 provides the following definition: $d_0 = d_i - (h/2) \sin\theta$

Figure 2C-3.04: Standard SUDAS/Iowa DOT Open-throat Curb Section



The following apply for SUDAS/
Iowa DOT open-throat intakes:

$$h = 5''$$

$$\theta = 66.7^\circ$$

$$(h/2)\sin\theta = 2.3'' = 0.19'$$

$$A_g = 1.67 \text{ ft}^2 \text{ - single intake}$$

$$A_g = 3.33 \text{ ft}^2 \text{ - double intake}$$

Unless otherwise approved by the Jurisdictional Engineer, intakes at low points or on dead-end streets on downgrades should be designed to intercept 100 percent of the design flow

- 3. Combination Intakes in Sags:** Combination intakes consisting of a grate and open-throat curb section are recommended for use in sags and locations where hazardous ponding can occur because of their superior hydraulic capacity and debris handling capabilities.

The interception capacity of a combination intake, where the open-throat section is equal in length to, and immediately behind, the grate, is essentially equal to that of a grate intake alone operating under weir flow conditions. In orifice flow, the capacity of a combination intake is equal to the capacity of the grate plus the capacity of the curb opening.

Where the depth at the curb is such that orifice flow occurs, the interception capacity of the intake is computed by adding equations 2C-3.12 and 2C-3.16.

$$Q_i = 0.67A_g(2gd)^{0.5} + 0.67hL(2gd_0)^{0.5} \quad \text{Equation 2C-3.18}$$

where:

A_g = Clear opening of the grate, ft²

g = Gravitational constant = 32.16 ft/s²

d = Depth at the curb, ft

H = Height of the open-throat orifice, ft

L = length of open-throat section, ft

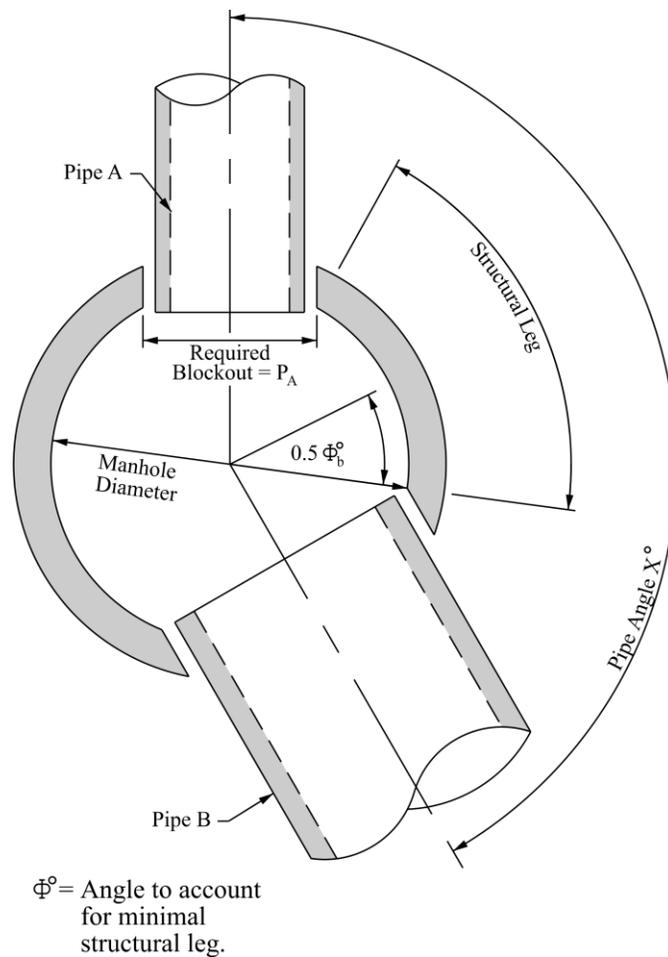
d_0 = effective depth at the center of the open-throat orifice, ft

G. Storm Sewer Structure Requirements

1. **Manholes or Intakes:** Manholes or intakes are required under the following conditions:
 - a. At the end of each sewer line.
 - b. At all changes in pipe size, elevation and grade, or alignment, and at all bends.
 - c. At all sewer pipe intersections, except where the size of the storm sewer conduit (54 inches diameter or greater pipe) eliminates the need for a manhole. Manholes are required for 54 inches or greater pipes when direct access is desired every 400 feet.
 - d. At all sewer pipe intersections and at intervals not exceeding 400 feet. If owner has adequate cleaning equipment, the allowable spacing may be increased to 500 feet for sewers 24 inches and larger.
2. **Openings:**
 - a. **Standard:** The minimum size for a manhole is 48 inches in diameter. Jurisdictions require concentric manholes, without built-in steps, with the manhole opening over the centerline of the pipe or on an offset not to exceed 12 inches. Some Jurisdictions may allow for eccentric manholes.
 - b. **Special:** For square or rectangular manholes, the manhole openings should be over the centerline of the pipes or on an offset not to exceed 12 inches. The distance from the centerline of the manhole opening to the face of the inside manhole wall should not exceed 30 inches to better facilitate video inspection and maintenance equipment. This may require more than one manhole opening.
 - c. **Determining Diameters:** When utilizing circular precast manholes, it is necessary to determine the diameter required to maintain the structural integrity of the manhole. As a general rule, a minimum structural leg of 12 inches should remain between the manhole blockouts for adjacent pipes.

There are two methods to determining the minimum manhole diameter. The first method utilizes corresponding equations and making the calculations. The second and quicker method uses the tables provided with the associated assumptions of outside pipe diameter, opening clearance, blockout sizing, manhole size, and a 12 inch minimum structural leg.

Figure 2C-3.05: Manhole Sizing Requirements

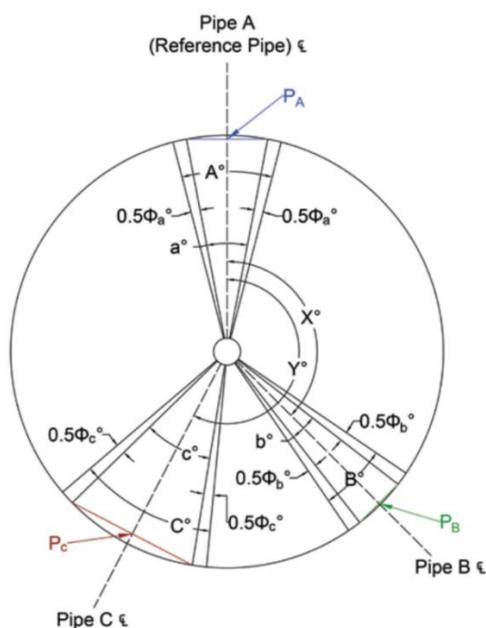


1) Option 1 - Sizing Method based on Calculations:

- a) Determine the blockout diameters for each opening. The blockout is the opening provided in the manhole for the pipe. Blockout dimensions are based on the outside diameter of the pipe. For storm sewer, a circular or doghouse type opening is provided with additional clearance to allow for the insertion of the pipe and sufficient space to accommodate placement of concrete grout in the opening. Typical blockout dimensions for various pipe sizes and materials are given in Table 2C-3.03 below.
- b) Select a manhole size. If unsure start with the diameter for the largest penetration from Table 2C-3.04.

The determination of acceptability of each entering pipe relative to all the other incoming pipe is based on the reference pipe, which is arbitrarily selected by the designer. For ease of design, it is best to use the largest pipe diameter as the reference pipe. The other incoming pipe are determined by their angle, X, Y, and Z (not shown in the figure below), to this reference pipe. The figure below and corresponding equations are used for making these verifiable calculations:

Figure 2C-3.06: Three Pipe Configuration



Variables:

- r = manhole internal radius (in inches)
- S = minimum structural leg (in inches) (recommended 12 inches)
- P_A, P_B, P_C, P_D = penetration in manhole to accommodate specified pipe (inches)

Pipe Penetration Equation:

P_A, P_B, P_C, P_D = pipe OD (in inches) + additional allowance for insertion (if unsure use 6 inches)

Table 2C-3.04: Minimum Manhole Diameter Required for Pipe Size

Pipe Diameter (inches)	Minimum Manhole Diameter (inches)					
	RCP	PVC	DIP	VCP	Polypropylene	HDPE
8	N/A	48	48	48	N/A	N/A
10	N/A	48	48	N/A	N/A	N/A
12	48	48	48	48	48	48
14	N/A	N/A	48	N/A	N/A	N/A
15	48	48	N/A	48	48	48
16	N/A	N/A	48	N/A	N/A	N/A
18	48	48	48	N/A	48	48
20	N/A	N/A	48	N/A	N/A	N/A
21	48	48	N/A	48	N/A	N/A
24	48	48	48	N/A	48	48
27	*60	48	N/A	48	N/A	N/A
30	*60	*60	*60	60	60	60
33	*60	N/A	N/A	N/A	N/A	N/A
36	*60	*60	*60	60	60	60
42	*72			72	N/A	N/A
48	*84				72	72
54	96				N/A	N/A
60	96				96	96

*48 inch diameter tee-section manhole may be used for storm sewer pipes 27 inches and greater, up to 48 inches.

Table 2C-3.05: Design Parameters for Two Pipes

Pipe Penetrations in Manhole	Pipe Angle with Respect to Reference Point	Pipe Angle Equations		Final Angle	Allowable Angle Range
		Initial Angle	Additional Angle to Account for Structural Leg		
Pipe A (Reference Pipe)	0°	$a^\circ = 2x \sin^{-1}\left(\frac{0.5x P_A}{r}\right)$	$\Phi_{a^\circ} = \frac{Sx 180^\circ}{\pi x r}$	$A^\circ = a^\circ + \Phi_{a^\circ}$	$A^\circ < 180^\circ$
Pipe B	X°	$b^\circ = 2x \sin^{-1}\left(\frac{0.5x P_B}{r}\right)$	$\Phi_{b^\circ} = \frac{Sx 180^\circ}{\pi x r}$	$B^\circ = b^\circ + \Phi_{b^\circ}$	$X^\circ - \frac{B^\circ}{2} > \frac{A^\circ}{2}$

Table 2C-3.06: Design Parameters for Three Pipes

Pipe Penetrations in Manhole	Pipe Angle with Respect to Reference Point	Pipe Angle Equations		Final Angle	Allowable Angle Range
		Initial Angle	Additional Angle to Account for Structural Leg		
Pipe A (Reference Pipe)	0°	$a^\circ = 2x \sin^{-1}\left(\frac{0.5x P_A}{r}\right)$	$\Phi_{a^\circ} = \frac{Sx 180^\circ}{\pi x r}$	$A^\circ = a^\circ + \Phi_{a^\circ}$	$A^\circ < 180^\circ$
Pipe B	X°	$b^\circ = 2x \sin^{-1}\left(\frac{0.5x P_B}{r}\right)$	$\Phi_{b^\circ} = \frac{Sx 180^\circ}{\pi x r}$	$B^\circ = b^\circ + \Phi_{b^\circ}$	$X^\circ - \frac{B^\circ}{2} > \frac{A^\circ}{2}$
Pipe C	Y°	$c^\circ = 2x \sin^{-1}\left(\frac{0.5x P_C}{r}\right)$	$\Phi_{c^\circ} = \frac{Sx 180^\circ}{\pi x r}$	$C^\circ = c^\circ + \Phi_{c^\circ}$	$Y^\circ - \frac{C^\circ}{2} > X^\circ + \frac{B^\circ}{2}$ and $Y^\circ + \frac{C^\circ}{2} < 360^\circ - \frac{A^\circ}{2}$

Table 2C-3.07: Design Parameters for Four Pipes

Pipe Penetrations in Manhole	Pipe Angle with Respect to Reference Point	Pipe Angle Equations		Final Angle	Allowable Angle Range
		Initial Angle	Additional Angle to Account for Structural Leg		
Pipe A (Reference Pipe)	0°	$a^\circ = 2x \sin^{-1}\left(\frac{0.5x P_A}{r}\right)$	$\Phi_{a^\circ} = \frac{Sx 180^\circ}{\pi x r}$	$A^\circ = a^\circ + \Phi_{a^\circ}$	$A^\circ < 180^\circ$
Pipe B	X°	$b^\circ = 2x \sin^{-1}\left(\frac{0.5x P_B}{r}\right)$	$\Phi_{b^\circ} = \frac{Sx 180^\circ}{\pi x r}$	$B^\circ = b^\circ + \Phi_{b^\circ}$	$X^\circ - \frac{B^\circ}{2} > \frac{A^\circ}{2}$
Pipe C	Y°	$c^\circ = 2x \sin^{-1}\left(\frac{0.5x P_C}{r}\right)$	$\Phi_{c^\circ} = \frac{Sx 180^\circ}{\pi x r}$	$C^\circ = c^\circ + \Phi_{c^\circ}$	$Y^\circ - \frac{C^\circ}{2} > X^\circ + \frac{B^\circ}{2}$
Pipe D	Z°	$d^\circ = 2x \sin^{-1}\left(\frac{0.5x P_D}{r}\right)$	$\Phi_{d^\circ} = \frac{Sx 180^\circ}{\pi x r}$	$D^\circ = d^\circ + \Phi_{d^\circ}$	$Z^\circ - \frac{D^\circ}{2} > Y^\circ + \frac{C^\circ}{2}$ and $Z^\circ + \frac{D^\circ}{2} < 360^\circ - \frac{A^\circ}{2}$

NOTE: Pipe D is not displayed on Figure 2C-3.05, but it would follow the same convention as Pipe A, Pipe B, and Pipe C as displayed on the diagram.

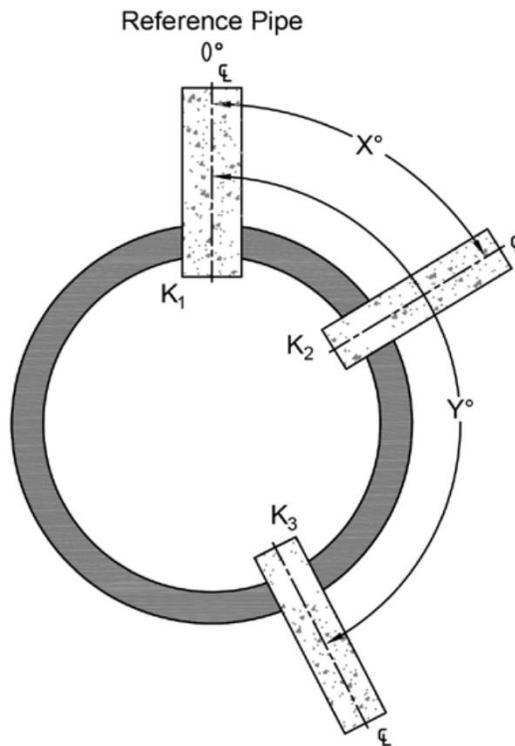
Both methods are from the National Precast Concrete Association's Manhole Sizing Recommendations

2) **Option 2 - Sizing Method Based on Assumptions and K Values in Tables 2C-3.03:**

This method can be used to determine minimum manhole size for as many as three incoming pipes. The analysis utilizes conservative assumptions of all the openings to be at the same springline elevation. The “K” Factor tables detail the assumptions regarding pipe wall thickness and clearances to determine the blockout size for the specified pipe materials. For installations with more than 3 pipes, reduced or increased structural leg requirements, or for materials with differing blockouts, use the equations in Tables 2C-3.05, 2C-3.06, and 2C-3.07.

- a) Based on the material and diameters of the pipes in question, select a manhole based on Table 2C-3.04.

Figure 2C-3.07: Typical Manhole Layout



- b) Select the formula applicable to the structure based on the number of pipes and configuration:

One Pipe: $180^\circ > K$

Two Pipes: $180^\circ \geq X^\circ > (K_1 + K_2) / 2$

Three Pipes: $180^\circ \geq X^\circ > (K_1 + K_2) / 2$ and

$$X^\circ + (K_2 + K_3) / 2 < Y^\circ < 360^\circ - (K_1 + K_3) / 2$$

Where K represents the K Factor found in the tables below for different types of pipe.

X° and Y° are the angles between the pipes with respect to the reference pipe, measured at the pipe centerlines.

Table 2C-3.08: Manhole Blockout Sizes and K Factor Tables**Table 2C-3.08A:** RCP - Class III or Class IV Wall Type B

Pipe Diameter (inches)	Pipe Wall Thickness (inches)	Opening Clearance (inches)	Manhole Blockout (inches)	Manhole Diameter (inches)						
				48	60	72	84	96	108	120
72	7	6	92						130	112
66	6.5	6	85						117	102
60	6	6	78					123	105	93
54	5.5	6	71					110	95	84
48	5	6	64				116	98	85	76
42	4.5	6	57			124	102	87	76	68
36	4	6	50		136	107	89	77	68	61
33	3.75	6	47		125	100	84	72	64	57
30	3.5	6	43		114	92	78	68	60	53
27	3.25	5	39		103	84	71	62	55	49
24	3	5	35	122	94	77	66	57	51	45
21	2.75	5	32	111	86	71	60	53	47	42
18	2.5	5	28	100	79	65	55	48	43	38
15	2.25	5	25	90	71	59	50	44	39	35
12	2	5	21	81	64	53	45	40	35	32

Table 2C-3.08B: PVC- Solid Wall

Pipe Diameter (inches)	Pipe Wall Thickness (inches)	Opening Clearance (inches)	Manhole Blockout (inches)	Manhole Diameter (inches)						
				48	60	72	84	96	108	120
48	1.4	6	57			123	101	87	76	68
42	1.25	6	51			108	90	78	68	61
36	1.15	4	42		113	91	77	67	59	53
30	1	3	35		94	77	66	57	51	45
27	0.4765	3	31	109	85	70	60	52	46	41
24	0.4	3	28	99	78	65	55	48	43	38
21	0.375	3	25	91	72	59	51	44	39	35
18	0.35	3	22	82	65	54	46	40	36	32
15	0.15	3	18	73	58	49	42	36	32	29
12	0.25	3	16	66	53	44	38	33	29	26
8	0.2	3	11	56	45	37	32	28	25	22

Table 2C-3.08: Manhole Blockout Sizes and K Factor Tables (continued)

Table 2C-3.08C: DIP - Class 52

Pipe Diameter (inches)	Pipe Wall Thickness (inches)	Opening Clearance (inches)	Manhole Blockout (inches)	Manhole Diameter (inches)						
				48	60	72	84	96	108	120
54	0.73	6	61				110	94	82	73
48	0.65	6	55			119	99	85	74	66
42	0.59	6	49			105	88	76	67	60
36	0.53	4	41		109	89	75	65	57	51
30	0.47	4	35		94	77	66	57	50	45
24	0.44	3	28	100	78	65	55	48	43	38
20	0.42	3	24	88	70	58	49	43	38	34
18	0.41	3	22	83	66	54	46	41	36	32
16	0.4	3	20	77	61	51	44	38	34	30
12	0.37	3	16	67	53	44	38	33	29	27
8	0.33	3	12	57	45	38	32	28	25	23

Table 2C-3.08D: VCP - ASTM C 700

Pipe Diameter (inches)	Pipe Wall Thickness (inches)	Opening Clearance (inches)	Manhole Blockout (inches)	Manhole Diameter (inches)						
				48	60	72	84	96	108	120
42	4.085	6	56			122	100	86	75	67
36	3.505	4	47		126	101	84	73	64	58
30	3.03	4	40		107	87	73	64	56	50
27	2.885	4	37	129	99	81	68	59	53	47
24	2.425	3	32	112	87	72	61	53	47	42
21	2.39	3	29	102	80	66	56	49	44	39
18	1.935	3	25	91	72	60	51	44	39	35
15	1.65	3	21	81	65	54	46	40	35	32
12	1.26	3	18	71	57	47	40	35	31	28
8	1.01	3	13	60	48	40	34	30	27	24

Table 2C-3.08E: Polypropylene - ASTM F 2764

Pipe Diameter (inches)	Pipe Wall Thickness (inches)	Opening Clearance (inches)	Manhole Blockout (inches)	Manhole Diameter (inches)						
				48	60	72	84	96	108	120
60	3.5	5	72					112	96	85
48	3	5	59			129	106	90	79	70
36	2.5	5	46		123	99	83	72	63	57
30	3	5	41		109	89	75	65	57	51
24	2	5	33	116	90	74	63	55	48	43
18	2	5	27	97	76	63	54	47	42	37
15	1.5	5	23	86	68	56	48	42	37	34
12	1.25	5	20	78	62	51	44	38	34	31

Table 2C-3.08: Manhole Blockout Sizes and K Factor Tables (continued)

Table 2C-3.08F: HDPE - AASHTO M 294

Pipe Diameter (inches)	Pipe Wall Thickness (inches)	Opening Clearance (inches)	Manhole Blockout (inches)	Manhole Diameter (inches)						
				48	60	72	84	96	108	120
60	3.5	5	72					112	96	85
48	3	5	59			129	106	90	79	70
36	2.5	5	46		123	99	83	72	63	57
30	3	5	41		109	89	75	65	57	51
24	2	5	33	116	90	74	63	55	48	43
18	2	5	27	97	76	63	54	47	42	37
15	1.5	5	23	86	68	56	48	42	37	34
12	1.25	5	20	78	62	51	44	38	34	31

Example #1: Two pipes - one 24 inch RCP pipe and one 27 inch PVC pipe at 115°

Trial #1 - 48 inch diameter manhole

$$180^\circ \geq X^\circ > (K_1 + K_2) / 2$$

$$180^\circ \geq 115^\circ > (122 + 109) / 2$$

$$180^\circ \geq 115^\circ > 115.5$$

Result: Not Acceptable

Trial #2 - 60 inch diameter manhole

$$180^\circ \geq X^\circ > (K_1 + K_2) / 2$$

$$180^\circ \geq 115^\circ > (94 + 85) / 2$$

$$180^\circ \geq 115^\circ > 89.5$$

Result: Acceptable

Example #2: Three pipes - one 18 inch PVC pipe, one 12 inch PVC at 90°, and one 27 inch VCP pipe at 180°

Trial #1 - 48 inch diameter manhole

$$180^\circ \geq X^\circ > (K_1 + K_2) / 2$$

$$180^\circ \geq 90^\circ > (82 + 66) / 2$$

$$180^\circ \geq 90^\circ > 74$$

$$X^\circ + (K_2 + K_3) / 2 < Y^\circ < 360^\circ - (K_1 + K_3) / 2$$

$$90^\circ + (66 + 129) / 2 < 180^\circ < 360^\circ - (82 + 129) / 2$$

$$90^\circ + 97.5 < 180^\circ < 360^\circ - 105.5$$

$$187.5 < 180^\circ < 254.5$$

Result: Not Acceptable

Trial #2 - 60 inch diameter manhole

$$180^\circ \geq X^\circ > (K_1 + K_2) / 2$$

$$180^\circ \geq 90^\circ > (65 + 53) / 2$$

$$180^\circ \geq 90^\circ > 59$$

$$X^\circ + (K_2 + K_3) / 2 < Y^\circ < 360^\circ - (K_1 + K_3) / 2$$

$$90^\circ + (53 + 99) / 2 < 180^\circ < 360^\circ - (65 + 99) / 2$$

$$90^\circ + 76 < 180^\circ < 360^\circ - 82$$

$$166 < 180^\circ < 278$$

Result: Acceptable

3. **Intake/Manhole Combination:** Intake/manhole combinations will be used when the size of the connecting pipes so indicate or when horizontal clearance is necessary behind the back of curb. The Engineer is encouraged to utilize intake/manhole combinations for storm sewers that are parallel to the street. This will prevent storm sewers from being installed under pavement; improving maintenance access without requiring pavement removal.
4. **Cleanouts:** Lamp holes or cleanout structures are required at the beginning of footing drains and subdrains in street right-of-way. Cleanouts may be allowed in place of a manhole at the end of lines that are less than 150 feet in length. Approval to use cleanouts is required.
5. **Access Spacing:** Storm sewer structures (manholes, intakes, combination intakes, or cleanouts) in street right-of-way must be located in areas that allow direct access by maintenance vehicles.

Areas outside the street right-of-way will be subject to the approval of the Jurisdictional Engineer.

- a. **Manhole Spacing:** Manholes are to be spaced at intervals not exceeding 400 feet or at intervals not exceeding 500 feet when adequate cleaning equipment is available.
- b. **Intake Spacing:** Locate street intakes upgrade from intersections, sidewalk ramps, and outside of intersection radii. At least one intake is to be installed at the low point of the street grade.
 - 1) **First Intake:** An intake should be located no further than 500 feet from the street high point.
 - 2) **Remaining Intakes:** To be spaced at a distance no greater than 400 feet, regardless of gutter flow capacity, in order to meet maintenance needs.
6. **Invert Drop:** When there is a change in pipe size at a structure, the invert of the smaller sewer must be raised to maintain the same energy gradient. An approximate method of doing this is to place the 0.8 depth point of both sewers at the same elevation. When the outgoing and incoming pipes are the same diameter and when there is a change in alignment between storm sewer of 45 degrees or greater, the suggested drop in the flow line is 0.3 foot and the minimum drop is 0.10 foot.

H. Manhole and Intake Standards

Table 2C-3.09: Manhole Standards

Figure No. ¹	Description	Use	
		Main Pipe Size	Depth Restrictions
6010.401	Circular Storm Sewer Manhole	12" min. See table on Figure 6010.401 for max. pipe size	N/A
6010.402	Rectangular Storm Sewer Manhole	12" to 54"	8' max.
6010.403	Deep Well Rectangular Storm Sewer Manhole	12" to 72"	12' max.
6010.404	Rectangular Base/Circular Top Storm Sewer Manhole	12" to 96"	12' min. to 22' max.
6010.405	Tee-section Storm Sewer Manhole	12" or greater	N/A

¹ The figure numbers listed in this table refer to figures from the SUDAS Specifications.

Table 2C-3.10: Manhole Castings

Figure No. ¹	Casting Type	Number of Pieces	Ring/Cover	Bolted Frame	Bolted Cover (Floodable)	Gasket
6010.602	E	2	Fixed ²	Yes	No	No
6010.602	F	3	Adjustable ³	No	No	No

¹ The figure numbers listed in this table refer to figures from the SUDAS Specifications.

² Typically used with non-paved or flexible surfaces, including HMA, seal coat, gravel, and brick.

³ Typically used with PCC surfaces, including castings in concrete boxouts.

Table 2C-3.11: Intake Standards

Intake Type ¹	Intake Casting ¹	Standard	Conditions
Curb-Grate 6010.501	6010.603 Type Q	Single, poured 6" walls	Intake depth $\leq 7'$ Pipe size: 18" max. on 2' side, 30" max. on 3' side
Curb-Grate 6010.502	6010.603 Type Q	Single, precast walls	Intake depth $> 7'$ Pipe size: 24" max. for 48" diameter
Curb-Grate (Combination) 6010.503/6010.504	6010.603 Type Q	Single, poured 6" walls	Intake depth $\leq 6' 6''$ Pipe size: 30" max. on 3' side, 36" max. on 6' side
Curb-Grate 6010.505	6010.603 Type Q	Double, poured 6" walls	Intake depth $\leq 7'$ Pipe size: 18" max. on 2' side, 66" max. on 6' 8" side
Curb-Grate (Combination) 6010.506	6010.603 Type Q	Double, poured 6" walls	Intake depth $\leq 6' 6''$ Pipe size: 30" max. on 3' side, 36" max. on 6' side, 48" max. on 6' 8" side
Curb Only 6010.507	N/A	Single open-throat, poured 6" walls	Intake depth $\leq 10'$ Pipe size: 30" max. on 3' side, 36" max. on 4' side
Curb Only 6010.508	N/A	Single open-throat, poured 6" walls	Intake depth $\leq 16'$ Pipe size: 36" max.
Curb Only 6010.509	N/A	Double open-throat, poured 6" reinforced walls	Intake depth $\leq 10'$ Pipe size: 30" max. on 3' side, 66" max. on 8' side
Curb Only 6010.510	N/A	Double open-throat, poured 6" reinforced walls	Intake depth $< 10'$ Pipe size: 36" max. on 4' side, 66" max. on 8' side
Driveway or Alley Grate Intake 6010.511	6010.604 Type 6	Single (Surface Intake), poured 6" walls	Intake depth $\leq 7'$ Pipe size: 18" max. on 2' side, 30" max. on 3' side
Area Intake 6010.512	6010.604 Type 3, 4, or 5	Precast, Area Intake	Intake depth $> 7'$ Pipe size varies on structure size
Ditch Intake 6010.513	6010.602 Type G	Area Intake (side open intake), poured 6" walls	Intake depth $\leq 7'$ Pipe size varies on structure size

¹ The figure numbers listed in this table (e.g. [6010.501](#)) refer to figures from the SUDAS Specifications.

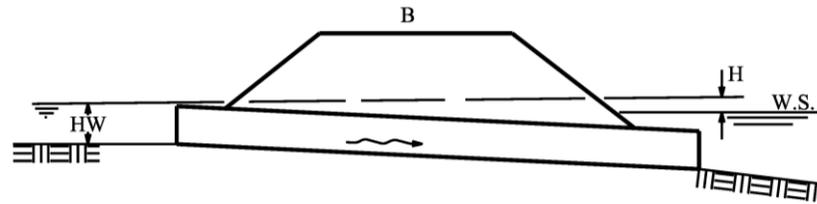
I. References

Comport, Thornton, & Cox. *Hydraulic Efficiency of Grate and Curb Inlets for Urban Storm Drainage*. Colorado State University. 2009.

U.S. Department of Transportation. *Urban Drainage Design Manual*. Hydraulic Engineering Circular No. 22. Third Ed. 2009.

- b. Figure 2E-2.02B depicts the outlet submerged with the inlet unsubmerged. For this case, the headwater is shallow so that the inlet crown is exposed as the flow contracts to the culvert.

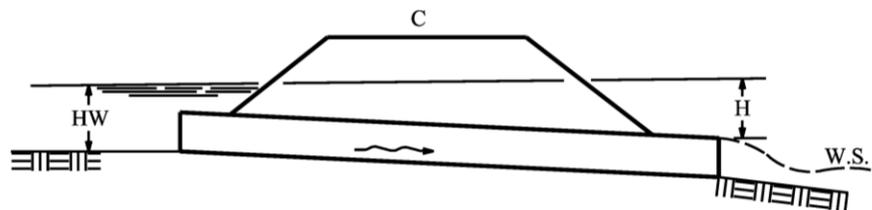
Figure 2E-2.02B: Outlet Submerged, Inlet Unsubmerged



Source: *Hydraulic Design of Highway Culverts*, FHWA

- c. Figure 2E-2.02C shows the entrance submerged to such a degree that the culvert flows full throughout its entire length while the exit is unsubmerged. This is a rare condition. It requires an extremely high headwater to maintain full barrel flow with no tailwater. The outlet velocities are usually high under this condition.

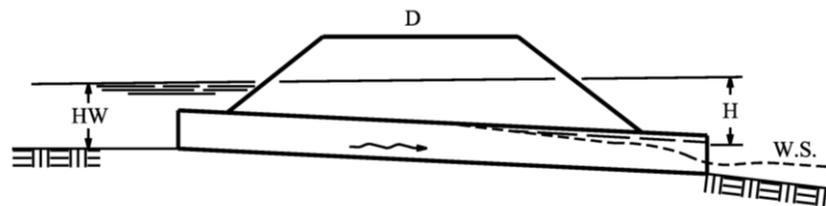
Figure 2E-2.02C: Inlet Submerged, Outlet Unsubmerged



Source: *Hydraulic Design of Highway Culverts*, FHWA

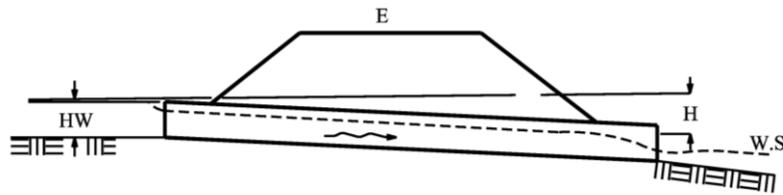
- d. Figure 2E-2.02D is more typical. The culvert entrance is submerged by the headwater and the outlet end flows freely with the low tailwater. For this condition, the barrel flows partly full over at least part of its length (subcritical flow) and the flow passes through critical depth just upstream from the outlet.

Figure 2E-2.02D: Inlet Submerged, Outlet Partially Submerged



Source: *Hydraulic Design of Highway Culverts*, FHWA

- e. Figure 2E-2.02E is also typical, with neither the inlet nor the outlet end of the culvert submerged. The barrel flows partly full over its entire length, and the flow profile is subcritical.

Figure 2E-2.02E: Inlet Unsubmerged, Outlet Unsubmerged

Source: *Hydraulic Design of Highway Culverts*, FHWA

C. Software Versus Nomographs

Culvert calculations utilizing the nomograph procedure are tedious and time consuming. Complex interactions between the headwater, tailwater, inlet control, and outlet control require initial assumptions and numerous trial and error iterations to arrive at a final design.

The designer may prefer to use culvert design software to assist in improving efficiency. [HY-8 Culvert Analysis Program](#) or the [Iowa DOT Culvert Program](#) are two publicly available programs that may be downloaded for free. When using the Iowa DOT Culvert Program, the Rational Method or the TR-55 Method should be used rather than the Iowa Runoff Curve to more accurately reflect urban hydrology. Proprietary design software may also be utilized.

D. Use of Inlet and Outlet Control Nomographs

The use of nomographs requires a trial-and-error solution. The solution provides reliable designs for many applications. It should be remembered that velocity, hydrograph routing, roadway overtopping, and outlet scour require additional separate computations beyond what can be obtained from the nomographs.

Figures 2E-2.07 and 2E-2.08 show examples for inlet-control nomographs that can be used to design concrete pipe culverts. Figures 2E-2.09 through 2E-2.11 show examples for outlet-control nomographs. For culvert designs not covered by these nomographs, refer to the complete set of nomographs given in *Municipal Stormwater Management*, Second edition, 2003 by Thomas N. Debo, Andrew J. Reese. Following is the design procedure that requires the use of inlet- and outlet-control nomographs:

Step 1: List design data

- Q = discharge (cfs)
- L = culvert length (ft)
- S = culvert slope (ft/ft)
- K_e = inlet loss coefficient
- V = velocity (ft/s)
- TW = tailwater depth (ft)
- HW = allowable headwater depth for the design storm (ft)

Step 2: Determine trial culvert size by assuming a trial velocity 3-5 ft/s and computing the culvert area, $A = Q/V$. Determine the culvert diameter (inches).

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3. **Special Manholes:** For square or rectangular manholes, the manhole openings should be over the centerline of the pipes or on an offset not to exceed 12 inches. The distance from the centerline of the manhole opening to the face of the inside manhole wall should not exceed 30 inches to better facilitate video inspection and maintenance equipment. This may require more than one manhole opening.
4. **Manhole Locations:**
 - a. Manholes should be installed:
 - 1) at the end of each sewer line
 - 2) at all changes in pipe size, grade or alignment, and at bends
 - 3) at all sewer pipe intersections
 - 4) at intervals not exceeding 400 feet for sewers 24 inches or less or at intervals not exceeding 500 feet when adequate cleaning equipment is available. Spacing of manholes over 500 feet may be permitted in sewers larger than 24 inches if the owner has adequate cleaning equipment.
 - b. Cleanouts may be substituted, with Jurisdictional approval, for mains shorter than 150 feet.
5. **Manhole Drop:**
 - a. Change in alignment - 0 to 45 degrees - none.
 - b. Change in alignment across manhole - greater than 45 degrees - 0.10 feet (minimum), 0.30 feet (preferred).
6. **Dissimilar Pipe Sizes:** Change in pipe size - match eight-tenths full points.
7. **Maximum Manhole Drop:** A drop connection is required when the invert to invert drop is greater than 2 feet, except when the eight-tenths points match exceeds 2 feet.
8. **Manhole Frames and Covers:** Bolt-down covers are required on manholes subject to inundation such as in flood plains, detention areas, and storm water easement areas subject to "major storms." Minimum access diameter of 27 inches is required.
9. **Manhole Coatings:** Exterior waterproof coating (bituminous) is not required unless specified by the Jurisdiction. Interior coatings should be required if sulfate protection is necessary. Drop sections should be coated along with the manhole to protect against sulfate.
10. **Manhole Sizes:** See [Section 2C-3, G, 2, c.](#)

M. Sewer Services

1. Each structure or complex under one ownership should be served by a separate service line connected to a public or private sanitary sewer. The service should be perpendicular to the sewer line where possible, with tee or wye connections to the public sewer.
2. Sewer services must meet all the Jurisdiction's requirements.
3. Unless individual onsite treatment systems are allowed, all platted lots of a proposed subdivision are to have separate sewer services for each owner and be adjacent to a public sanitary sewer main without crossing any adjacent properties. Additional sewer services will be required for each additional principal structure on a given lot.
4. Sewer services across one property to provide service to an adjacent property should be avoided. If a condition exists that requires crossing an adjacent property, the following should be met:
 - a. A private utility easement is provided that is 10 feet wide (minimum) or two times the depth, whichever is greater.
 - b. The Jurisdictional Engineer determines that a sewer main extension will not be necessary and in all likelihood no future development of abutting properties will benefit from a main extension.
5. Connect sewer services to sewer mains. Connections directly to manholes will require Jurisdiction's approval. Individual single family residential services will not be connected to a manhole unless at terminal manholes which cannot possibly be extended in the future. The services may not enter the manhole at greater than 2 feet above the invert of the outlet. Sewer flow channels in the manhole bottom must be provided for all services. Commercial and multi-family sewer services can be connected, with Jurisdictional approval, to a manhole on the collector sewer if flows are large enough to keep the manhole clean.

N. Force Mains

1. **Minimum Velocity:** 2 fps at minimum pumping condition.
2. **Air Release Valves:** Should be located at high points to control the excess accumulation of sewage gases.

O. Siphons

In general, sanitary sewer siphons should be avoided and will only be accepted where no feasible alternative exists and where there will be sufficient flow in the sewer so that maintenance will be held to a minimum. All siphons should have a minimum of two barrels with a minimum pipe size of 6 inches diameter. Design provisions should be made for diversion of normal flow to either barrel for maintenance. Sufficient head should be provided to insure velocities of at least 3 feet/second for average flow.

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K. Thrust Blocks, Anchor Blocks, and Restrained Joints

Concrete thrust blocks, anchor blocks, and restrained joints are used to counteract joint movement at points where piping changes directions or at dead-ends.

1. **Thrust Blocks:** Concrete thrust blocks are typically used on pipes 12 inches in diameter or smaller on horizontal and upward bending fittings. Thrust blocks may be used on pipes independently or in combination with restrained joints. The minimum bearing surface table shown on [SUDAS Specifications Figure 5010.101](#) assumes a bearing area of thrust blocks based on 1,000 psf soil pressure and 150 psi water pressure. Where water pressures are higher and/or soil conditions are poor, the designer should design the correct block size using the equation below. No bolts should come into contact with the concrete thrust blocks. If necessary, polyethylene wrap should be wrapped around the pipe, including the bolt circle, before the concrete is placed. Concrete should have a minimum compressive strength of 4,000 psi at 28 days.

$$\text{Required Area, ft}^2 = S_f (2) (\text{water pressure, psi})(\text{cross-sectional area of pipe outside diameter, in}^2) \\ (\sin(\text{angle of bend} / 2)) / (\text{allowable soil pressure, psf})$$

Note - AWWA Recommends a 1.5 factor of safety (S_f), which is not part of the table on [SUDAS Specifications Figure 5010.101](#) or the formula above.

2. **Anchor Blocks:** Anchor blocks are typically used on pipes 12 inches in diameter or smaller on vertical downward bend fittings. Mains larger than 12 inches should use restrained joints as the primary means of thrust restraint on vertical downward bend fittings. Anchor blocks may be used on pipes independently or in combination with restrained joints. Table 4C-1.01 size of the anchor block based on a 150 psi water pressure. Where water pressures are higher, the designer should design the correct block size using the equation below Table 4C-1.01. Where an anchor block is the sole means of restraint on a vertical downward bend, the plans should detail the size and shape of the anchor block. The engineer should also verify the face of the anchor block can resist the horizontal thrust component (T_x) created by the fitting. No bolts should come into contact with the concrete thrust blocks. If necessary, polyethylene wrap should be wrapped around the pipe, including the bolt circle, before the concrete is placed. Concrete should have a minimum compressive strength of 4,000 psi at 28 days.

Table 4C-1.01: Anchor Block Sizing

Pipe Diameter	Degree Bend (Θ)	Weight (Pounds)	Volume (Cu. Yards) (V _g)	Strap Bar Size ¹	Embedment ¹
4	11.25	530	0.1	#5	18
	22.5	1,040	0.3		
	45	1,920	0.5		
6	11.25	1,100	0.3	#5	18
	22.5	2,150	0.6		
	45	3,970	1.0		
8	11.25	1,890	0.5	#5	18
	22.5	3,700	1.0		
	45	6,830	1.7		
10	11.25	2,840	0.7	#5	18
	22.5	5,560	1.4		
	45	10,270	2.6		
12	11.25	4,010	1.0	#5	18
	22.5	7,860	2.0		
	45	14,520	3.6	#7	24
14	11.25	5,390	1.4	#5	18
	22.5	10,560	2.7	#6	24
	45	19,510	4.9	#8	30
16	11.25	6,960	1.8	#5	18
	22.5	13,650	3.4	#7	24
	45	25,230	6.3	#9	30

¹ - Values were taken from the Oregon DOT Standard Detail RD250 Table C

Values in the table have a safety factor $S_f = 1$

$$V_g = S_f PA \sin\Theta / W_m \quad T_x = PA (1 - \cos\Theta)$$

3. Restrained Joints:

- a. **For Pipe Diameters 8 inch through 12 inch:** Provide a minimum of 40 feet of restrained pipe in all directions along the pipe from the fitting for pipe diameters 8 inch through 12 inch, depths of bury of at least 5 feet, and a maximum test pressure of 150 psi.
- b. **For Pipe Diameters Greater than 12 inch:** Restrained joints are typically used on pipes larger than 12 inches in diameter. They may be used on other pipe sizes independently or in combination with concrete thrust blocks. See pipe manufacturer's recommendations for determining restrained lengths of pipe required.

L. Crossings

1. **Railroad Crossings:** The regulations of the railroad company involved will govern when a water main is installed under or over any railroad tracks.
2. **Roadway Crossings:** The jurisdiction responsible for the roadway should have regulations for crossing a roadway. For primary and interstate highways, the Iowa DOT is the responsible jurisdiction. For non-primary, federal-aid roadways use the most recent version of the “Policy for Accommodating Utilities on the County and City Non-Primary Federal-Aid System.” For all other roadways, contact the responsible jurisdiction.

M. Flushing, Disinfection, and Pressure Tests

Before going into service, all new mains should be adequately flushed, pressure tested, and disinfected according to the rules and regulations of the local Jurisdiction and Iowa DNR. The procedures, once approved by the Jurisdiction, should be conducted under the supervision of the Jurisdiction or designated representative.

1. **Disinfection:** Disinfect the water main according to AWWA C651. Verify requirements and acceptable methods with the Engineer. Three methods of disinfecting new water mains are available. They include the tablet method, the continuous feed method, and the slug method. The tablet method is the most convenient, but the least effective. [SUDAS Specifications Section 5030](#) indicates that the tablet method is not to be used unless approved by the Engineer. The continuous feed method is acceptable for general application. The goal for disinfection is to obtain a concentration in the new main of 25 mg/L free chlorine. The chlorine is to be retained in the pipe for a minimum of 24 hours, but no more than 48 hours.
2. **Flushing:** Once the main has passed the chlorination tests, it is to be flushed according to the requirements of AWWA C651 until the water in the new main is at the same chlorine level as the other sections of the distribution system. The velocity in the main should be at least 2.5 feet per second for adequate flushing. If there is any potential threat the highly chlorinated water will damage the environment, a neutralizing chemical should be added to the water to render it acceptable.
3. **Hydrostatic Pressure Testing:** Pressure test according to AWWA C600. All air must be expelled from the new main. The test pressure should be 1.5 times the working pressure of the system or 150 psi, whichever is greater. The test should continue for a minimum of 2 hours. If the pressure falls by 5 psi or more, additional makeup water must be added to return the pipe to the test pressure. The amount of makeup water used must meet the requirements of [SUDAS Specifications Section 5030](#).

Figure 4C-1.02: Standard Water Main Location at Cul-de-sac

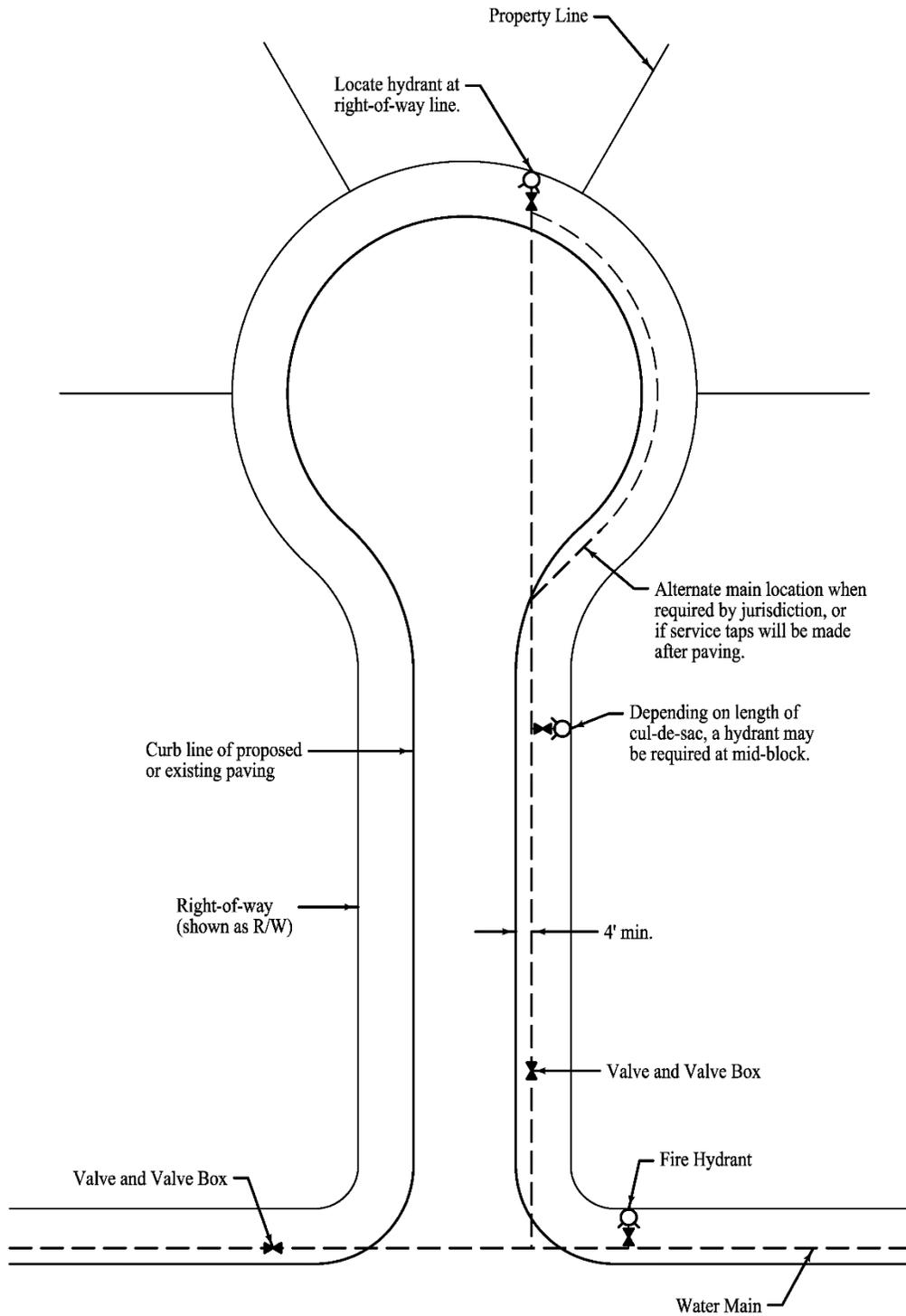
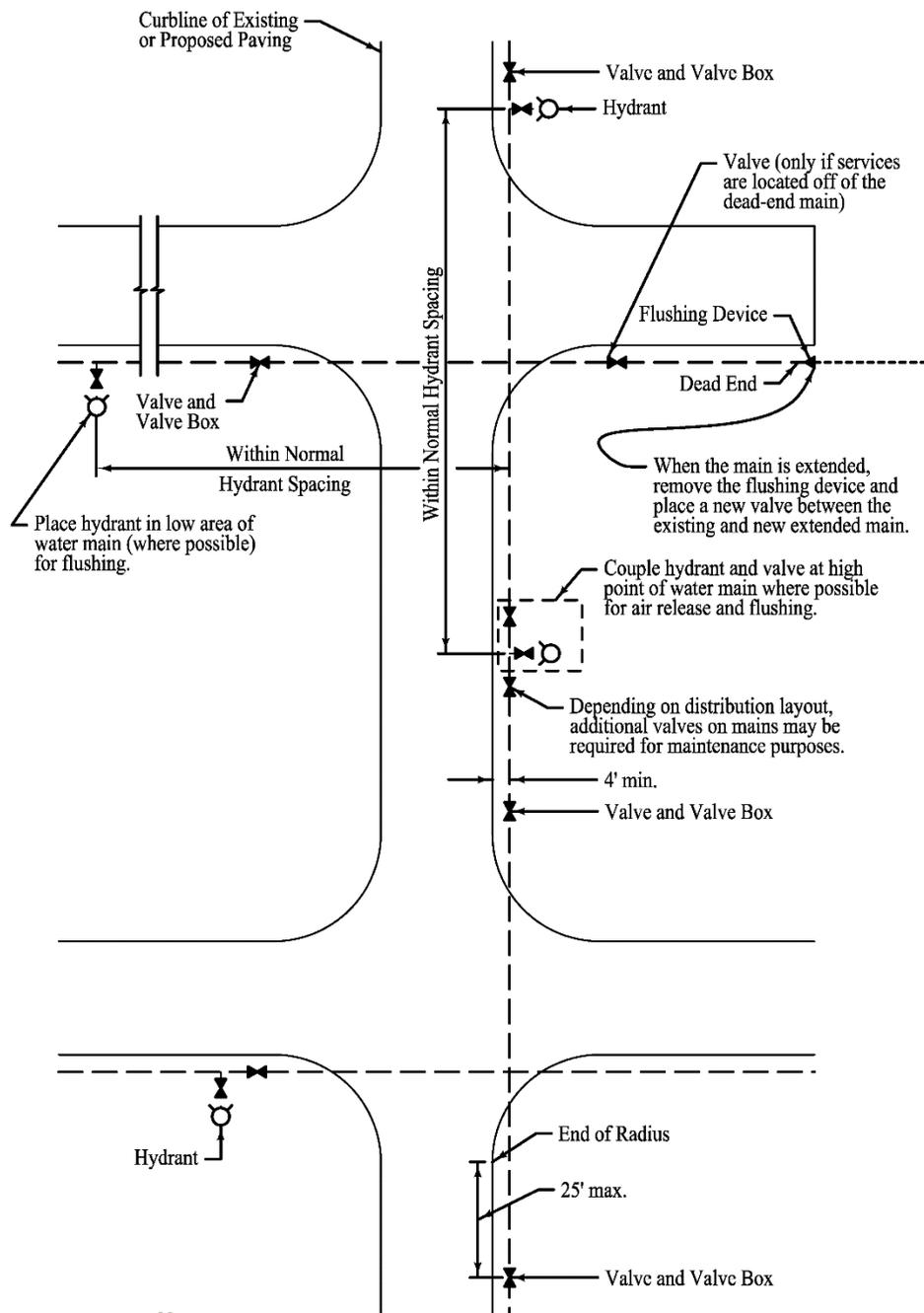


Figure 4C-1.03: Standard Water Main Location



Notes:

1. Install three valves and one fire hydrant at each intersection, except at T-intersections, which will have two valves.
2. Where possible, locate fire hydrant near high point.
3. Locate fire hydrants within 25 feet of intersection return radius, but outside of radius to avoid conflicts with storm sewers and intakes.
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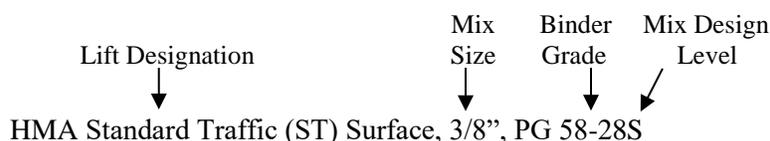
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- d. **Aggregate Properties:** The mixture design criteria ([SUDAS Specifications Section 7020, Table 7020.01](#)) is derived from [Iowa DOT Materials I.M. 510, SUDAS Specifications Section 7020, Table 7020.01](#) specifies a 15% increase in percent crushed aggregate for surface and intermediate mixes 1 M ESALs and less to account for slow, stop, and turning conditions. This will be a local decision based on past performance and available aggregates. The actual percent crushed needed to achieve the mix design gyratory compaction volumetrics will vary with the quality of the aggregates used. Both the specified percent crushed and the gyratory compaction volumetrics must be satisfied by the asphalt mixture.
- 7. **Check for Availability of Materials to Meet the Mix Design Criteria:** Review the mix design criteria selected in step 6 and determine if the binder and aggregates required to meet the mix design criteria are readily available or accessible at a reasonable cost. Contact local producers and/or district materials engineers, if the designer plans to use non-standard criteria. Imported aggregates and modified binders generally cause higher costs. The designer should be ready to justify the mix selection decision.
- 8. **Place Mix Criteria in the Project Plans and Proposal:** The following information should be placed in the plans and proposal:
 - a. **Traffic and ESAL₂₀ Projections:** The traffic and ESAL₂₀ projections should be listed on the title sheet of the plans. The ESAL₂₀ value should coincide with the selected mix design level. If seasonal ESALs are used for design, the title sheet should note that the ESAL₂₀ value is based on seasonal loading. The following is an example title sheet.

Traffic	
Current ADT	_____
Future ADT	_____
Present Trucks	_____
ESAL ₂₀	_____

- b. **Asphalt Mixture:** Each asphalt mixture bid item is defined by the ESAL level, lift designation, and aggregate size. The mixture properties for each mixture level are specified in the specifications and [SUDAS Specifications Section 7020, Table 7020.01](#). If the designer specifies a different percent crushed aggregate, this should be identified in the bid item note on the plans. The designer should avoid placing the mix size in additional sections of the plans to minimize errors associated with duplication. The exception to this guide would be a bid item note or tabulation intended to identify locations of different mix sizes for the same lift.
- c. **Asphalt Binder Grade PG XX -YY:** The asphalt binder grade should be specified in the bid item. The designer should avoid placing the binder grade in additional sections of the plans to minimize errors associated with duplication. The exception to this guide would be a bid item note or tabulation intended to identify binder use when multiple binders are specified. The following is an example bid item.



D. Material Properties

1. **Typical PG Grades and Their Application:** PG 58-28S is the common conventional binder used in Iowa.

Some applications utilize specific binder grades. Use PG 58-34E meeting AASHTO T-321 with a minimum of 100,000 cycles to failure for asphalt interlayer applications. Use PG 64-34E+ meeting AASHTO T-324 with a minimum 90% elastic recovery for high performance thin lift applications.

When recycled asphalt materials (RAM) are used and they exceed 20% replacement of the total binder, the binder grades may need to be modified. See [Iowa DOT Materials I.M. 510](#).

If warm mix asphalt (WMA) technologies are utilized, the binder grade selection is based on plant mixing temperatures and the level of field compaction. See [Iowa DOT Materials I.M. 510](#) for information on the appropriate binder grade.

2. **Aggregate Source Properties:** Aggregate source properties are defined in [Iowa DOT Specifications Section 4127](#). The mixture criteria listed in [SUDAS Specifications Section 7020, Table 7020.01](#) defines the aggregate type for each mixture level specified for the project. Each individual source of aggregate is expected to meet these criteria. The designer may specify a different aggregate type in the bid item note.
3. **Aggregate Consensus Properties:** Aggregate consensus properties are listed in [SUDAS Specifications Section 7020, Table 7020.01](#) for each mixture level. These properties include percent crushed aggregate, fine aggregate angularity, clay content (sand equivalent), and flat and elongated particles. These aggregate properties are measured on the combined aggregate, not individual aggregates.

If the designer specifies a value different from [SUDAS Specifications Section 7020, Table 7020.01](#), the value selected should be based on the local practice and desired pavement performance. The asphalt mixture must satisfy both the percent crushed aggregate and laboratory compaction volumetric criteria. The percent crushed aggregate specified is interdependent on the compaction level and the quality of the aggregate.

E. Use of Mixture Selection Guide and Design Criteria Tables

Two tables in Subsection H are provided to assist designers with the selection of asphalt materials for projects. The Asphalt Mixture Selection Guide (Table 5D-1.02) provides the project designer with a set of standard material selections that will satisfy most projects. The Asphalt Mixture Design Criteria ([SUDAS Specifications Section 7020, Table 7020.01](#)) is derived from [Iowa DOT Materials I.M. 510](#) and provides the mix designer with the detailed mix criteria for each mixture level. The mixture selection guide and mixture design criteria represent the current understanding of accepted asphalt properties for application on urban routes.

The Asphalt Mixture Selection Guide (Table 5D-1.02) represents commonly used mixture parameters, but does not preclude the project designer from deviating from the "recommended" values. The designer should understand the impact of any modification. The first two columns define the standard mixture levels based on traffic loading. The middle columns establish lift thickness and mix size relationships. It should be noted that Table 5D-1.02 does not address required pavement thickness to meet structural needs ([Section 5F-1](#)). The Bid Item Designation column ties the mixture levels to the bid items. The final column gives a general statewide guide for the estimated binder content. Local binder content experience may be more appropriate for project estimated quantities. This table does not address the need for special friction aggregate. In general terms, urban routes do not require special friction aggregate.

As mentioned earlier, the Asphalt Mixture Design Criteria ([SUDAS Specifications Section 7020, Table 7020.01](#)) is derived from [Iowa DOT Materials I.M. 510](#). However, the table differs from I.M. 510. For the surface and intermediate layers of the LT mixes, the amount of crushed aggregate was increased by 15% and for the ST mixes, all layers have an additional 15% crushed aggregate. A different aggregate type and the percent crushed aggregate may be specified by the designer for the project. These values established in the table are prescribed for each mixture and care should be exercised if altered by the project designer. The designer should only change these values when familiar with the material properties and mixture performance for the local area. The bid item plan note must include these values, if it differs from the value in [SUDAS Specifications Section 7020, Table 7020.01](#).

F. Example Plans

- Title Page:** The traffic and ESAL₂₀ projections should be listed on the title sheet of the plans. The ESAL₂₀ value should coincide with the selected mix design level. If seasonal ESALs are used for design, the title sheet should note that the ESAL₂₀ value is based on seasonal loading.
- Typical Section:** Lift thickness should be shown on the typical section. The lift thickness should match or exceed the recommended lift thickness for the mixture size selected, provided compactive requirements are also achieved. The lift should be designated as surface, intermediate, or base. Mixture size or design ESAL₂₀ level should not be added to the typical section (it is specified in the bid item).
- Bid Items:** Unless otherwise specified, each bid item covers the mixture and binder grade selected. The corresponding bid item note must specify the minimum percent crushed aggregate, if it differs from the value in [SUDAS Specifications Section 7020, Table 7020.01](#).

G. Examples for Determination of Traffic ESALs

Similar to pavement thickness design, the asphalt mixture is designed for the frequency and size of the load applied to the pavement. While it is important to have a good understanding of the traffic, it is possible to select the asphalt paving materials based on reasonable approximations. If the designer has actual traffic data, including a distribution of truck types and loads, the current annual ESAL value can be computed from the AASHTO pavement design tables. For most projects however, the designer will determine estimated values based on a general familiarity with the route. The following examples can be used to approximate the design ESAL₂₀ for a project.

Example 5D-1.01: Two Lane, Two Way Traffic, Low Volume Street

Step	Task	Values
1	Given: Current AADT Percent Trucks Percent Annual Growth Rate Design Period	1,000 5% 2% 20 years
2	Base Year Design ESALs [from Section 5F-1, Table 5F-1.08]	8,000 ESALs
3	Growth Factor [from Section 5F-1, Table 5F-1.11]	24.3
4	Compute ESAL ₂₀ [8,000 ESALs x 24.3]	194,400 ESALs
5	Select mixture design level [from Table 5D-1.02, Mixture Selection Guide]	≤ 0.3 M

Example 5D-1.02: Two Lane, Two Way Traffic, High Volume Street

Step	Task	Values
1	Given: Current AADT Percent Trucks Percent Annual Growth Rate Design Period	10,000 3% 3% 20 years
2	Base Year Design ESALs [from Section 5F-1, Table 5F-1.08]	50,000 ESALs
3	Growth Factor [from Section 5F-1, Table 5F-1.11]	26.9
4	Compute $ESAL_{20}$ [50,000 ESALs x 26.9]	1,345,000 ESALs
5	Select mixture design level [from Table 5D-1.02, Mixture Selection Guide]	1 to 10 M

Example 5D-1.03: Four Lane Street

Step	Task	Values
1	Given: Current AADT Percent Trucks Percent Annual Growth Rate Design Period	15,000 5% 2% 20 years
2	Base Year Design ESALs [from Section 5F-1, Table 5F-1.10]	75,000 ESALs
3	Growth Factor [from Section 5F-1, Table 5F-1.11]	24.3
4	Compute $ESAL_{20}$ [75,000 ESALs x 24.3]	1,822,500 ESALs
5	Select mixture design level [from Table 5D-1.02, Mixture Selection Guide]	1 to 10 M

H. Tables

Table 5D-1.02: Mixture Selection Guide

Design ESAL ₂₀ (Millions)	Layer Designation	Lift Thickness ³			Mix Size ¹	Bid Item Designation	Binder Content ²
		<i>min</i>	<i>rec</i>	<i>max</i>			
≤ 0.3	Surface	1.5	1.5	2.5	1/2"	Low Traffic (LT)	6.00
	Intermediate	1.5	1.5	3			
	Base	1.5	3	4.5			
0.3 to 1.0	Surface	1.5	1.5	2.5	1/2"	Standard Traffic (ST)	6.00
	Intermediate	1.5	1.5	3			
	Base	1.5	3	4.5			
1.0 to 10.0	Surface	1.5	2	2.5	1/2"	High Traffic (HT)	6.00
	Intermediate	2	2.5	3	3/4"		5.50
	Base	3	4	4.5	1"		5.25

¹ The Common mix size is shown. When other mix sizes are used, the minimum lift thickness also changes (see Section 5D-1, C, 6, b).

² These values are for estimating quantities only. The actual asphalt binder content is established in the approved job mix formula.

³ Some lift thickness values in this guide may conflict with traffic control or allowable compaction criteria.

See [SUDAS Specifications Section 7020, Table 7020.01](#) for mixture design criteria.

- b) **Adjusting Isolation Joints for Utility Fixtures:** After developing the jointing plan, plot any catch basins, manholes, or other fixtures that are within the intersection. Non-telescoping manholes will require a boxout or isolation joint to allow for vertical and horizontal slab movement. Consider using rounded boxouts to avoid crack-inducing corners. Also, for square boxouts, wire mesh or small-diameter reinforcing bars in the concrete around any interior corners will hold cracks tight should they develop. Telescoping manholes can be cast integrally within the concrete, and do not necessarily require a boxout. The multiple piece casting does not inhibit vertical movement and is less likely to create cracks within the pavement.

When a joint is within 5 feet of a fixture, it is desirable to adjust the joint so that it will pass through the fixture or the boxout surrounding the fixture. The following diagram shows several acceptable ways to skew or shift a joint to meet fixtures.

- b. **Expansion Joints:** Expansion joints are defined as full depth, full width transverse joints placed at regular intervals of 50 to 500 feet (with contraction joints in between). This is an old practice that was used to relieve compressive forces in pavement. Unfortunately, this practice often caused other problems in the pavement such as spalling, pumping, faulting, and corner breaks.

Good design, construction, and maintenance of contraction joints has virtually eliminated the need for expansion joints, except under special conditions. In addition to the problems listed above, the improper use of expansion joints can lead to high construction and maintenance costs, opening of adjacent contraction joints, loss of aggregate interlock, sealant failure, joint infiltration, and pavement growth. By eliminating unnecessary expansion joints, these problems are removed and the pavement will provide better performance.

Pavement expansion joints are only needed when:

- 1) The pavement is divided into long panels (60 feet or more) without contraction joints in between to control transverse cracking.
- 2) The pavement is constructed while ambient temperatures are below 40°F.
- 3) The contraction joints are allowed to be infiltrated by large incompressible materials.
- 4) The pavement is constructed of materials that in the past have shown high expansion characteristics.

Under most normal concrete paving situations, these criteria do not apply. Therefore, expansion joints should not normally be used (PCA, 1992).

See the following SUDAS Specifications Figures:

- [Figure 6010.508 - Single Open-Throat Curb Intake, Large Box](#)
- [Figure 6010.514 - Boxout for Grate Intakes](#)
- [Figure 7010.103 - Manhole Boxouts in PCC Pavement](#)

Table 5G-2.02: Summary of Joints
(Derived from the [Iowa DOT Design Manual, Section 7A-2](#), Tables 1 and 2)

Joint	Type			Method of Load Transfer				Thermal Movement				Comments
	Transverse	Longitudinal	Isolation/Expansion	Aggregate Interlock	Key	Tie Bar	Dowel Bar	Doweled to allow movement	Tied to prevent movement	Isolation/Expansion joint allows movement	Lack of reinforcing allows movement	
B	X	X									X	Used between dissimilar materials or when other joints are not suitable.
C	X			X							X	Transverse joint used when T < 8 inches.
CD	X			X			X	X				Transverse joint used when T ≥ 8 inches.
CT	X			X		X			X			Specialty tied contraction joint.
DW	X					X			X			Used by contractor as a stopping point.
HT	X					X			X			Used at the end of rigid pavement prior to placement of second slab.
RD	X						X	X				Joint between new and existing pavements, dowels are used.
RT	X					X			X			Joint between new and existing pavements, tie bars are used.
BT-1		X							X			Longitudinal joint used when T < 8 inches, interchangeable with L-1 depending on paving sequence.
BT-2		X							X			Used when L-2 and the KT-2 are not possible, T ≥ 8 inches.
BT-3		X							X			Joint used between new and existing pavements. Tie bars are used when T ≥ 8 inches.
BT-4		X							X			Joint used between new and existing pavements. Tie bars are used when T ≥ 8 inches.
BT-5		X							X			Joint used between new and existing pavements. Tie bars are used when T < 8 inches.
K		X			X						X	T > 8 inches, minimal usage.
KS		X			X				X			Used in reinforced pavements.
KT-1		X			X				X			Longitudinal joint used when T < 8 inches, interchangeable with L-1 depending on paving sequence.
KT-2		X			X				X			Longitudinal joint used when T ≥ 8 inches, interchangeable with L-2 depending on paving sequence.
KT-3		X			X				X			Longitudinal joint used when T ≥ 8 inches, interchangeable with L-3 depending on paving sequence.
L-1		X		X					X			Longitudinal joint used when T < 8 inches, interchangeable with BT-1.
L-2		X		X					X			Longitudinal joint used when T ≥ 8 inches, interchangeable with KT-2 depending on paving sequence.
L-3		X		X					X			Longitudinal joint used with pavements of large width, interchangeable with KT-3 depending on paving sequence.
CF	X		X							X		4 inch expansion joint.
E	X	X	X							X		1 inch expansion joint.
ED	X		X				X	X		X		1 inch doweled expansion joint.
EE	X		X				X	X		X		2 inch doweled expansion joint.
EF	X		X				X	X		X		4 inch doweled expansion joint.
ES			X							X		Used in curb to match expansion joint in pavement.

D. Transverse Dowel Bar Size and Length

Table 5G-2.03 reflects the dowel bar size and length based on the pavement thickness. This information was obtained from the Portland Cement Association, the American Concrete Paving Association, and American Highway Technology. The SUDAS and Iowa DOT Specifications call for dowels when the slab is 8 inches or greater. Dowels are typically set at 12 inch spacing. The designer should note that a dowel bar that is too small induces high bearing stresses and causes the concrete matrix around the dowel to deteriorate or elongate. Elongation of the dowel bar hole then reduces the load transfer capabilities. Under special circumstances, smaller diameter and different shaped dowel bars may be used in thinner slabs.

Table 5G-2.03: Dowel Bar Size and Length

Pavement Thickness (inches)	Dowel Size (diameter in inches)	Dowel Length (inches)
8	1 1/4	18
9	1 1/4	18
10	1 1/2	18
11	1 1/2	18
12	1 1/2	18

E. Jointed Reinforced Concrete Pavements

Jointed reinforced concrete pavements (JRCP), sometimes referred to as distributed steel reinforcing, are not commonly used in Iowa jurisdictions. However, variations of JRCP are used effectively by several jurisdictions in Iowa. Therefore, the following is provided as an explanation of JRCP.

JRCs utilize bar mats between transverse joints. Typically, the bar mats extend full width across the pavement, but with traditional JRCs, they do not extend through the transverse joints. JRCs use many of the same types of joints as jointed plain concrete pavements (JPCP), but the tie bars for longitudinal joints are replaced with the bar mats. Transverse joints, including doweled joints, are the same for both types of pavements since the bar mats of traditional JRCP do not extend through the transverse joints. Because of the bar mats, transverse joint spacing can be much longer than with JPCP, usually 27 feet to 45 feet. JRCP should not be confused with continuously reinforced pavement, which has very few or no joints.

JRCs are used primarily to control cracking of concrete pavements, to provide for load transfer between joints, and to maintain the structural integrity of the slab between transverse joints. Just like JPCPs, random cracking of JRCs may still occasionally occur even though the steel is present. The steel serves to hold the cracks close together, thus preventing the progressive opening of the cracks over time.

The added cost of the additional reinforcement for JRCs is often offset by specifying a somewhat thinner slab. However, as pointed out by the American Concrete Institute (ACI), “the use of reinforcing steel will not add to the load-carrying capacity of the pavement nor compensate for poor subgrade preparation or poor construction practices.” By holding random cracks tightly closed, it will maintain the shear resistance of the slab, and, consequently, will maintain its load carrying capacity. This improves the ride when the vertical displacement is controlled.

As mentioned previously, several jurisdictions in Iowa specify a variation of JRCP. The Iowa variations of JRCP typically include extending the longitudinal reinforcing bars through the ‘C’ plain transverse contraction joints. When ‘CD’ doweled transverse joints are specified, the longitudinal

reinforcement does not extend through the transverse joints. In addition, the transverse joint spacing is generally not lengthened as described for traditional JRCPs and follows the same guidelines as for JPCP. Figures 5G-2.09 and 5G-2.10 illustrate JRCP details typically used in Iowa.

Figure 5G-2.09: Iowa Jointed Reinforced Pavement Detail - 26' Back-To-Back Street

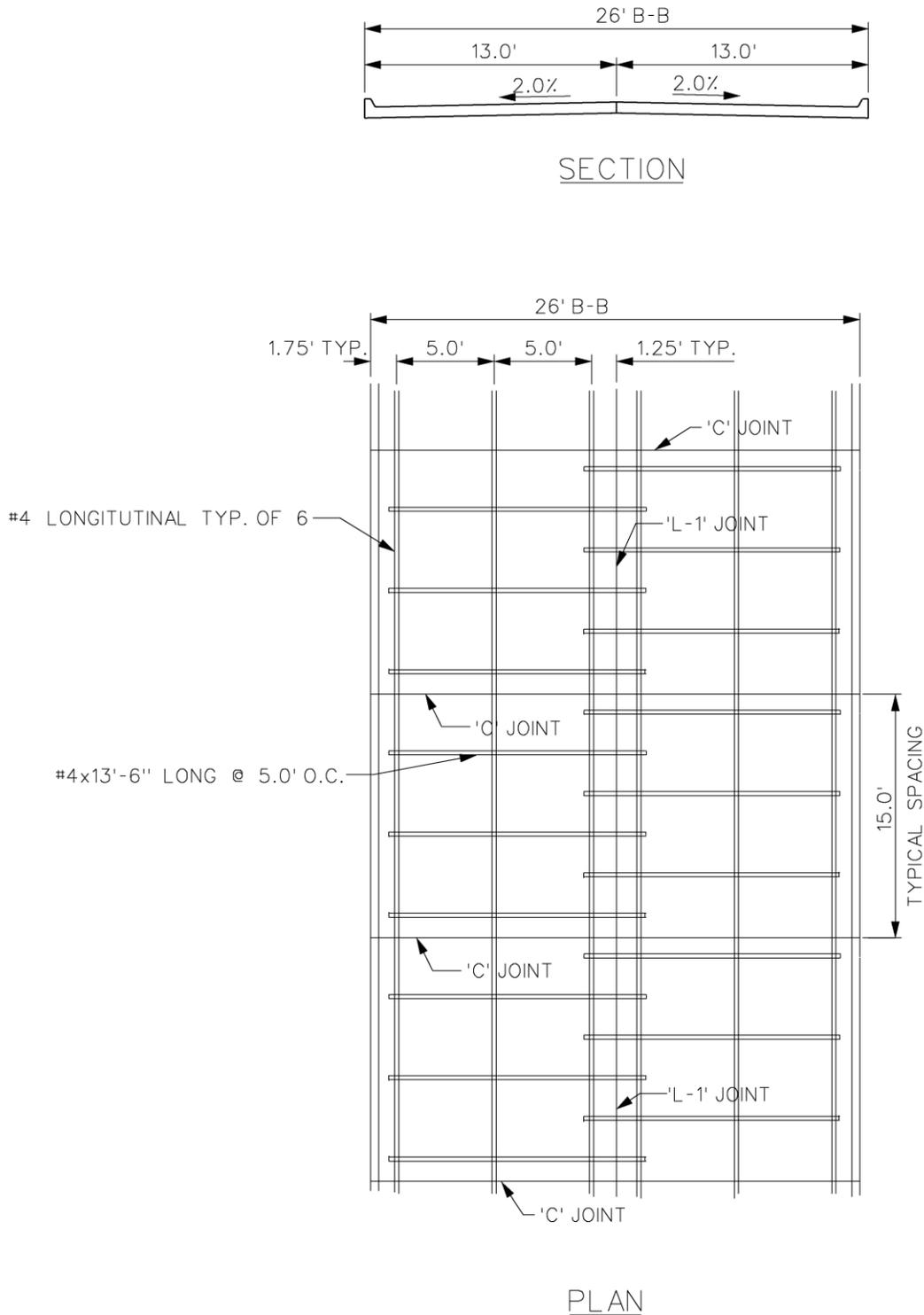


Figure 5G-2.10: Iowa Jointed Reinforced Pavement Detail - 31' Back-To-Back Street

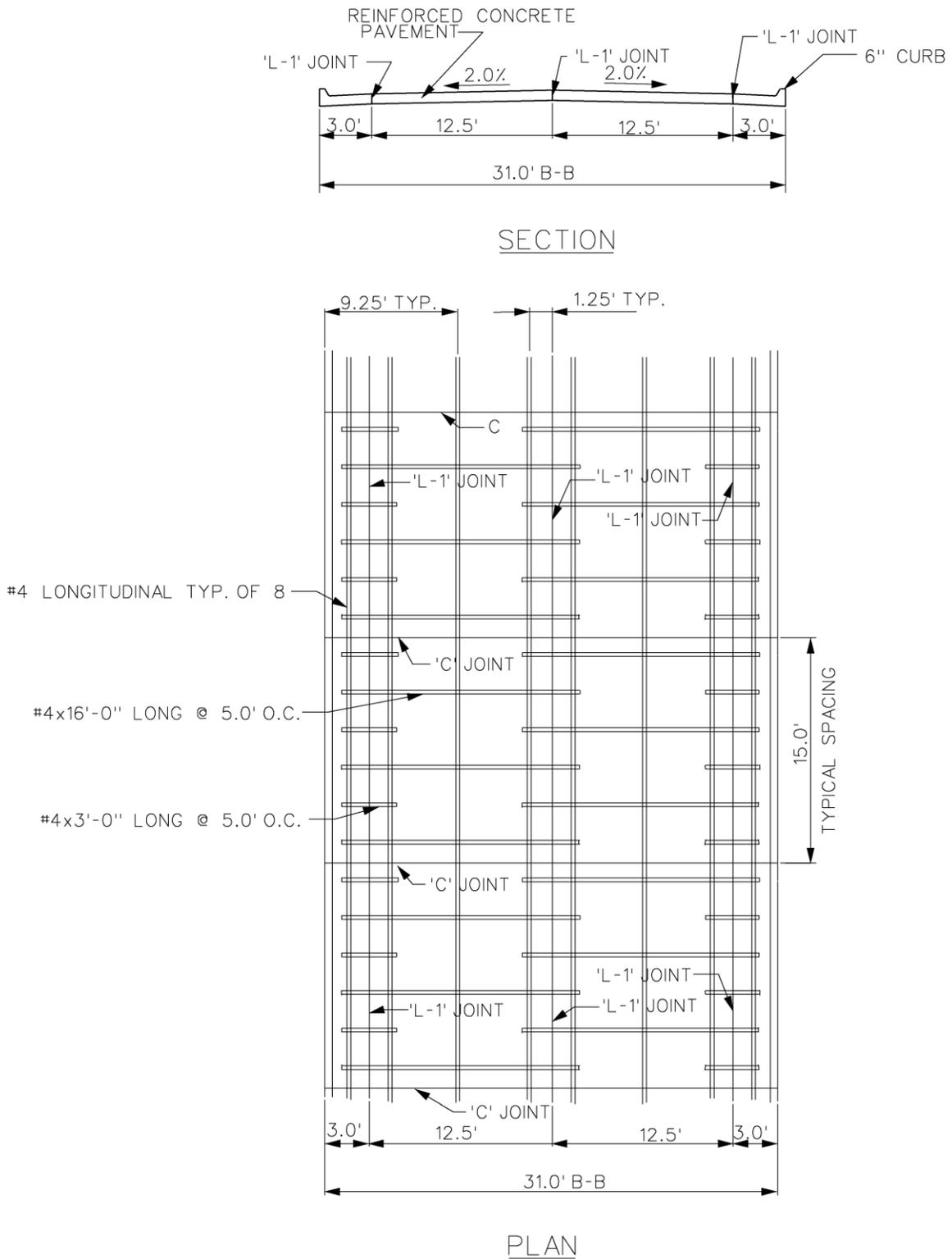


Figure 5G-2.12: 49' B/B and 53' B/B C&G/HMA Pavement

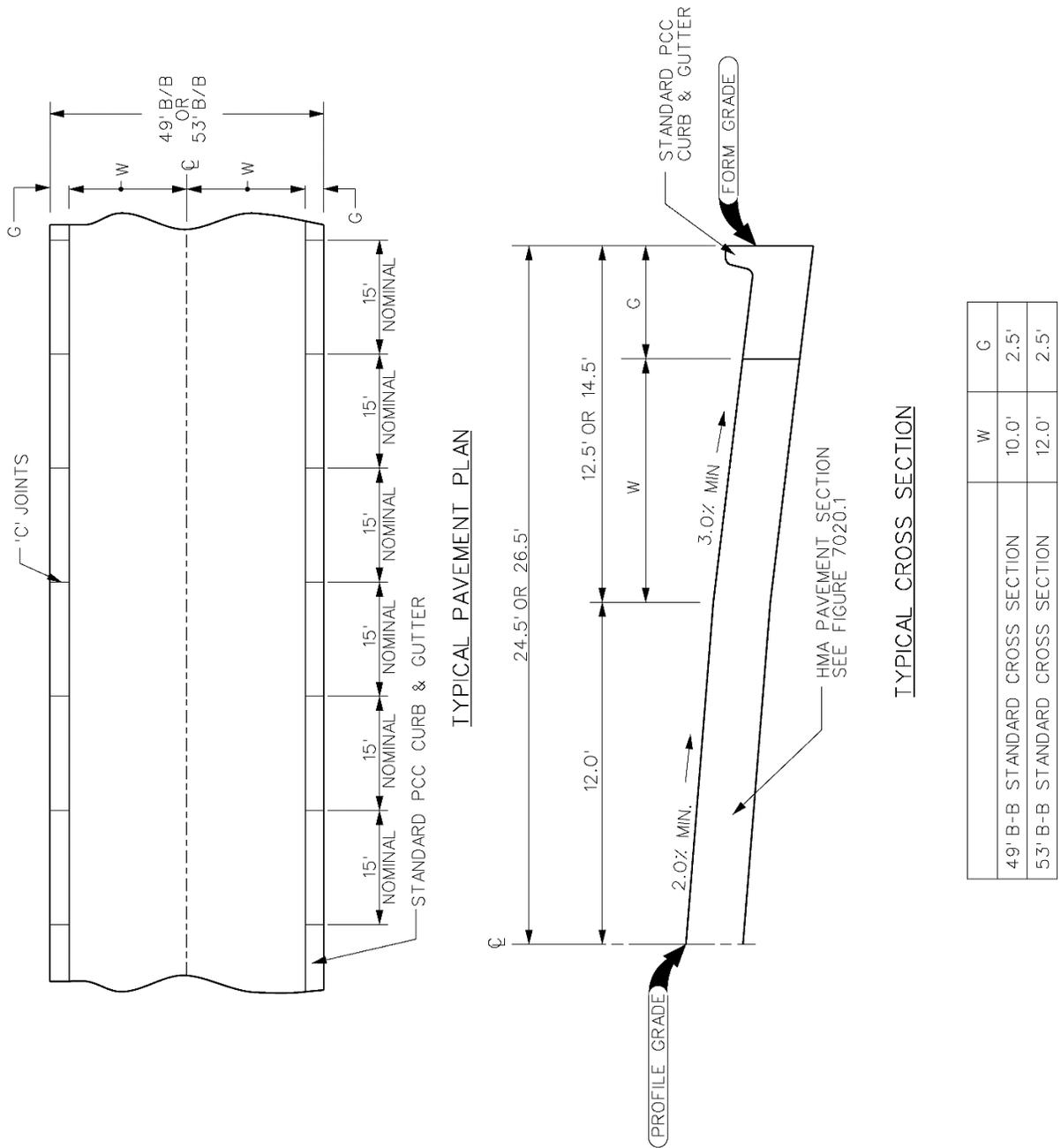


Figure 5G-2.13: 24' Rural PCC Pavement Jointing and Crown Detail

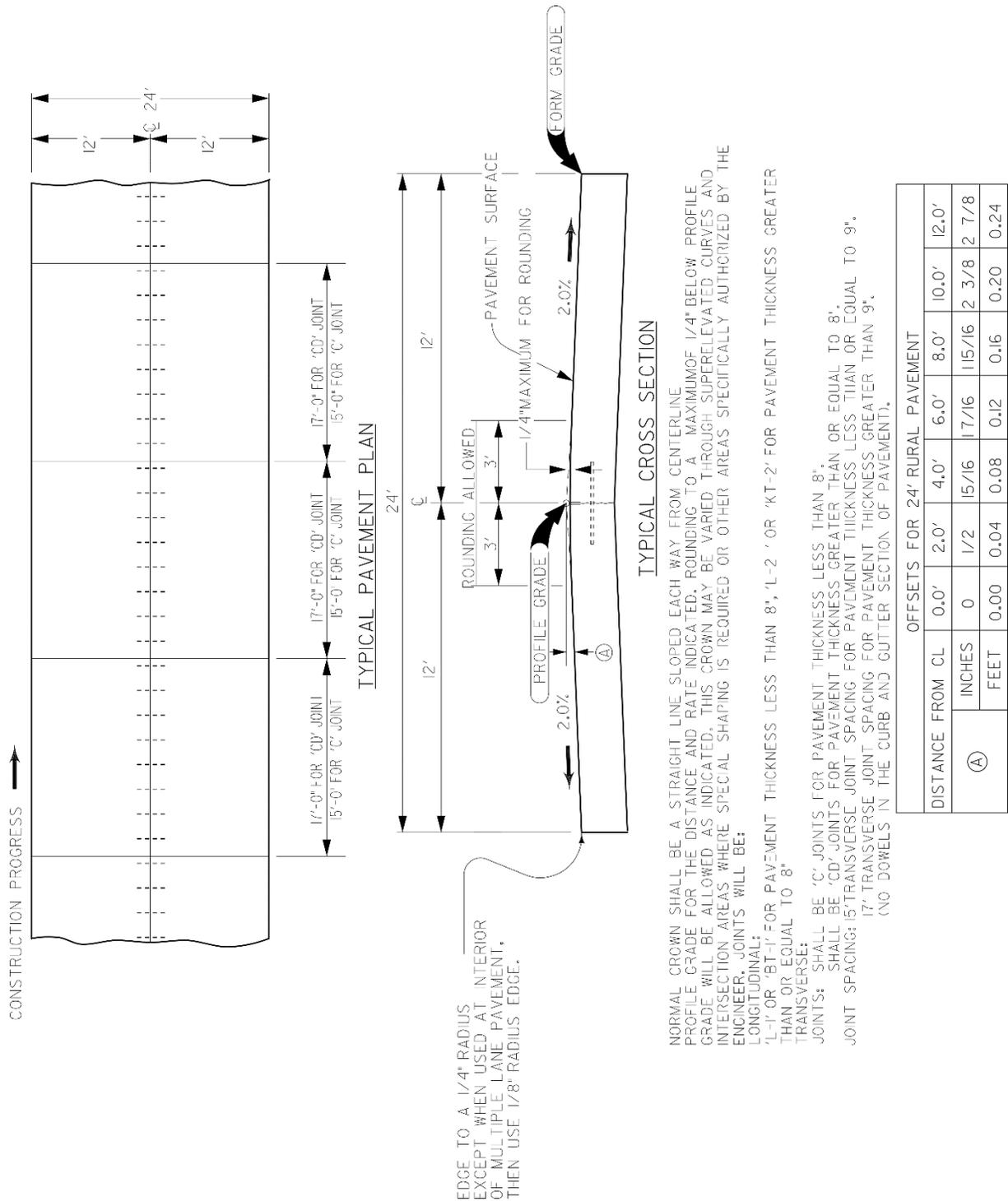


Figure 5G-2.14: 48' Rural PCC Pavement Jointing and Crown Detail

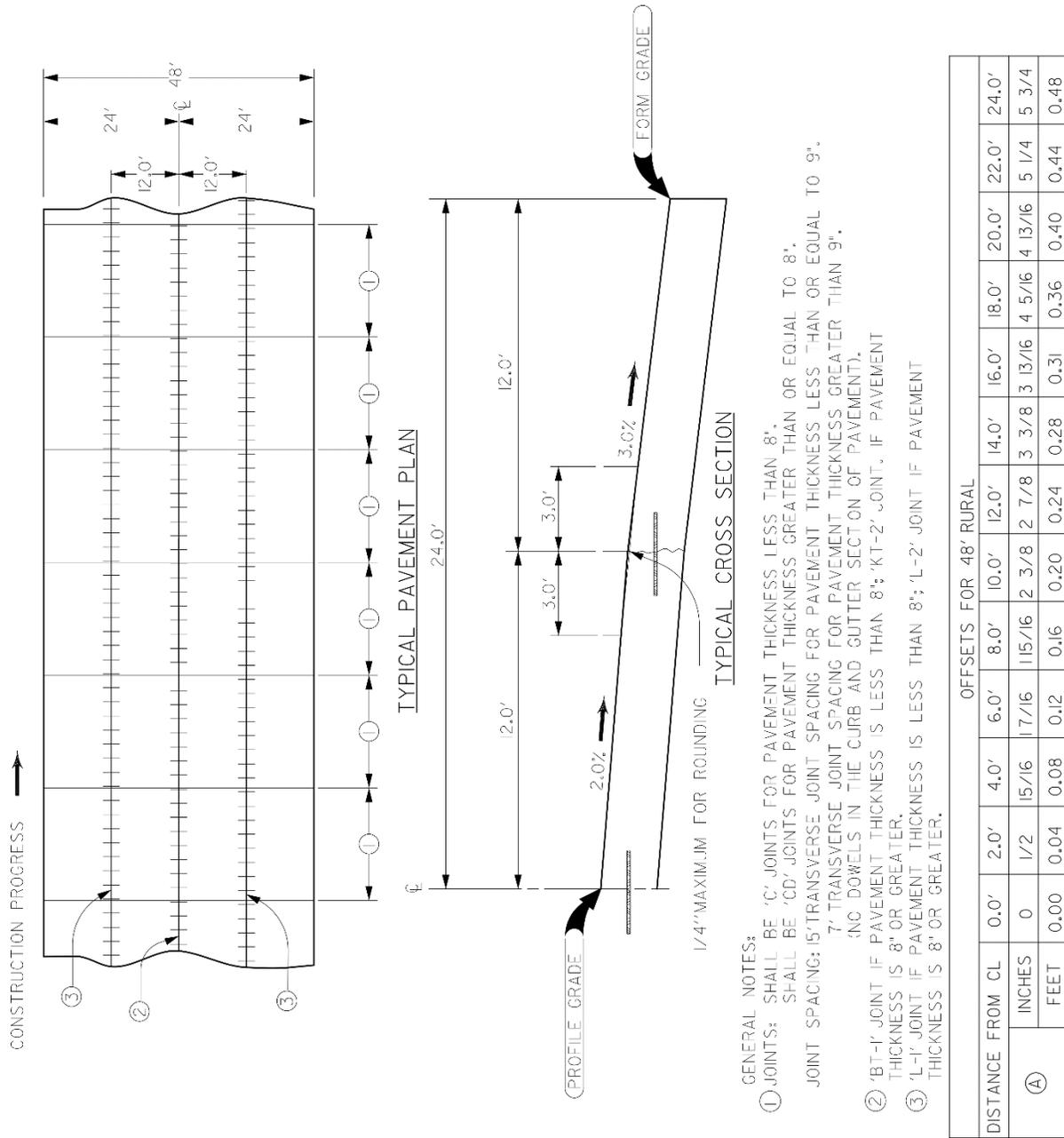
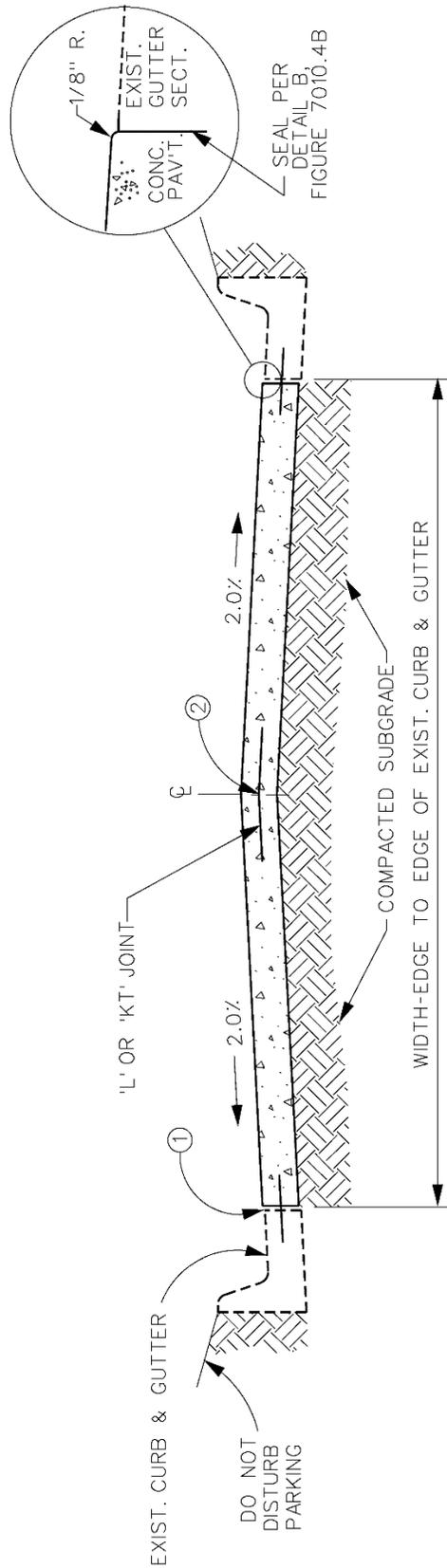


Figure 5G-2.15: PCC Pavement Section Between Existing Curb and Gutter



FOR CROWN SEE FIGURES 7010.1A (SHEET 1 OR 2) OR 7010.1B

- ① 'BT-1' JOINT IF PAVEMENT THICKNESS IS LESS THAN 8"; 'BT-2' JOINT IF PAVEMENT THICKNESS IS 8" OR GREATER.
- ② 'L-1' OR 'BT-1' JOINT IF PAVEMENT THICKNESS IS LESS THAN 8"; 'L-2' OR 'KT-2' JOINT IF PAVEMENT THICKNESS IS 8" OR GREATER.

G. References

Portland Cement Association. *Portland Cement Association Manual*.1992.

A. Jointing Urban Transition Areas

This section provides examples of how to joint transition areas, such as approaches, to intersections. Many times, approaches to intersections are wider than the street and thus require a transition section.

The importance of considering constructability when developing jointing layouts for transition areas cannot be overstated. As previously noted, lane delineation with jointing should not be the predominate factor in joint layouts, particularly in urban areas. Critical lane delineation can be handled with other methods, such as pavement markings and a raised island.

Therefore, adequate jointing should be governed by the function of the joint, proper load transfer, and constructability.

Two basic widening types (with and without medians) are shown in the following figures. There are:

1. Two-lane to Three-lane: (i.e. 31 foot to 41 foot)

- Quarter-point jointing
 - Concentric widening (Figure 5G-3.03)
 - One side widening (Figure 5G-3.04)
- Third-point jointing
 - Concentric widening (Figure 5G-3.05)
 - One side widening (Figure 5G-3.06)
- Gutterline jointing
 - Concentric widening (Figure 5G-3.07)
 - One side widening (Figure 5G-3.08)

2. Four-lane to Five-lane:

- Concentric widening (Figure 5G-3.09)
- Widening one side (Figure 5G-3.10)

Figure 5G-3.03: Quarter-Point Jointing - Concentric Widening (31 Foot to 41 Foot)

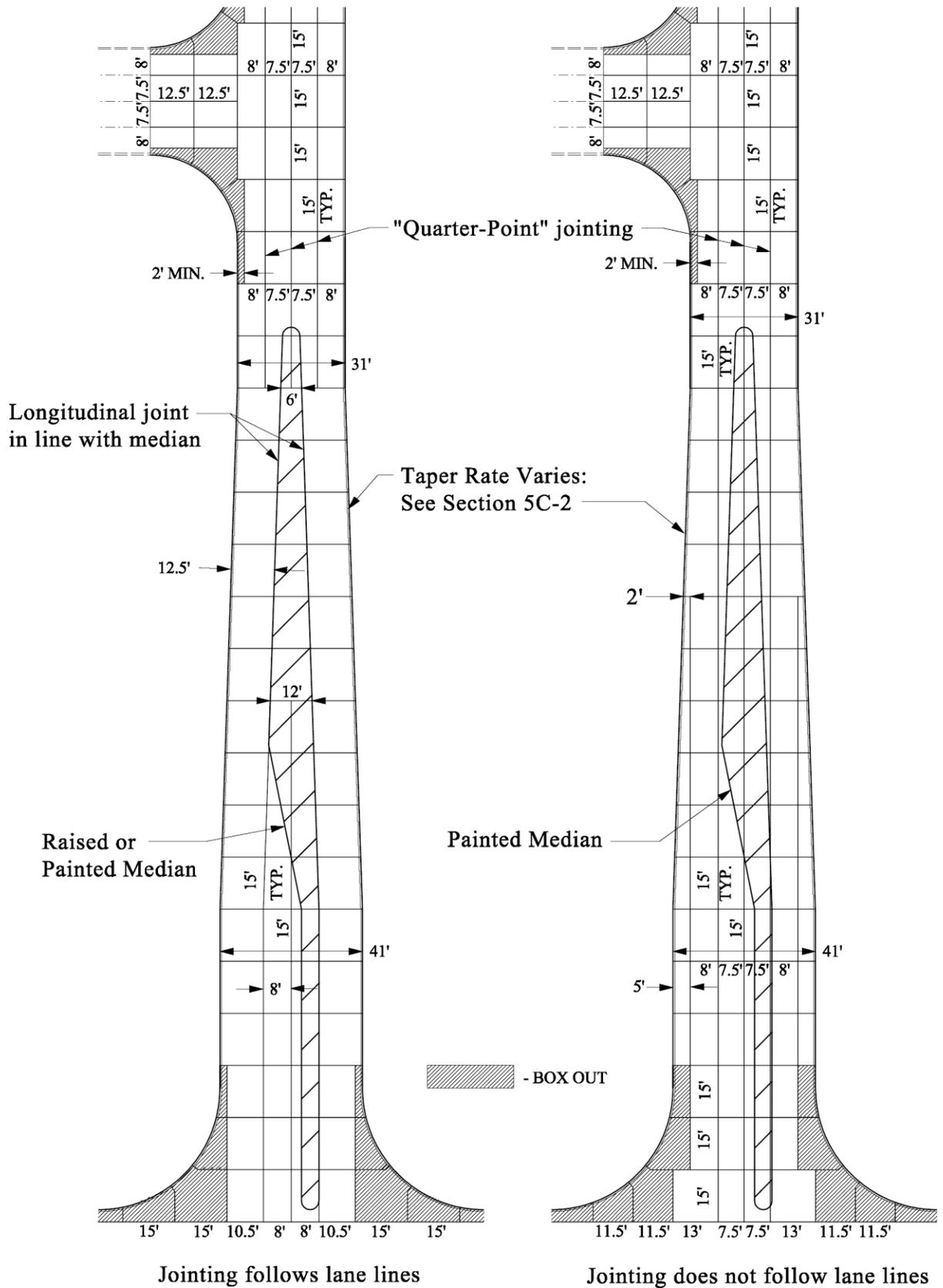


Figure 5G-3.05: Third-Point Jointing - Concentric Widening (31 Foot to 41 Foot)

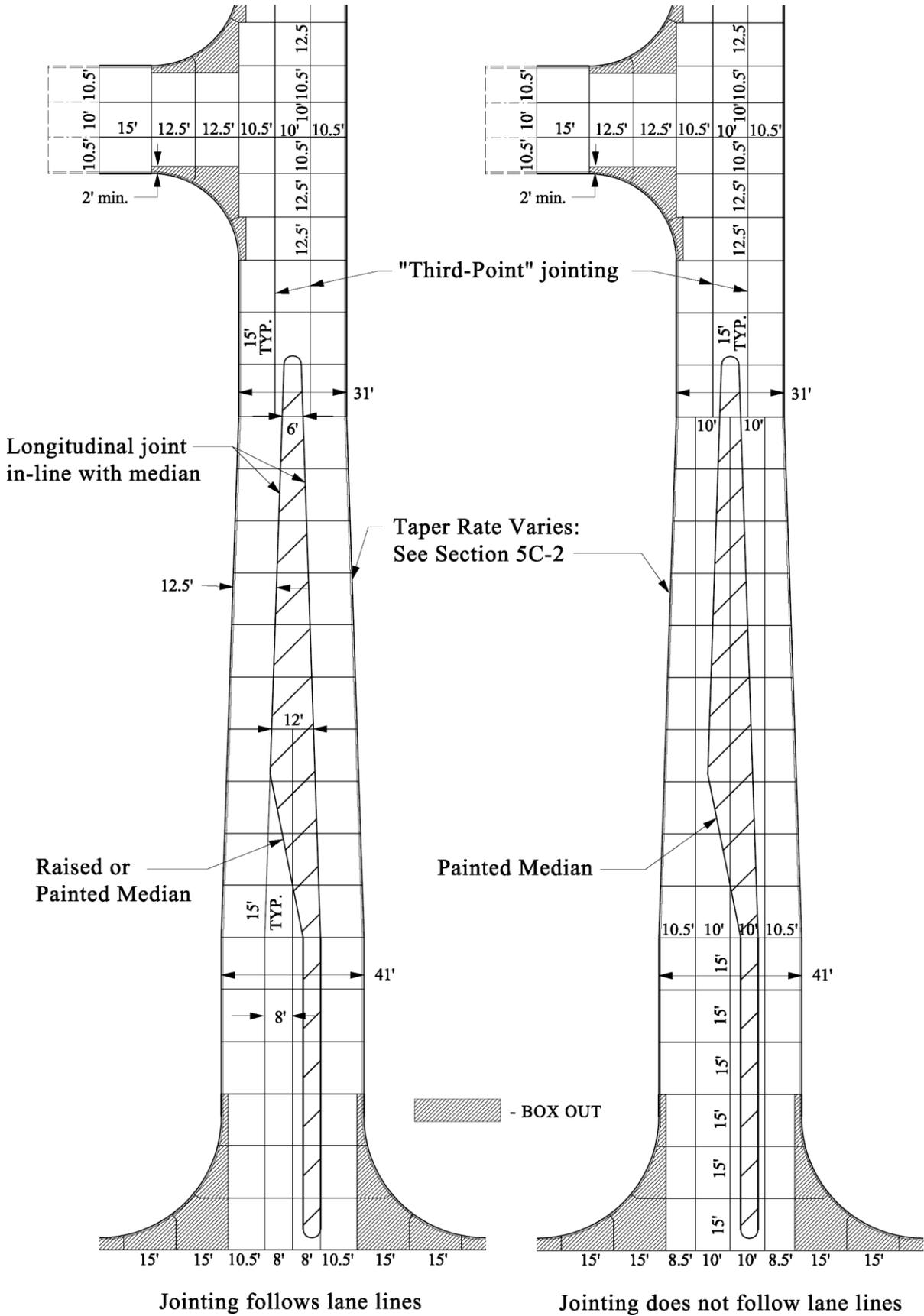


Figure 5G-3.06: Third-Point Jointing - Widening One Side (31 Foot to 41 Foot)

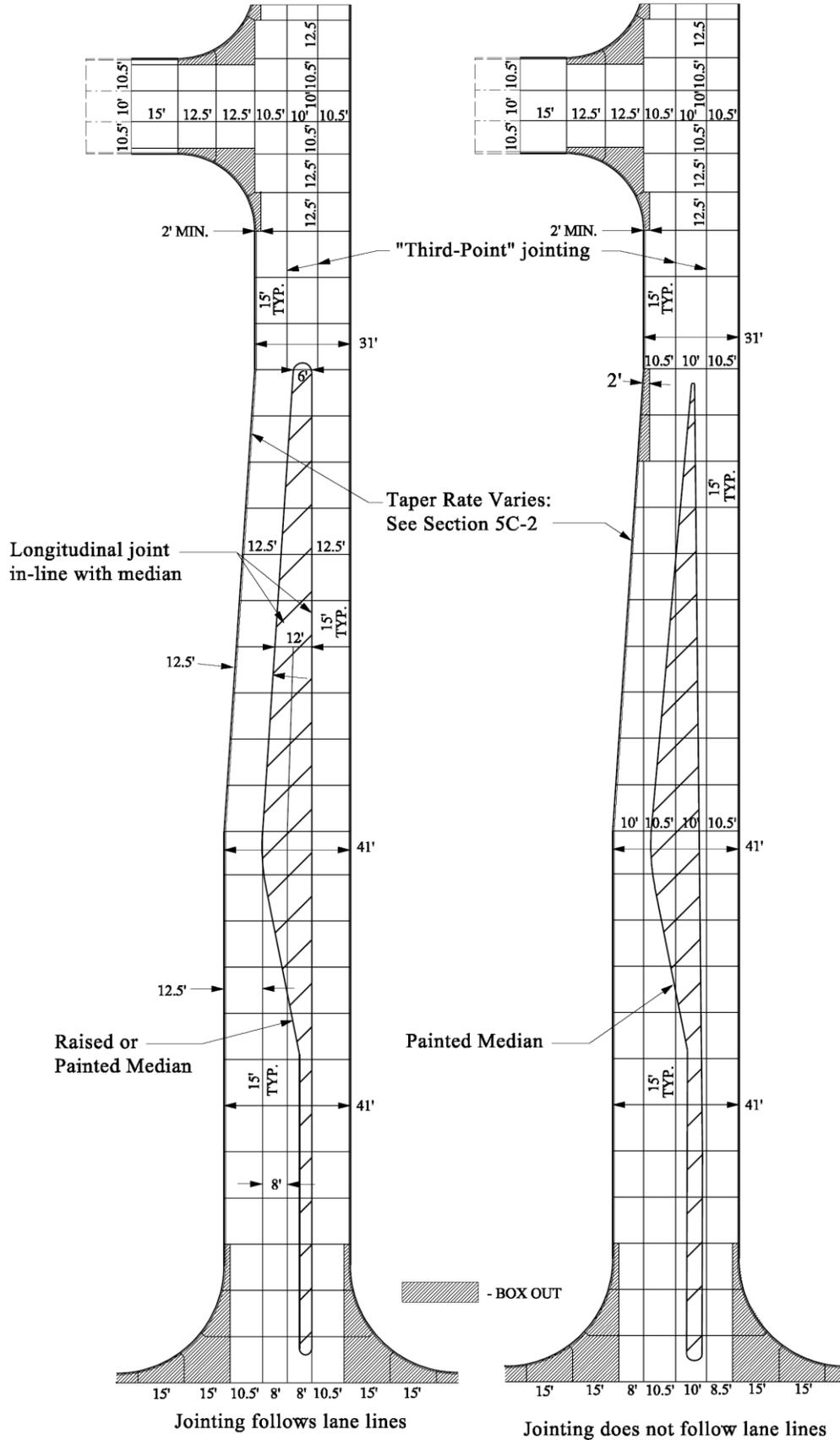


Figure 5G-3.07: Gutterline Jointing - Concentric Widening (31 Foot to 41 Foot)

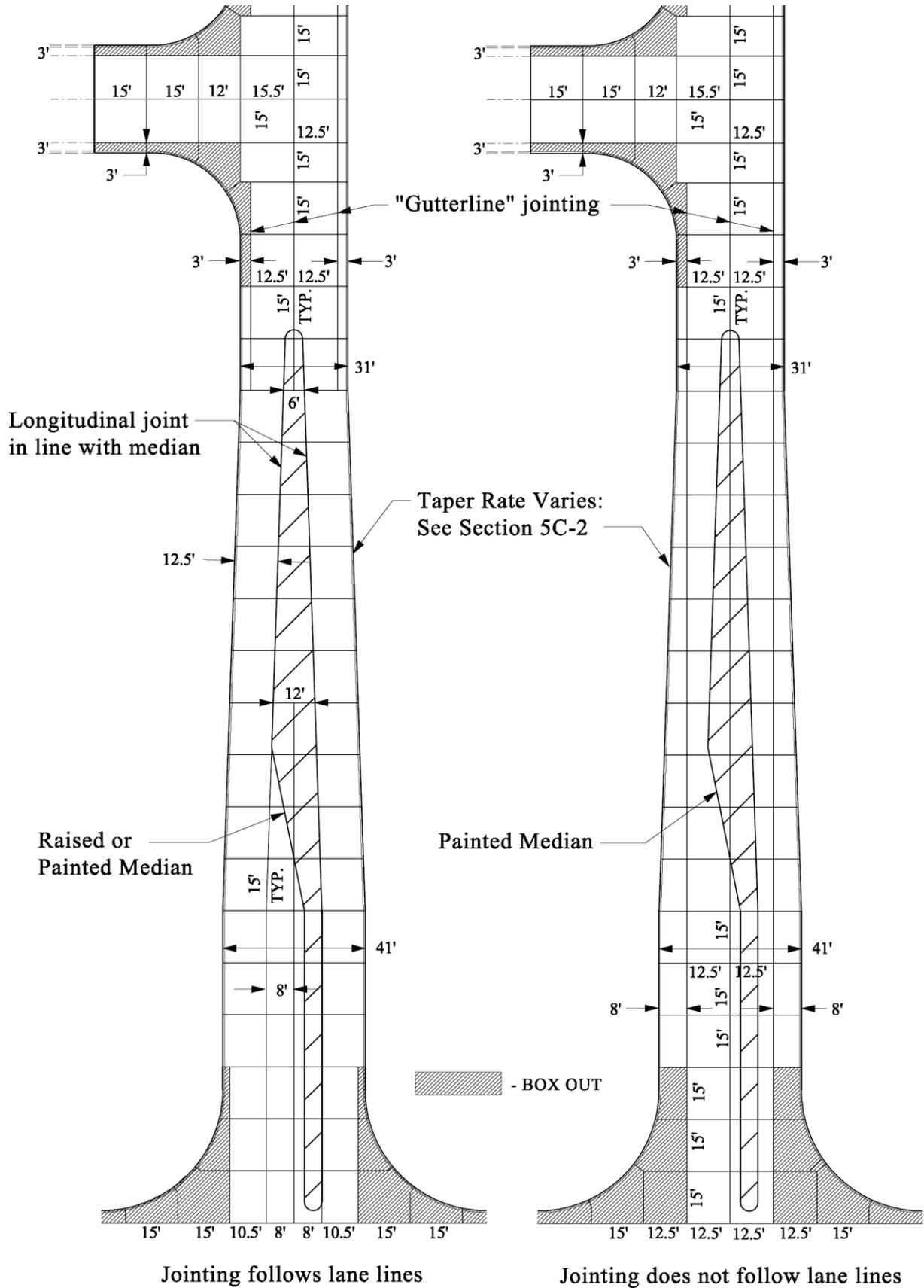


Figure 5G-3.08: Gutterline Jointing - Widening One Side (31 Foot to 41 Foot)

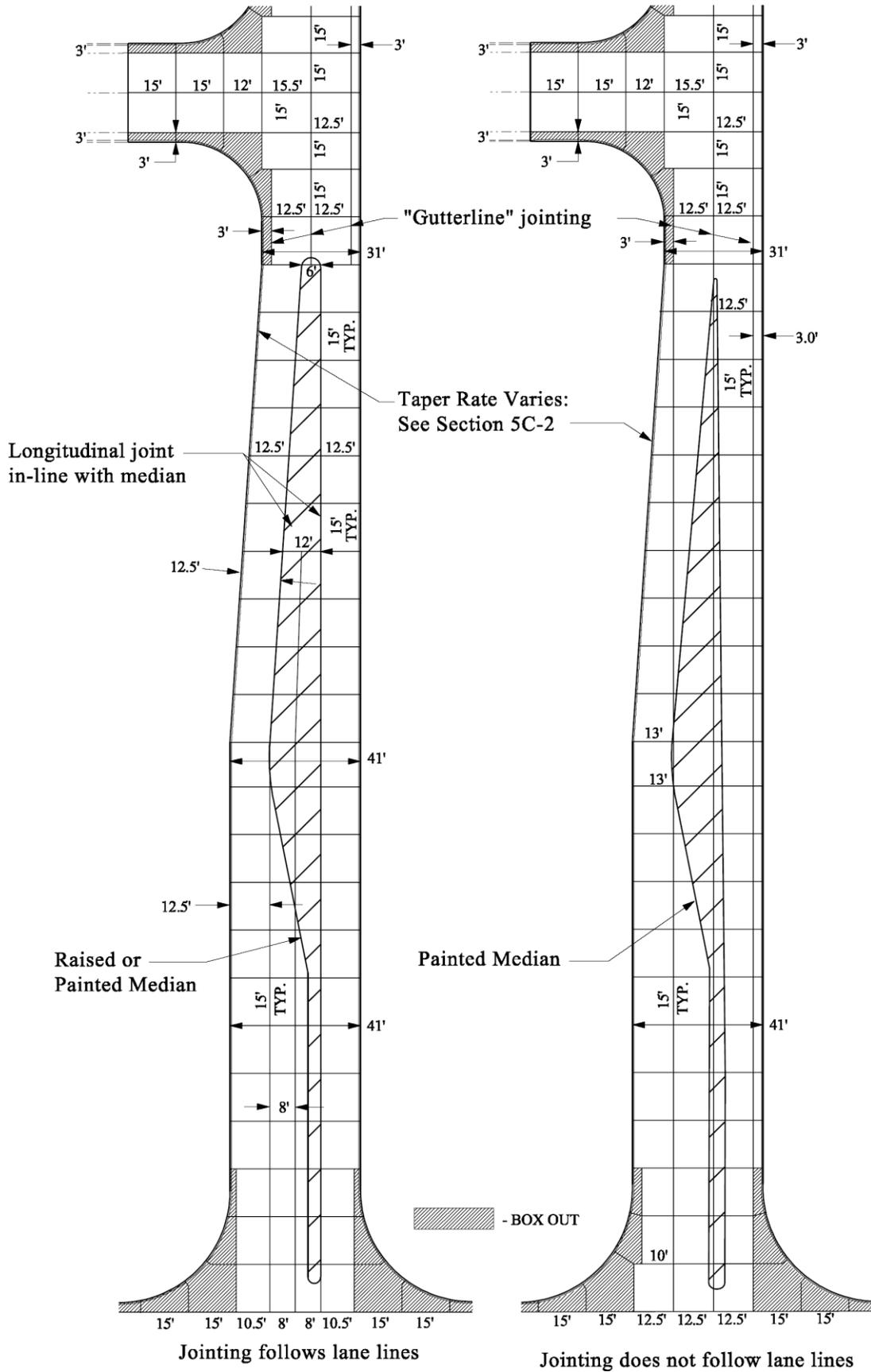


Figure 5G-3.09: Concentric Widening - Four Lane to Five Lane

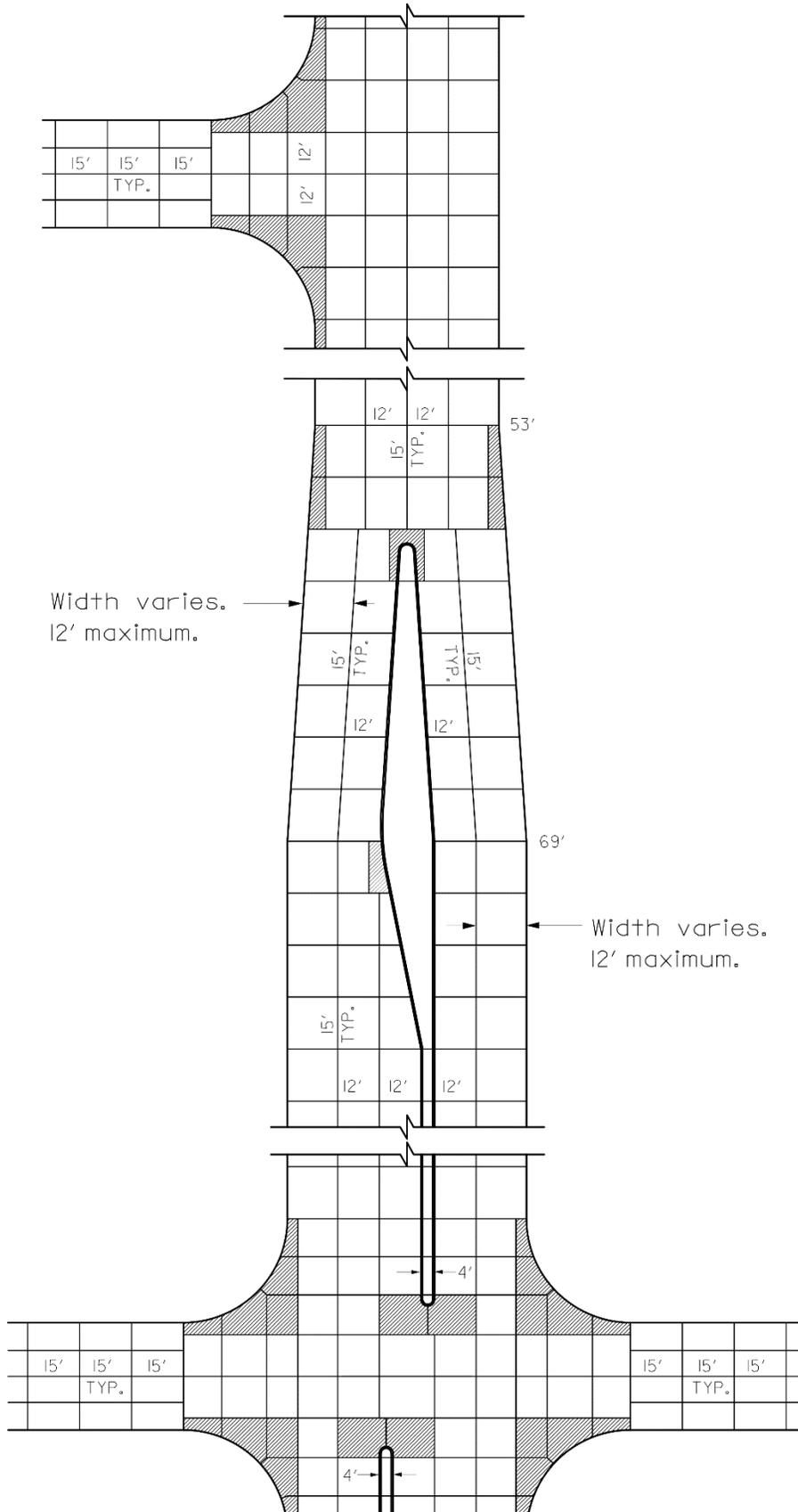
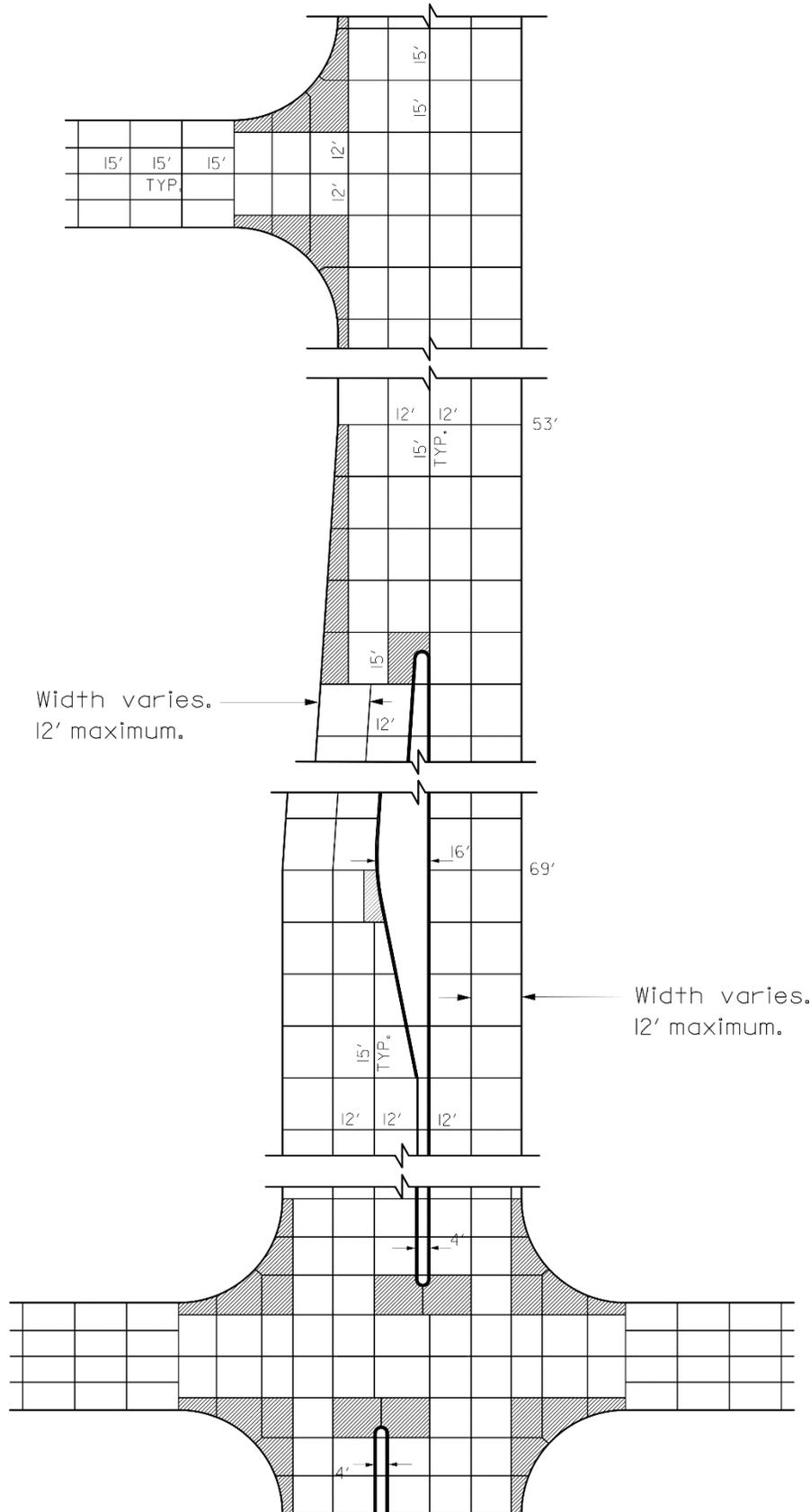


Figure 5G-3.10: Widening One Side - Four Lane to Five Lane



B. Jointing Cul-de-sacs

This section describes how to joint a cul-de-sac. The process is illustrated through an example of a street that is terminated with a cul-de-sac. Assume the pavement thickness is 7 inches.

Step 1: Locate Longitudinal Joints

The longitudinal joints running down the street should be extended into the cul-de-sac. The remaining longitudinal joints in the cul-de-sac should be placed roughly a lane width apart - somewhere in the range of 8 to 12 feet is acceptable.

A BT-1 or L-1 is an appropriate longitudinal joint, since the pavement thickness is less than 8 inches.

Step 2: Locate Transverse Joints

The next step is to place the transverse joints. The maximum spacing for transverse joints is 15 feet and the minimum spacing is 12 feet. Therefore, the joints within the cul-de-sac should be spaced within this range (see Figure 5G-3.11).

A C joint is the appropriate joint to use since the pavement thickness is less than 8 inches.

Step 3: Extend Joints Through the Free Edge of the Pavement

When extending the previously placed joints through the free edge of the pavement, the acute angle between the joint and the pavement edge (and between the joint and other joints) must be greater than or equal to 70 degrees. Also, all joints should be at least two feet long. Details A, B, and C in Figure 5G-3.12 illustrate how this can be accomplished.

- Detail A shows a transverse joint that is extended through the free edge of the pavement unaltered. These are acceptable because all angles between the transverse joint and the longitudinal joints and between the transverse joint and the free edge of the pavement are greater than 70 degrees.
- Detail B uses a dashed line to show the original position of a transverse joint whose angle, with the free edge of the pavement, is less than 70 degrees. This joint should be skewed to make it perpendicular to the free edge of the pavement, as shown by the solid line.
- Detail C illustrates a situation where skewing the joint to make it perpendicular to the free edge of the pavement would cause the angle between the joint and a longitudinal joint to be less than 70 degrees (shown by the dashed line). When this situation occurs, the joint is extended a minimum of two feet beyond the longitudinal joint, and then it is skewed to make it perpendicular to the free edge of the pavement. Both segments of the joint should be at least two feet long.

Step 4: Label Joints

The completed jointing layout for the cul-de-sac is shown in the figures that follow. The L-1 and BT-1 joints may be used interchangeably, at the contractor's discretion, depending on the paving sequence. Therefore, the designer may identify the longitudinal joints as either L-1 or BT-1 on the jointing layout.

Because the majority of the joints are either the C or the BT-1 or L-1, it is not necessary to identify every joint on the jointing layout. A note on the plan describing the transverse joints as C and longitudinal joints as L-1 or BT-1 except as noted otherwise is sufficient, provided that a few key joints on the diagram are identified. Whenever a series of joints changes to a different type of joint, the joint at the location of change is identified. Any joint that may be a source of confusion should also be labeled.

Joint lengths are also shown on the jointing layout, normally rounded to the nearest foot. Similar to labeling joint types, not every length needs to be indicated. However, any length that cannot be inferred from the diagram should be labeled.

Figure 5G-3.11: Placement of Longitudinal and Transverse Joints

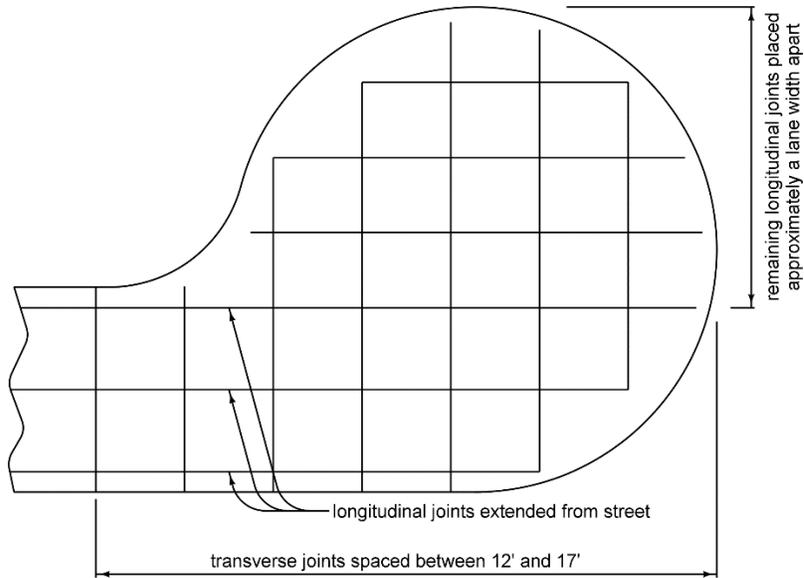
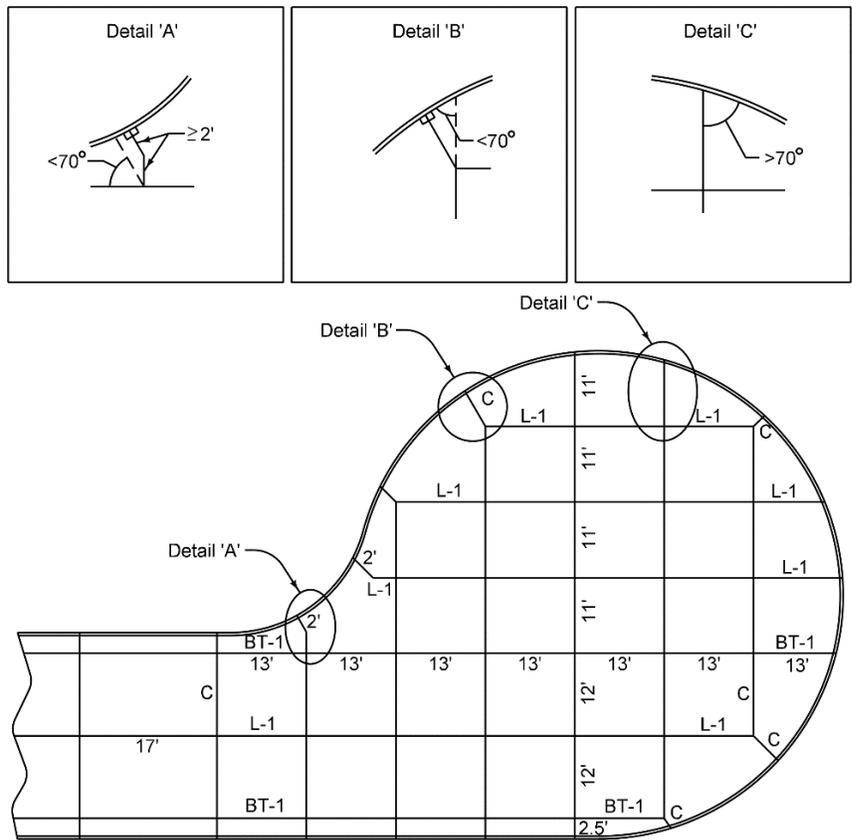


Figure 5G-3.12: Final Jointing Layout - Gutterline Jointing Examples



NOTE:
 1) All transverse joints will be 'C' unless indicated otherwise.
 2) All longitudinal joints will be either 'BT-1' or 'L-1' unless indicated otherwise.

The displacement of the rubbilized pieces into the subgrade should be minimized. A steel drum vibratory roller having a minimum gross weight of 10 tons is required to compact the rubbilized pavement.

In areas of soft subgrade, it may be necessary to remove the pavement and patch with 2 inch limestone chokestone. Geogrid may be used under the patch rock to add additional support.

A 2 inch to 3 inch rock interlayer of 3/4 inch roadstone may be placed on the rubbilized concrete and rolled prior to placing the asphalt overlay if surface variations remain after rolling. The use of the interlayer provides a more stable work platform and enhances the overlay's ability to stop reflective cracking.

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Railroad Crossings

A. Railroad Crossing Improvements

Improvements to railroad crossings can take several forms. These include closing of an existing crossing, improvements to the existing crossing, and separating the roadway from the railroad tracks. Potential improvements to existing crossings include installation of adequate signage, signals, and signals with gate arms.

The local jurisdiction must use judgment in the selection process for crossing improvements. Several factors weigh into the selection process including the amount and speed of traffic on the roadway and railroad, available sight distance, and safety benefits. Traffic control systems for railroad-highway grade crossings must comply with the Manual on Uniform Traffic Control Devices (MUTCD).

The Jurisdiction should contact the offices of Rail Transportation and Local Systems at the Iowa DOT for any agreements and requirements that must be followed.

B. Railroad Crossing Construction

When railroad crossings are required on streets subject to heavy loads, an approved high quality grade crossing material should be installed. Some railroads may require an asphalt separation between the header and the crossing to allow for easier railroad maintenance of the crossing. Some railroads may require that the crossing material be installed by their own forces, with the costs borne by or shared with the local jurisdiction. Example railroad crossing approaches are included in Figures 1 and 2. In all cases, the railroad should be contacted for their specific crossing requirements.

C. Working with a Railroad

Working with a railroad company requires coordination at numerous steps along the planning, design, and construction process. A list of potential coordination steps follows; however, these requirements differ for each company and should be verified early in the planning process.

Phase	Possible Coordination Required
Planning	Right of entry permit for survey Coordination regarding potential modifications/improvements
Design	Right of Entry Permit for Survey Utility Accommodation Permit Maintenance Consent Agreement Coordination regarding crossing material and safety elements
Construction	Railroad Protective Liability Insurance Right of Entry for Construction Railroad Flaggers

D. Railroad Related Agencies in Iowa

Two governmental agencies are involved in regulating railroad activities within the State of Iowa. Additional information about these organizations is available at their respective websites:

- [Iowa DOT, Rail Transportation](#)
- [Federal Railroad Administration](#)

E. Railroad Companies in Iowa

Currently there are 18 railroads operating within the State of Iowa. These include three Class I railroad companies, Amtrak, and several regional and local railroads. The Iowa DOT maintains a [website with links](#) to the websites of the freight railroads operating within the state.

F. Specifications

See [SUDAS Specifications Figure 7010.903](#) for PCC railroad crossing approach details and [Figure 7010.902](#) for asphalt railroad crossing approach.

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6G Subsurface Drainage Systems

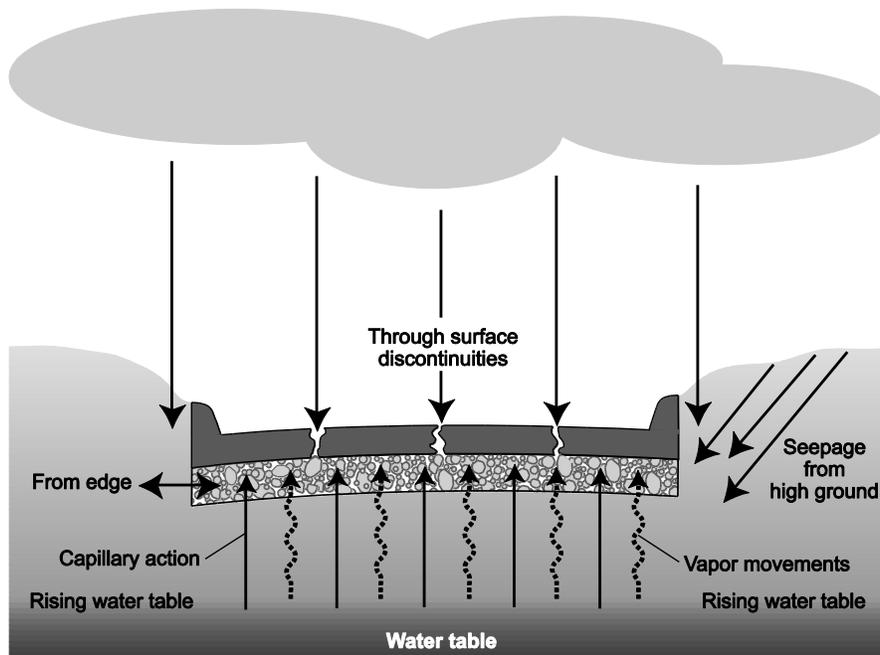
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B. Need for Subsurface Drainage

The damaging effects of excess moisture on pavement have long been recognized. Moisture from a variety of sources can enter a pavement structure. Figure 6G-1.02 shows that moisture in the subgrade and pavement structure can come from many different sources. Water may seep upward from a high ground water table, or it may flow laterally from the pavement edges. Knowledge of ground water and its movement are critical to the performance of pavement as well as the stability of adjacent sideslopes. Ground water can be particularly troublesome for pavements in low-lying areas. When pavements are constructed below the permanent or a seasonally high water table, drainage systems must perform or rapid pavement failure will occur. This moisture, when combined with traffic loads, voids in pavement sections, and freezing temperatures, can have a negative effect on both material properties and overall performance of a pavement system.

The most significant source of excess water in pavements is typically infiltration through the surface through joints, cracks, and other defects in the surface that provide an easy path for water. The problem only worsens with time. As pavements age and deteriorate, cracks become wider and more abundant and joints and edges deteriorate into channels through which water is free to flow. The result is more water being allowed into the pavement structure with increasing age, which leads to accelerated development of moisture-related distresses and pavement deterioration. Excess moisture in a pavement structure can adversely affect pavement performance. While a pavement structure can be stable at given moisture contents, the pavement structure may become unstable if the materials become saturated. High water pressures can develop under traffic loads. Water in the pavement structure can freeze and expand, developing high internal pressures on the pavement structure. Flowing water can carry soil particles and lead to clogging of drains and, in combination with traffic, lead to pumping of fines from the subbase or the subgrade.

Figure 6G-1.02: Sources of Moisture in Pavement Systems



Source: Based on FHWA-NHI 2004

C. Types of Drainage Systems

To avoid moisture-related problems, a major objective in pavement design should be to keep the subgrade, subbase, and pavement structure from becoming saturated or exposed to high moisture levels. Three approaches exist for controlling or reducing the problems caused by moisture:

1. Prevent moisture from entering the pavement system
2. Use materials and design features that are insensitive to the effects of moisture
3. Quickly remove moisture that enters the pavement system.

No single approach can completely negate the effects of moisture on the pavement system over a period of many years. It is practically impossible to effectively seal the pavement from water intrusion. While materials that resist moisture can be incorporated, this is often not cost effective and in many cases such materials are simply not available locally. Indeed, subgrades that are susceptible to moisture deterioration cannot easily or cost effectively be replaced. Thus, the need for drainage systems that can quickly and effectively remove water from the pavement system is necessary.

Positive drainage can be affected with three elements:

1. Subbase to provide rapid drainage of free water that may enter the pavement structure.
2. Longitudinal subdrain collector system to convey accumulated water from the subbase.
3. Filter-separator layer to prevent the migration of fines (minus 200 sieve material) into the subbase from the subgrade (see [SUDAS Specifications Figure 4040.231](#), Cases A and C).

Unrestricted flow to the subbase must be ensured. The filter-separator layer, whether aggregate or geotextile, must be properly designed to prevent migration of fines and possible base contamination. Since many existing pavements have been designed and constructed with impermeable subgrades, rapid lateral drainage from the base of these rehabilitated pavement sections is not feasible. Here, retrofit with longitudinal subdrains can affect drainage of water that has infiltrated the pavement structure and migrated to the slab/subgrade interface. Subdrains placed adjacent to the pavement can intercept this water and shorten the time it is present at the interface, thereby minimizing the potential degradation effects (see [SUDAS Specifications Figure 4040.231](#), Case B).

Generally, footing drains for adjacent structures may drain to a storm sewer system or a combination subdrain/footing drain collector. However, a combination subdrain/footing drain collector, as shown on [SUDAS Specifications Figure 4040.231](#), Cases D and E, may be installed to serve both purposes. See [Chapter 2 - Stormwater](#), for guidance on sizing of footing drain collectors; normally pipe sizes range from 8 to 12 inches in diameter.

D. Design

Design of subsurface pavement drainage systems consists of balancing permeability and stability and removing collected water rapidly. Important components consist of subbase material, a separating layer to prevent infiltration of subgrade materials into the subbase, and a collection and removal system. Design approaches for each of the components are summarized below.

- 1. Subbase:** For the design of subbases, see [Section 6F-1 - Pavement Subbase Design and Construction](#). One of the purposes of the subbase is to remove infiltration water. The subbase should consist of durable, crushed, angular aggregate with the best porosity so that it will release the maximum amount of water. However, the structural requirements for the overall pavement section must be met using appropriate pavement design practices. The subbase can be stabilized or unstabilized. Effective subbase design must address structural, hydraulic, material durability and quality, constructability, and maintenance requirements.

Hydraulic requirements must be addressed for specific project conditions; however, the time period that free water is present within the pavement structure should be minimized, preferably less than 2 hours following end of precipitation. To maintain positive flow through the base, the road section should be sloped as much as possible, with a minimum cross slope of 2%. The highest permeability materials are unstable under construction traffic; therefore, it is desirable to use a more stable material with a lower permeability, such as 150 to 350 feet per day (75 to 175 inches per hour).

FHWA (1992) guidelines indicate that the quality of crushed aggregates is the single most important factor for the stability of a subbase. Breakdown of the aggregate could cause both loss of support and a decrease in permeability. Los Angeles Abrasion Wear should not exceed 50%, and aggregate soundness loss should not exceed the requirements for a Class B aggregate as specified by AASHTO M 283 (i.e., 12% for sodium sulfate test or 18% for magnesium sulfate test).

To enable proper construction of subbases, several construction guidelines have been proposed (Christopher and McGuffey 1997). Unstabilized materials generally are used in thicknesses of 4 inches or more. Asphalt and cement stabilized materials can be built as thin as 2 inches, however, 4 inches is recommended as a minimum. Material gradations vary widely; see White et al. (2004) for a review.

Of the subbase materials included in [SUDAS Specifications Section 2010](#), only granular subbase and modified subbase will provide adequate permeability. Granular subbase provides the highest permeability, however it is generally unstable under construction traffic. Modified subbase provides both stability and good permeability.

- 2. Separator/Filter Layers:** There is usually a need for a separator/filter layer between the subbase and the subgrade. Filtration compatibility of the subbase must be evaluated with respect to both the subgrade and the subbase to prevent migration of the subgrade into the subbase.

Geotextiles are commonly used as separators/filters. The FHWA geosynthetics manual (Holtz et al. 1995) provides guidelines on design procedures. Care must be exercised in the amount of cover material over geotextiles as there is potential for damage from equipment. Normally, 6 inches is considered the minimum thickness when earthmoving equipment is used for placement.

Dense-graded (low permeability) subbase can be placed below the permeable subbase and provide adequate separation. Filter criteria need to be checked for impermeable subbase materials that will be adjacent to the permeable subbase.

3. Subdrains:

- a. **New Construction:** Subdrains for new construction generally consist of pipe in a trench lined with non-woven geotextile (engineering fabric) and filled with aggregate. Typical installation sections are shown in [SUDAS Specifications Figure 4040.231](#), Cases B, C, and E. Design of subdrains for new construction and major reconstruction projects consists of ensuring that the trench backfill and subdrain pipe have the capacity to handle the design flow from the subbase.

The size of pipe is often based on maintenance requirements for cleaning capabilities and reasonable distance between outlets. Although FHWA recommends a minimum pipe diameter of four inches, the SUDAS Specifications require a minimum of 6 inch diameter pipe for Type 1 subdrain installations and a minimum of eight inch diameter pipe for Type 2 combination subdrain/footing drain collectors. The larger diameter subdrain pipe allows for additional capacity, easier cleaning, and inspection. Cleanouts are required for all Type 2 subdrains, at the end of line or at 300 feet spacings. For exceptionally long Type 1 installations, greater than 300 feet from an outlet, consideration should be given to providing cleanouts as required for Type 2 subdrains.

Trench backfill aggregate could be the same as the subbase or a material with greater permeability. AASHTO No. 57 stone, [Iowa DOT Gradation No. 3](#) has been used for trench backfill. The [SUDAS Specifications Section 3010](#) requires porous backfill to comply with [Iowa DOT Gradation No. 29](#) or the use of commercially available pea gravel. The non-woven geotextile used to line the subdrain trench must be designed as a filter, considering both the subbase and subgrade soils. The geotextile should not be extended between the interface of the subbase and the trench backfill aggregate because it may form a barrier. Also, geotextile should not be wrapped around the perforated drainage pipe.

One of the most critical items for subdrains is the grade of the invert. Construction control of very flat grades usually is not possible, leaving ponding areas that result in subgrade weakening and premature failures. It may be necessary to raise the pavement grade to develop adequate drain slopes for the subsurface drainage facilities. To achieve a desirable drainage capacity, a minimum slope that is greater than the slope of the road may be required for the subdrain, although this is often not practical and the pipe will mostly be sloped the same as the roadway. When adequate slopes cannot be achieved, rigorous maintenance should be anticipated.

The outlet for the subdrain must be low and large enough so that flow from the subdrain does not back up. FHWA recommends that the outlet pipe be at least 6 inches above the 10-year storm flow line of the ditch or hydraulic structure into which the outlet is flowing.

The designed drain trench and backfill must be constructible with normal construction equipment. Construction of subdrains is time-consuming. Care must be taken so that the trench backfill does not become contaminated with adjacent soil that might clog the drainage capacity.

- b. **Retrofit Subdrains:** A majority of pavement distress problems are related to excess moisture in the pavement structure. Retrofit subdrains can be used in rehabilitation projects to remove water. The design of retrofit subdrains is substantially different than new construction. Subdrains should be just one of the methods to consider to correct water problems. The principles for the design of retrofit subdrains apply to both HMA and PCC pavements. For the design of retrofit subdrains, the designer is referred to the Concrete Pavement Preservation Guide, 2nd Edition (National Concrete Pavement Technology Center, September 2014) and the Material Subsurface Pavement Drainage Manual (Idaho Transportation Department, 2007).

- c. **Geocomposite Subdrains:** Prefabricated, geocomposite subdrains (PGEDs) have recently been in high use and have been found to be very effective in removing water, with drainage rates equal to or better than pipe drains. Although many states have found PGEDs to be cost effective for retrofit applications, problems of clogging and intrusion of fines and buckling during construction have somewhat limited their use. Design considerations for PGEDs are detailed in NCHRP Report 367 (Koerner et al. 1994).

E. Construction Issues

Construction decisions and actions can have a significant impact on the performance of the pavement section. The design and construction groups must consider (1) each phase of construction, including subgrade preparation, placement of separation/filtration layers, construction of drains, placement of subbase, and construction of the pavement section; and (2) how the decisions of one group will affect the actions and decisions of the other group.

In the design phase, the designer must be concerned with how construction details, sequencing of work, site accessibility, and protection of drainage components will integrate with both the methods and equipment that can be used for pavement and drainage facility construction. Design decisions such as location of collector pipes and outlets, temporary and permanent surface drainage, and aesthetic treatments will influence how construction can be conducted. Such decisions will affect the right-of-way required for construction of the drainage systems.

Sequencing is best left to the contractor unless there is a significant impact on the performance of the drainage system. An important construction related design consideration is pipe access at the upstream end of a segment so that inspection and maintenance flushing activities can take place.

One of the primary reasons for bringing construction personnel in at the design phase is to acquaint them with the impact of construction on design. Care exercised during construction of the designed section without compromising the effectiveness of the design is essential to the pavement's long-term performance. Key performance elements for construction personnel include the following (Christopher and McGuffey 1997).

- Good pavement starts with a good foundation. A stable platform is required for construction of the subbase.
 - Quality of aggregate and its ability to meet gradation requirements is essential for meeting expected design performance levels.
 - Awareness is needed concerning the fact that the introduction of fines into the subbase during construction could result in premature failure of the pavement.
 - Unstabilized base tends to displace under traffic loadings.
 - Too much compaction or fine grading can significantly reduce the expected permeability of the subbase.
1. **Subgrade Preparation:** The foundation/subgrade surfaces are required to be level, somewhat smooth, and constructed to required grades. On drainable pavement sections, constructing and maintaining required subsurface grades is essential to maintain positive drainage until the pavement is constructed. Local depressions resulting from soft areas or depressions from equipment trafficking can lead to ponding of water below the pavement structure and subsequent loss of foundation support.
 2. **Separator/Filter Layers:** For granular subbase separator/filter layers, the gradation of materials needs to be checked carefully against the design specifications. Materials that are more openly-graded than specified requirements may allow migration of fines through or from the subbase, which can contaminate the permeable layer. Good compaction of the separator/filter layer is

essential for placement of the subbase. The subbase should be observed for rutting during compaction and subsequent trafficking; surface rutting may be an indication of subgrade rutting, which requires immediate attention. Increasingly, geotextile separation/filter layers are being used. For these, material and certification should be checked against the design requirements to ensure that the proper materials have been received and are being used. In constructing geotextile separation or filter layer, a smooth subgrade surface is essential. Therefore, sharp rock protrusion and loose rocks should be removed to avoid damage to the geotextile.

3. **Subdrains:** Proper grade control is required for subdrains to be effective. Undulating lines are not acceptable because water will accumulate in depressed portions of the pipe. Good practice dictates that subdrains be properly connected to the subbase and the outlets. For maintenance purposes, outlet spacing is limited to 300 feet. Subdrains need to be properly connected to the permeable subbase and outlets. Outlets are required to be set at the proper grades, and ditch lines are graded according to drainage requirements. Subdrain lines should be carefully marked to avoid damage due to construction equipment. Therefore, subdrains can sometimes be constructed after pavement construction. In this case, temporary subdrains are required for the permeable subbase.
4. **Permeable Subbase Materials:** Unstabilized subbase material requires close control of material gradation and activities that might produce segregation of the material during placement.

Subbase materials are very susceptible to segregation during placement. Special care is needed to prevent fines from migrating into the material and clogging the system. The addition of 2% to 3% water by weight reduces the potential for segregation during hauling and placement.

Excessive compaction with heavy vibratory compactors is not recommended on subbases because of the potential for damage and reduced permeability. Adequate compaction may be achieved with lightweight vibratory compactors or smooth drum rollers because of the relatively narrow gradation range of subbase.

Care is required to protect the subbase from contamination from dirty equipment, adjacent backfilling operations, or erosion sediment. The subbase should not be allowed to be used as a haul road. Good practice dictates that traffic be minimized and restricted to low speeds with minimal turning. No equipment should be allowed on the permeable materials until the complete drainage of the base and subbase has been confirmed.

F. Maintenance

Maintenance of pavement subsurface drainage systems has been identified as essential to the long-term success of drainage systems and, subsequently, pavements. The most effective maintenance programs use a five-phase approach:

- Routine inspection and monitoring
- Routine preventive maintenance
- Spot detection of problems (occurrences)
- Repair
- Continued monitoring and feedback

Budget constraints have resulted in usually only two phases being conducted: spot detection and repair. Studies show that inspection in conjunction with preventative maintenance can be very cost effective with \$3 to \$4 return in benefits for every \$1 invested (Christopher and McGuffey 1997).

- 1. Inspection and Monitoring:** The inspection phase of maintenance provides important data on the effectiveness of drainage elements and the need for further maintenance. Inspection practices include visual inspection and effectiveness testing. Visual inspection consists of inventorying outflow during storm events and assessing outlet condition. Outflow inventories are generally qualitative (e.g., high, moderate, low, or no flow). Visual inspection can be enhanced through the use of video cameras. Effectiveness testing can provide a more quantitative assessment of performance through the use of post-storm event monitoring with bucket sampling or direct upstream inflow coupled with downstream outflow measurements.
- 2. Preventative Maintenance:** Preventative maintenance actions that promote good subsurface drainage system performance include: clean and seal joints and cracks, clean and verify the grade of outlet ditches, clean catch basins and other discharge points, and clean outlet screens and area around headwalls. Based on the results of the outlet inspection program, a routine outlet cleaning program should be implemented.
- 3. Repair:** It is generally accepted that once pavement damage from blocked subsurface drainage is visible, the damage is irreversible, and that pavement life has been shortened. For this reason, any problems observed, no matter how minor in appearance, should be addressed immediately to confine the problems to a localized area.
- 4. Continuous Monitoring and Feedback:** Monitoring is a continuous improvement process and improvements are achieved only through providing feedback to the design and construction groups. Thus maintenance should provide inspection results long with performance indicators to design and construction groups for review. Pavement management methodologies and maintenance strategies are reviewed in NCHRP Syntheses 222 and 223 (Zimmerman and ERES Consultants 1995 and Geoffroy 1996).

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Level Spreaders



Source: Umstead Coalition, 2005

<u>BENEFITS</u>			
	L	M	H
Flow Control	██████████		
Erosion Control	□	□	□
Sediment Control	□	□	□
Runoff Reduction	□	□	□
Flow Diversion	██████████		□

Description: A level spreader is a low-cost method to convert small volumes of concentrated runoff into sheet flow and release it onto an area stabilized by existing vegetation.

Typical Uses: Level spreaders are commonly used at the outlet of a diversion structure or sediment removal structure to convert concentrated flow to uniform sheet flow prior to releasing the runoff onto stabilized downstream slopes. Level spreaders are also used to convey runoff from impervious surfaces, such as parking lots, onto vegetated areas or into detention basins.

Advantages:

- Widely used BMP due to ease of installation and availability of materials.
- Low cost and simple to construct.

Limitations:

- Flows from a level spreader should be limited to clean, diverted runoff, or runoff that has been passed through a sediment removal structure.
- The downstream slope must have existing vegetation and be capable of accepting sheet flow without incurring erosion.
- May require adjustment after freeze-thaw cycle due to heaving.

Longevity: One year

SUDAS Specifications: Refer to [Section 9040.2.09](#), [3.12](#), and [Figure 9040.109](#).

A. Description/Uses

A level spreader is a device used at the outlets of dikes and berms to convert the concentrated flows to sheet flow prior to discharging the flow onto a vegetated area downstream of the disturbed site.

A level spreader normally consists of a shallow excavation that serves as a stilling basin to allow runoff to pond up and dissipate its kinetic energy. An overflow weir is constructed to release the accumulated runoff. This weir is normally constructed from a 2 by 8 inch pressure-treated wooden timber placed at 0% grade to ensure uniform flow over the weir. For low flow applications, an earthen weir may also be constructed; however, special attention must be paid to ensure that the weir is level. If low points exist, concentrated flows will result and these could cause damage to the weir and the downstream slope.

B. Design Considerations

The grade of the last 20 feet of the diversion structure channel should be 1% or less to slow the velocity of the flow prior to draining into the depression. This will help reduce turbulence and erosion within the depression.

It is imperative that the receiving area downstream of the weir be stabilized sufficiently to receive the flows from the spreader without causing erosion. The receiving area must also be smooth to preserve the sheet flow and prevent the flow from concentrating. The slope of the receiving area should be less than 10%.

For level spreaders constructed from earthen embankments, a layer of erosion control matting should be placed on either side of the weir to provide additional stability to the surface.

C. Application

The length of the weir and depth of the depression required behind the weir are dependent on the anticipated flows over the weir. Select the length and depth of the spreader from Table 7E-9.01 based upon the 10 year peak flow.

Table 7E-9.01: Level Spreader Properties

Flow (cfs)	Min. Depth (feet)	Min. Length (feet)	Material
0-4	0.5	10	Stabilized Earth
5-10	0.5	10	2" x 8" Timber
10-20	0.6	20	2" x 8" Timber
20-30	0.7	30	2" x 8" Timber
30-40	0.8	40	2" x 8" Timber

D. Maintenance

The downstream slope should be inspected for signs of rilling. If rilling occurs, the length of the spreader may need to be increased, or additional stabilizing practices may need to be employed on the slope. If silt accumulates within the depression, it should be cleaned out when it loses one-third of its volume.

After a freeze-thaw cycle, the level spreader should be inspected to ensure that heaving has not occurred. Any displacement should be corrected to ensure that it is completely level.

E. Time of Year

Level spreaders will function on a year-round basis.

F. Regional Location

For soils that are highly sensitive to erosion, even when fully vegetated, the length of the spreader may need to be increased beyond that shown in the table.

Rip Rap



Source: Mississippi State University

<u>BENEFITS</u>	
	L M H
Flow Control	██████████
Erosion Control	██████████
Sediment Control	□ □ □
Runoff Reduction	□ □ □
Flow Diversion	□ □ □

Description: Rip rap is a common method of protecting a channel downstream of a storm sewer or culvert outlet from erosion. A layer of crushed stone placed on the bottom and sides of the channel protects the channel and dissipates the energy of the high velocity flow.

Typical Uses: Used at the outlet of storm sewer pipes, roadway and driveway culverts, and at any point concentrated runoff enters a channel.

Advantages:

- Widely used method of erosion protection.
- Materials are readily available in most areas.
- Effective at reducing scour when properly designed and installed.

Limitations:

- Commonly undersized.
- Not aesthetically pleasing.
- May not be adequate for flows from large pipes (>48 inches).
- May be higher cost due to limited availability of stone.

Longevity: Temporary or permanent

SUDAS Specifications: Refer to [Section 9040.2.10](#), [3.13](#), [Figure 9040.110](#), and [Figure 9040.111](#).

A. Description/Uses

The most common method of protecting a channel at an outlet is to place a layer of crushed stone along the bottom and sides of the channel. The purpose of the stone is to protect the channel until the outlet flow loses sufficient velocity and energy, so that erosion will not occur in the downstream channel. Rip rap is provided by constructing a blanket of crushed stone, to a specified depth at the outlet. The layer of the stone is constructed so that the top is flush with the invert elevation of the outlet pipe. The stone should be placed on a layer of engineering fabric to protect the underlying soil from the erosive action of the churning water.

For larger pipes, or for discharges from pipes with large head pressures, greater protection may be required. Additional protection can be provided by constructing a rock-lined plunge pool, stilling basin, or through the use of concrete energy dissipaters (see [Chapter 2 - Stormwater](#)).

B. Design Considerations

The following design information only applies to the design of rock protection at outlets. It does not apply to rock lining of channels or streams. In addition, the design of rock plunge pools or stilling basins, and other types of energy dissipaters is not covered in this section. Refer to the Federal Highway Administration Hydraulic Engineering Circular No. 14 (HEC-14), "Hydraulic Design of Energy Dissipaters for Culverts and Channels" for information on designing these structures.

The Iowa DOT Culvert Program (version 2.0) includes three methods of designing rock protection at the outlet of culverts. The methods include HEC-14 rip rap basins, U.S. Army Corps of Engineers scour hole design and U.S. Bureau of Reclamation plunge basin design. This program is available online and can be obtained from the Iowa DOT's Bridges and Structures Bureau.

The steps below describe the method of designing rip rap:

- 1. Tailwater Depth:** The first step is to find the tailwater depth at the pipe outlet, corresponding to the appropriate design-year storm event for the outlet structure (see [Chapter 2 - Stormwater](#) for design criteria for various structures). Normally, the tailwater depth is found by determining the normal depth in the channel using Manning's equation (see [Chapter 2 - Stormwater](#)). If downstream restrictions such as a culvert, dam or channel constriction exist, a more thorough analysis is required.

If the tailwater is less than half of the discharge flow depth (pipe diameter or box height if flowing full) it is classified as a *minimum tailwater condition*. If the tailwater is greater than or equal to half of the discharge flow depth, it is classified as a *maximum tailwater condition*. The tailwater condition will determine which figure (Figure 7E-10.01 or 7E-10.02) to use to find the necessary rock size and apron dimensions.

Pipes that outlet onto flat areas without a well-defined channel can be assumed to have a minimum tailwater condition.

If the tailwater condition cannot be easily determined for a channel, the apron should be designed for the maximum tailwater condition as a conservative approach.

- 2. Stone Size:** As the discharge flows over the crushed stone, the flow imposes shear stresses on the individual stones. Since the stones are only held in place by the force of gravity, they must have sufficient mass to prevent them from being dislodged by the force of the flowing water. For rip rap design, the crushed stone material is selected based upon its average, or d_{50} , diameter. The d_{50}

diameter represents the size at which half of the individual stones (by weight) are smaller than the specified diameter.

The d_{50} diameter is determined with Figure 7E-10.01 or 7E-10.02, for the appropriate tailwater condition. This value represents the minimum average diameter of stone necessary to resist the anticipated flows.

- a. **Pipes Flowing Full:** The appropriate figure is entered along the x-axis at the design discharge. A vertical line is projected to the curve for the appropriate pipe diameter in the lower set of curves. From this point, a horizontal projection is made to the right, and the minimum d_{50} diameter is read.
- b. **Partially Full Pipes and Box Culverts:** Using the depth of flow and velocity at the outlet, the intersection of d and v in the lower portion of the appropriate figure is found. From this point, a horizontal projection is made to the right, and the minimum d_{50} diameter is read.

Most crushed stone used for outlet protection is specified by weight, not by diameter. The following table lists the standard SUDAS and Iowa DOT revetment and erosion stone weights and corresponding d_{50} diameters. These gradations are also shown on Figures 7E-10.01 and 7E-10.02. Alternative gradations may be selected and specified if available from local aggregate suppliers.

Table 7E-10.01: Standard Revetment and Erosion Stone Properties

Standard Classification	d_{50} Weight (lbs)	Average d_{50} Diameter ¹ (feet)	Maximum Weight (lbs)	Avg. max. Diameter ¹ (feet)
Class A Revetment Stone	125 ²	1.1 ²	400	1.7
Class B Revetment Stone	275	1.5	650	2.0
Class D & E Revetment Stone	90	1.0	250	1.4
Erosion Stone	---	0.5	---	0.75

¹ Diameters based upon an assumed specific gravity of 2.65.

² Approximate values for design purposes. Actual d_{50} value is not specified. ($d_{75} = 75$ lbs).

3. **Apron Length:** A sufficient length of protection must be provided in order to reduce the velocity and energy of the flow to the level anticipated in the downstream channel. This length is dependent on the volume and velocity of the flow at the discharge point. It is also dependent on the tailwater condition of the downstream channel. The length, L_a , is found from Figure 7E-10.01 or 7E-10.02 for the appropriate tailwater condition.

From the intersection of discharge and pipe diameter, or for velocity and flow depth found in the previous step, a vertical line is projected to the appropriate discharge depth/pipe diameter in the upper set of curves. From this intersection, a horizontal line is projected to the left to determine the minimum length of rock protection required.

4. **Apron Width:** For pipes that discharge into a well-defined channel, the width of the apron should extend to the top of the bank, or at least 1 foot above the maximum tailwater depth, whichever is less, along the entire length of the apron.

For outlets that discharge onto flat areas, the width of the apron at the upstream end of the culvert should be three times the diameter of the pipe, or equal to the width of the concrete pipe apron if one is provided. The width of the apron at the downstream end should be equal to the length of the apron, L_a , plus the diameter of the pipe, D .

5. **Apron Depth:** The depth of the apron should be equal to one and one-half times the maximum stone diameter (see Table 7E-10.01 for maximum diameter).

The channel downstream of the rock apron must be analyzed to ensure that existing or proposed channel liner is sufficient and that it will not be eroded under the anticipated flow depths. Methods for analyzing channel liners can be found in [Section 7E-23](#).

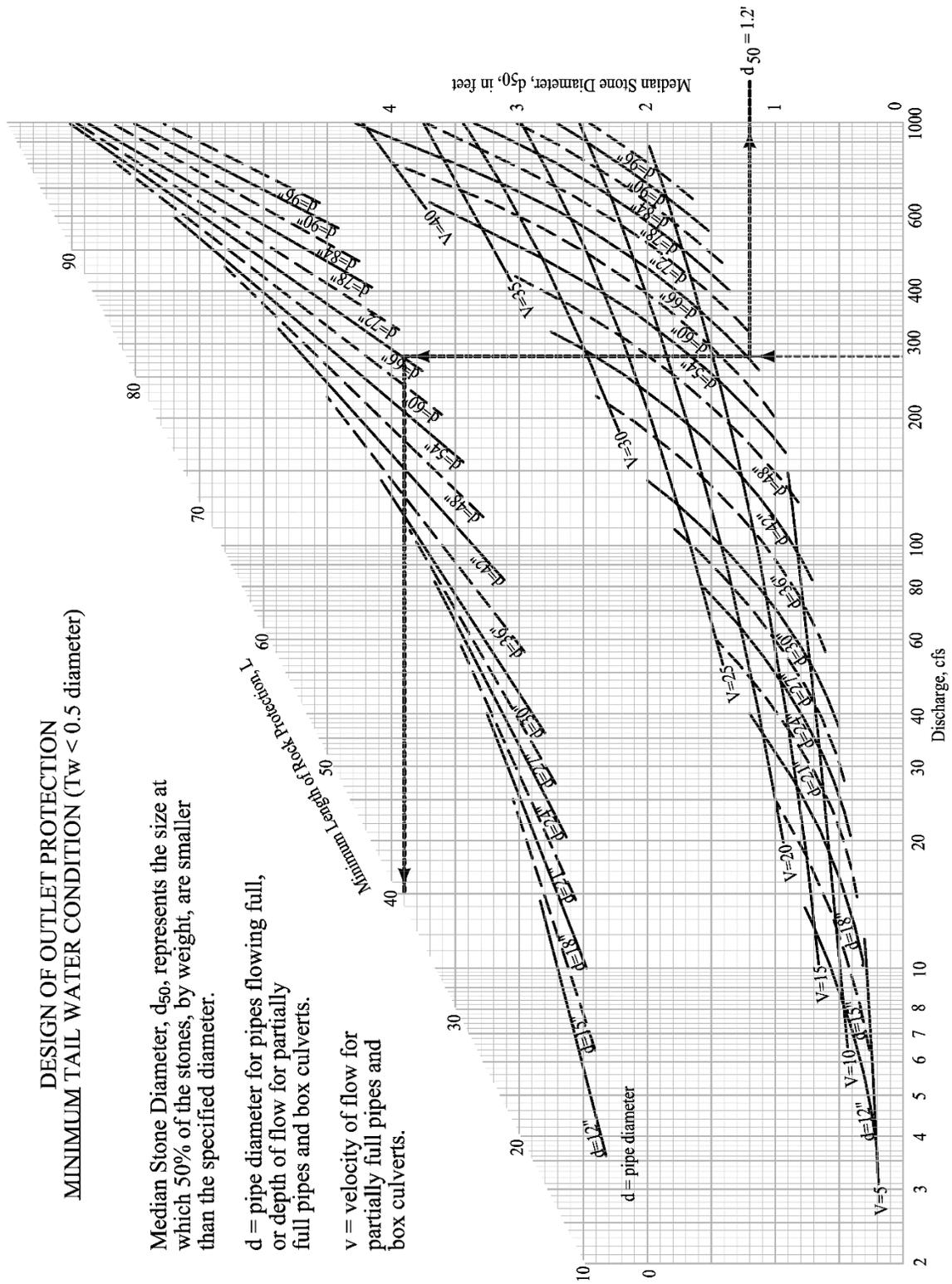
C. Application

Outlet protection should be considered at all pipe and culvert outlets. Rip rap is an easily constructed method of protection and is sufficient for many situations.

D. Maintenance

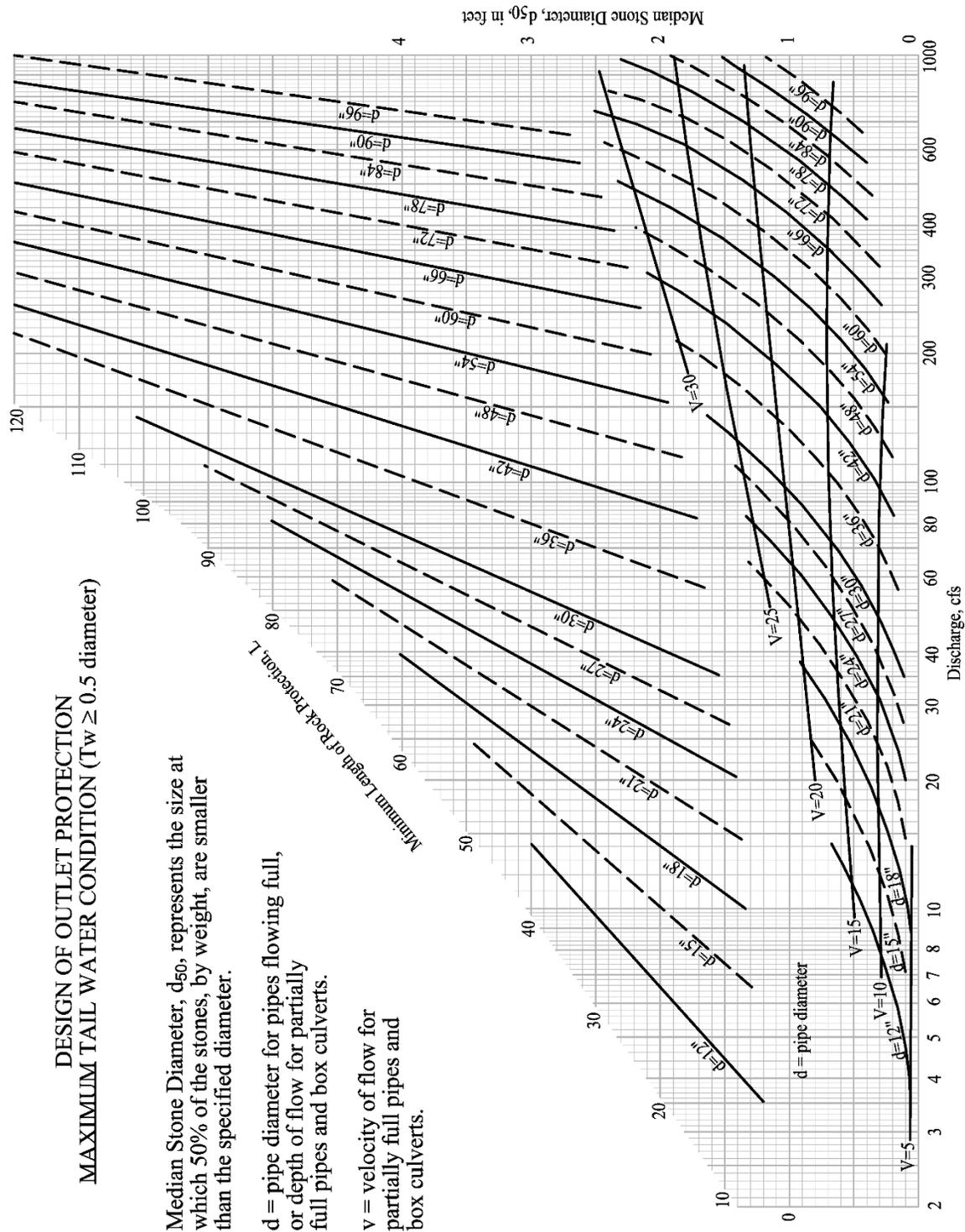
After installation, rock aprons should be inspected regularly. Special attention should be paid to the end of the apron, as it transitions to a natural channel. If scour or erosion is occurring at this junction, the apron should be extended, and additional stabilization methods may be required.

Figure 7E-10.01: Design of Outlet Protection, Minimum Tailwater Condition



Source: USDA NRCS, 2004

Figure 7E-10.02: Design of Outlet Protection, Maximum Tailwater Condition



Source: USDA NRCS, 2004

Temporary Pipe Slope Drains



Source: Mississippi State University

<u>BENEFITS</u>			
	L	M	H
Flow Control	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Erosion Control	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sediment Control	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Runoff Reduction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Flow Diversion	[REDACTED]		

Description: Temporary slope drains consist of a pipe or tubing, installed from the top to the bottom of a disturbed slope. The drain transports concentrated runoff down the slope to a stabilized outlet, reducing the potential for erosion caused by runoff flowing over the disturbed slope.

Typical Uses: Used to transport concentrated runoff collected by a diversion structure, down a slope to a stable outlet or channel.

Advantages:

- Highly effective method for transporting runoff down a disturbed slope with minimal erosion.
- Easily constructed.
- Materials may be reused.

Limitations:

- Area around drain inlet must be carefully constructed to prevent water from flowing along the pipe, and breaching the diversion.
- The drain outlet must be discharged to a stable area, or outlet protection must be provided.

Longevity: Temporary, until vegetation is established

SUDAS Specifications: Refer to [Section 9040, 2.11, 3.14](#), and [Figure 9040.112](#).

A. Description/Uses

Temporary slope drains are constructed of flexible pipe or tubing, running from the top to the bottom of a disturbed slope. Slope drains provide a means of transporting collected runoff from the top of the slope to the bottom of the slope and prevent the erosive potential created by concentrated runoff flowing over the face of a disturbed slope.

Slope drains are commonly used in conjunction with diversion structures. A diversion structure at the top of the slope collects upland runoff and transports it to the desired outlet point. The slope drain provides an outlet for the diversion structure, safely carrying the collected runoff down the slope.

After grading, slopes are highly susceptible to erosion caused by sheet and concentrated flows from upland areas. Stabilizing the slope by seeding can be difficult as runoff over the slope may wash away seed and seedlings. Slope drains are used as a temporary measure to transport runoff down a slope, until the slope can be permanently stabilized. Eliminating flows over the face of a slope reduces erosion and provides newly planted seed an opportunity to establish itself without being washed away.

B. Design Considerations

Temporary slope drains should be sized to carry a two-year storm event. Table 7E-11.01 provides a summary of recommended pipe diameters based upon the contributing drainage area.

Table 7E-11.01: Slope Drain Diameters by Drainage Area

Maximum Drainage Area (acre)	Minimum Pipe Diameter (inches)
0.5	8
1.0	10
1.5	12
2.5	15
4	18
5	21
> 5	Special Design Required

Note: Values assumed a 2 year storm, 15 minute T_c , and a runoff coefficient of 0.5

Slope drains are normally installed in conjunction with diversion structures. The diversion structure should have a height or depth at the pipe inlet of at least 18 inches, or 6 inches greater than the pipe diameter, whichever is larger. The soil under and around the inlet of the pipe should have a low permeability, and be carefully compacted to ensure that seepage does not occur along the pipe-soil interface. The area around the inlet should be graded to ensure that flows are directed toward the pipe inlet.

The slope drain should have a minimum grade of 3%. A metal or flexible apron should be provided at the inlet of the pipe. If the area draining to the diversion and slope drain is disturbed, the slope drain should outlet to a sediment trap or sediment basin. If the upland area is undisturbed, the pipe outlet should bypass any sediment basins or traps, and drain to a stabilized area.

Unless the pipe drains to a stable outlet, protection such as rip rap or a rolled erosion control product may be required at the outlet.

C. Application

Slope drains should be considered whenever a diversion structure is constructed on a disturbed slope steeper than 3%. When properly incorporated, diversion structures with slope drains provide a method to separate runoff from disturbed and stabilized areas, reducing the size requirements for sediment basins or traps.

D. Maintenance

The slope drain should be inspected for signs of leaking joints, pipe movement, erosion at the inlet and outlet, and seepage through the berm at the inlet.

E. Design Example

Assume the runoff from 7.5 acres of bare ground is intercepted by a diversion structure and carried to the location of a proposed slope drain. Determine the required diameter of the slope drain.

Using the techniques described in [Chapter 2 - Stormwater](#), the following information is determined:

Time of Concentration, $T_c = 15$ minutes

Rainfall Intensity, $I = 3.48$ (Region 7)

Runoff Coefficient for bare ground, $C = 0.5$.

Using this information, the peak runoff is found to be 13.1 cfs by the Rational Method.

The minimum pipe diameter is found with the orifice equation (assume head to top of pipe).

$$Q = (0.6)(A)\sqrt{2gh}$$

Where:

- Q = Runoff volume, cfs
- A = Area of pipe opening
- g = Acceleration of gravity, 32.2 ft/s²
- h = Head pressure (h=D/2 for head to top of pipe)

$$13.1 = (0.6) \left(\frac{\pi \times D^2}{4} \right) \sqrt{2 \times 32.2 \times \frac{D}{2}}, \text{ Solving for } D \text{ yields a diameter of } 1.9' \text{ or } 23 \text{ inches.}$$

Conclusion: Based upon the analysis, a 24 inch diameter pipe would be selected.

- 3. Soil Stabilizers and Dust Suppressants:** These are chemicals applied on or mixed into the soil surface that maintain the moisture levels in exposed soils, or chemically bind the surface material to reduce fugitive dust emissions from the site. These products include:
- a. Calcium Chloride:** Maintains water levels in the surface layer by absorbing humidity out of the air. May be applied by mechanical spreader as loose, dry granules or flakes, or as a liquid solution. Generally requires one or two treatments per season. Calcium chloride treated soils can inhibit the growth of vegetation and runoff from these areas can pollute water bodies. Therefore, calcium chloride should not be applied to large areas for site-wide dust control. When used, calcium chloride applications should be restricted to haul roads, and small areas.
 - b. Lignosulfonate:** Derived from wood pulp, lignosulfonate is a byproduct of the paper industry and is often referred to as “tree sap.” It is applied as a liquid to the ground surface, and binds the surface particles together. Generally requires one or two treatments per season.
 - c. Soybean Oil (Soapstock):** Acidulated soybean oil soapstock is a by-product of the refining process of soybean oil. It is applied as an undiluted liquid to the ground surface and binds the surface particles together. Proper storage and transportation of soybean oil require that the material be kept at a constant temperature of 155 degrees Fahrenheit and continuously agitated. Application of the material may require special pumping equipment. These restrictions may limit the use of soybean oil for dust control. Generally requires one treatment per season.
- 4. Track-out Control:** (See [Section 7E-15 - Stabilized Construction Exit](#)). Soil tracked out onto streets by construction vehicles eventually dries and creates a fugitive dust. A stabilized construction entrance should be provided to aid in removing soil from vehicles before they enter the roadway.

C. Application

Apply chemical controls at the manufacturer's specified rates and according to all federal, state, and local regulations governing their use. If a chemical dust control treatment is over-applied, excess chemicals could potentially cause both surface and groundwater contamination. Recommended application rates are listed in the table below. Chemical products must be stored, handled, and disposed of according to all applicable local, state, and federal regulations.

Table 7E-16.01: Recommended Application Rates for Dust Suppression Products

Product	Mixture	Application Rate ¹
Calcium chloride	Dry flake or liquid solution	1 lb/SY on anhydrous basis
Lignosulfonate	Diluted with water to 25% solids	1 gal/SY
Soybean oil (soapstock)	Undiluted	0.70 gal/SY

¹Application rates are approximate and may need to be adjusted based upon site conditions

Source: Bolander, 1999 and Morgan, 2005

D. Maintenance

All dust control methods are temporary and require periodic maintenance. Wetting the ground surface with water may be necessary several times a day during hot and dry weather. Other methods provide longer effectiveness, and may only need to be applied once or twice per year.

Utility Cut Restoration

A. General

Utility cuts are made in existing pavement sections to install a myriad of utilities and to repair those that experience maintenance needs. Once a utility cut is made in the pavement, the restoration materials and process will have a significant impact on the life of the pavement patch. When a utility cut is made, the native material surrounding the perimeter of the trench is subjected to loss of lateral support. This leads to loss of material under the pavement and bulging of the soil on the trench sidewalls into the excavation. Subsequent refilling of the excavation does not necessarily restore the original strength of the soils in this weakened zone. The weakened zone around a utility cut excavation is called the “zone of influence.” Poor performance of pavements over and around utility trenches on local and state systems often causes unnecessary maintenance problems due to improper backfill placement (i.e., under compacted, too wet, too dry). It has been reported that the life of a utility cut replacement patch is only 2 to 3 years. The costs of repairing poorly performing utility cut restorations can potentially be avoided with a better understanding of proper material selection and construction practices. In addition to the resources spent by the public agency to maintain the pavement patch area, there is a significant impact to the traveling public due to rough streets and the traffic interruptions that occur frequently when maintenance activities are occurring.

The improper use and placement of backfill materials and failure to provide for the loss of lateral support of the trench walls are the primary causes of pavement patch failure.

While planning of utility modifications can be accommodated as part of a larger project, frequently these excavations occur at odd-hours and with no advance notice to repair a facility (i.e., water main break). It is therefore important to plan ahead to help ensure that desirable methods are used to restore utility trenches, even when weather, timing, or other factors may be less than ideal.

B. Background

The Iowa Highway Research Board (IHRB) commissioned two projects focusing on how best to reconstruct utility trenches. The goal of the projects has been to mitigate the negative effects utility trenches have on the surrounding roadway pavement. The two studies are described below.

- IHRB Project TR-503 (2005) [Utility Cut Repair Techniques - Investigation of Improved Cut Repair Techniques to Reduce Settlement in Repaired Areas](#)
- IHRB Project TR-566 (2010) [Utility Cut Repair Techniques - Investigation of Improved Utility Cut Repair Techniques to Reduce Settlement in Repaired Areas, Phase II](#)

The research identified the following problems with current trench restoration methods:

- Large equipment bearing on the trench edges (causing damage to the trench sidewalls and the remaining pavement)
- 2 to 4 foot lifts of backfill material
- Sporadic compaction of the backfill lifts
- Utilizing native, saturated material in the excavation in an attempt to clean the excavation site
- General lack of density and moisture quality control

The research identified three modes of failure for the utility trenches.

- Settlement of utility cut restoration, caused by poor compaction and wet/frozen conditions
- A “bump” forming over the restoration, resulting from uplift or settlement of surrounding soil
- Weakening of the surrounding soils

Many of the studied patches showed signs of failure within 2 years.

C. Factors Affecting Patch Performance

- 1. Compaction:** Proper compaction of the non-manufactured backfill material is a critical element of good trench construction. Use of granular backfill has previously been thought of as a means to achieve an acceptable level of trench compaction with a minimal level of effort; however, that is not the case. Even with granular materials, the material should be placed in lifts not exceeding 12 inches in thickness. Each lift of granular material should receive an appropriate level of compactive effort to achieve a minimum relative density of 65%. If cohesive soils are used in the top 2 feet to match existing subgrade materials, the soil should be placed in 8 inch lifts and compacted to 95% of Standard Proctor Density for that soil.

Backfill materials are often compacted using large compaction equipment, which is placed close to the edges of the cut, resulting in damage to pavement surfaces around the perimeter of the excavation. Note Figure 9D-1.01. It is important to keep equipment away from the edges of the trench.

Figure 9D-1.01: Cracking Pavement Surrounding the Utility Cut Area Because of Construction Equipment Getting Too Close to the Edge of the Open Cut



Source: IHRB Project TR-566