Annual Revisions to the SUDAS Design Manual
2019 Edition

Please 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 of the sheet 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, SUDAS Program Coordinator, at 515-294-2869 or brich@iastate.edu.

Please replace the following: the small business card on the spine with the card titled "2019 Edition," and the Contributors and Acknowledgments page. You might also find it helpful to keep this sheet just behind the general table of contents.

Chapter	*Section*	*pg #*	*Summary of Revision(s)*
1	Table of Contents	ii	Updated to reflect changes made in Chapter 1.
	1A-1, C	2	Updated the first sentence to match current list of chapters.
	1D-1, I through K	11-62	Revised "Items to be Specified" list based on SUDAS Specifications revisions. Updated "Incidental or Included Items" list. Updated "Bid Items" list.
	1E-1, B, 3	1	Corrected spelling error.
2	2A-4, C, 4, a	6-8	Deleted references that no longer exist; affected pages the followed.
5	Table of Contents	ALL	Updated to reflect changes made in Chapter 5.
	5D-1	ALL	Modified binder grades per new climate information.
	5E-1, I, 2, c	13	(4th paragraph) changed the maximum water-cement ratio from 0.45 to 0.42.
	5F-1	ALL	Updated and expanded truck mix tables; modified parameters to use AASHTO charts for seasonal variability, resilient modulus, and modulus of subgrade reaction; developed new thickness tables.
	5J-2 (new)	ALL	Added new design section for cold-in-place recycling projects.
	5J-3 (new)	ALL	Added new design section for full depth reclamation projects.
6	6H-1, D, 2	8	Minor correction to fix numbering.
7	Table of Contents	i	Updated to reflect changes made in Chapter 7.
	7A-1	ALL	Updated the requirements to reflect changes in General Permit No. 2 regulations (effective 3/1/18).
	7B-1	ALL	Updated the requirements to reflect changes in General Permit No. 2 regulations (effective 3/1/18).
12	12A-2, E	6-7	Enhanced design information on the use of bricks and pavers in pedestrian access routes.
	12A-3	1-3	Updated Iowa DOT logo; corrected reference and figure title.
13	Table of Contents	i	Updated to reflect changes made in Chapter 13.
	13E-1	7-19	Added option for placement of traffic signal pole foundation in rock; affected pages that followed.

Contributors and Acknowledgments

In 2018, SUDAS staff held many meetings to accomplish the various revisions reflected in the 2019 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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Chapter 1 - General Provisions

1A General Conditions

1B Classifications of Improvements and Definitions

1C Submittal Procedures

1D Detailed Plans for Construction of Public Improvements

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1F Plans of Record

1G Proprietary Products

General Conditions

A. Purpose

The SUDAS Design Manual has been prepared as a mechanism to implement uniform design standards, procedures, and regulations for the preparation of urban public improvement construction plans. Public improvements are those that meet any of the following:

1. Are initiated, designed, and constructed by or under the supervision of the Jurisdiction as a public improvement and maintained by the Jurisdiction.

2. Are initiated, designed, and constructed by the private owner/developer's private engineer and contractor. Upon acceptance of the improvements in the local Jurisdiction system, the improvements are maintained by the Jurisdiction.

Those improvements that require review and approval by the Jurisdiction, but will remain under private ownership, may be required to follow the SUDAS Design Manual. Each jurisdiction will decide on their own if these types of improvements are to follow the SUDAS Design Manual.

B. Intent of the SUDAS Design Manual

The values contained herein are considered fundamental concepts of basic design criteria that will serve as a framework for satisfactory design on new public improvements. The Project Engineer is encouraged to develop the design based on this framework and tailored to particular situations that are consistent with the general purpose and intent of the design criteria through the exercise of sound engineering judgment. Situations do arise that require special considerations. Therefore, to eliminate hardships or problems, the Jurisdiction may choose to vary the design criteria, procedures, and regulations. Should variances from the SUDAS Design Manual be required, the reason for the variance should be documented and evaluated on a case-by-case basis.

The design standards as described for new public improvements may not be attainable for restoration and rehabilitation projects. Each project of this type must be considered individually to determine if these design standards apply.

The SUDAS Design Manual and the Jurisdiction’s supplemental design standards should be used for the preparation of all design plans for new improvements or major reconstruction submitted by the Project Engineer for Jurisdictional review. The Jurisdiction will review all submittals for general compliance with the specific design criteria, procedures, and regulations. Approval by the Jurisdiction does not relieve the Project Engineer from the responsibility of ensuring that the calculations, design, and plans are accurate or comply with the SUDAS Design Manual and fit the needs of a particular project.

The technical criteria not specifically addressed in the SUDAS Design Manual should follow the provisions of each jurisdiction's own policy or criteria.

C. Organization of the Manual

The SUDAS Design Manual is organized into fourteen chapters: General Provisions, Stormwater, Sanitary Sewers, Water Mains, Roadway Design, Geotechnical, Erosion and Sediment Control, Parking Lots, Utilities, Street Tree Criteria, Street Lighting, Sidewalks and Bicycle Facilities, Traffic Signals, and Trenchless Construction. The chapters include general information, report documentation, plan design, and federal and state requirements. The manual provides a compilation of readily available literature relevant to the design of urban facilities. The chapters are designed so that revisions can be made by updating the effected sections, as necessary, to reflect up-to-date engineering practices and changes in technology.

D. Jurisdiction and Agencies

The SUDAS Design Manual applies to participating local governments except where superseded by state and federal requirements.

E. Amendment and Revisions

The standards and criteria will be amended as new technology is developed and/or experience gained in the use of SUDAS Design Manual indicates a need for revision. The revisions will be adopted and jurisdiction engineers will monitor the performance and effectiveness of the design standards and will recommend changes and/or amendments through the SUDAS program as needed.

F. Enforcement Responsibility

Each jurisdiction is responsible for enforcing the adopted provisions of the SUDAS Design Manual.

G. Interpretation

The Jurisdiction will make the interpretation and application of the SUDAS Design Manual. The following classification of improvements and definitions are provided for a clearer understanding of general policy.

H. Innovation

Nothing in the SUDAS Design Manual limits the designer's use of new and innovative technology. Each alternative proposed utilizing new or unproven technology must receive approval prior to implementation. Materials meeting the technical specifications should be allowed unless specifically prohibited by the Jurisdiction.

I. Items to be Specified on Plans or in Contract Documents

The SUDAS Standard Specifications specify many items and methods that can be used for the construction of improvements. Following is a list of items in the SUDAS Standard 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 Standard 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, 1, a	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, J, 3	Specify whenever removal of pipe and conduits will include capping.
2010, 1.08, L	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, 3.03, 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.

I. Items to be Specified on Plans or in Contract Documents (Continued)

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, 2.03, B	Specify whenever Class V material can be used as other than topsoil.
3010, 2.06, D	Specify if foamed cellular concrete may be substituted for flowable mortar.
3010, 3.05, A, 6	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.
3020, 3.04, A, 2, b, 2), b)	Specify the minimum depth of pressurized pipe.
3020, 3.04, D	Specify when to fill the annular space between the carrier and casing pipe with flowable mortar, CLSM, or foamed cellular concrete.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 4010 - Sanitary Sewers

4010, 1.08, E	Specify the distance beyond the right-of-way line that the sanitary sewer service stub is to extend, if other than 10 feet.
4010, 1.08, H, 3	For removal of sanitary sewer, specify if capping is required.
4010, 2.01, A, 1	For solid wall PVC pipe, 8 inch to 15 inch, specify if SDR 35 may be used.
4010, 2.01, C, 2, a	For corrugated PVC, 8 inch to 10 inch, specify if a minimum pipe stiffness of 46 psi may be used.
4010, 2.02, A	Specify when joint restraints for ductile iron pipe force mains are required.
4010, 2.02, B	Specify when restrained joints are required for PVC force mains.
4010, 2.02, E, 2	Specify the color of plastic post used for tracer wire station.
4010, 3.02, B, 7	Specify the location for installation of wye or tee service fitting.
4010, 3.05, B, 2	Specify the location for any installation of a tracer wire station in addition to each end of the force main.
4010, 3.06, A	Specify the locations for installation of sanitary sewer service stub.
4010, 3.06, C	Specify the distance beyond the right-of-way line that the sanitary sewer service stub is to extend, if other than 10 feet.
4010, 3.06, C, 3	Specify the depth of sanitary sewer service stub at its termination, if other than 10 to 12 feet.
4010, 3.06, C, 5	Specify method of marking the end of the sanitary sewer service line.
4010, 3.08, B, 2	Specify when to fill an abandoned sanitary sewer with flowable mortar, foamed cellular concrete, or CLSM.
4010, 3.10	Specify where to provide sanitary sewer cleanouts.

Section 4020 - Storm Sewers

4020, 1.08, C, 3	Specify if capping is required for removal of storm sewer.
4020, 2.01, A, 3	Specify when to use a rubber O-ring or profile gasket in lieu of a tongue and groove joint wrapped with engineering fabric.
4020, 2.01, B, 3	Specify when to use a rubber O-ring or profile gasket in lieu of a tongue and groove joint wrapped with engineering fabric.

I. Items to be Specified on Plans or in Contract Documents (Continued)

4020, 2.01, C, 3	Specify when to use a rubber O-ring or profile gasket in lieu of a tongue and groove joint wrapped with engineering fabric.
4020, 2.01, G, 1, d	Specify gage of corrugated metal pipe, if other than Iowa DOT Standard Road Plan DR-104.
4020, 2.01, I, 2	Specify gage of coated corrugated metal pipe, if other than Iowa DOT Standard Road Plan DR-104.
4020, 3.04, B, 2	Specify the use of a rubber O-ring or profile gasket.
4020, 3.05	Specify where to install pipe aprons, apron footings, and apron guards.
4020, 3.08, B, 2	Specify when to fill a line to be abandoned with flowable mortar, foamed cellular concrete, or CLSM.

Section 4030 - Pipe Culverts

4030, 2.01, C, 5	Specify gage of the structural plate culverts, if other than Iowa DOT Standard Road Plan DR-104.
4030, 3.02, A	Specify the locations to install pipe aprons.
4030, 3.02, B	Specify the locations to install apron footings.
4030, 3.02, E	Specify the locations to install apron guards.
Figure 4030.225	Specify when to extend the bottom cross bar through the apron.

Section 4040 - Subdrains and Footing Drains

4040, 1.08, A, 3	Specify the use of engineering fabric.
4040, 1.08, E	Specify the distance beyond the right-of-way that the storm sewer service stub is to extend, if other than 10 feet.
4040, 3.01, A, 1	Excavate trench and provide pipe bedding and backfill as shown on the figures. Install engineering fabric if specified in the contract documents.
4040, 3.02, B	Specify the use of engineering fabric.
4040, 3.03, A	Specify the locations to install footing drain service stubs.
4040, 3.03, C	Specify the distance beyond the right-of-way that the footing drain service stub is to extend, if other than 10 feet.
Figure 4040.231	For Type 1 subdrains, specify Case A, B, or C. For Type 2 subdrains, specify Case D or E and the pipe diameter. When using Case A or Case D, specify the distance from back of curb. For both types, specify when engineering fabric is to be used.
Figure 4040.232	Specify the type of subdrain cleanout to be used.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Figure 4040.233	Specify when to use a CMP outlet.

Section 4050 - Pipe Rehabilitation

4050, 1.07, C	Specify who will provide water for installation of cured-in-place pipe if not the owner.
4050, 2.01, A, 3	Specify the maximum outside diameter and SDR of polyethylene or polyolefin pipe for sliplining.
4050, 2.06, B, 1	Specify the nominal internal diameter and length of existing pipe.
4050, 2.06, B, 5	Specify the minimum SDR wall thickness for DRP-HDPE.
4050, 2.07, B, 1	Specify the nominal internal diameter and length of existing pipe.
4050, 2.07, B, 5	Specify the minimum SDR wall thickness for FFP-PVC pipe lining.
4050, 2.09, B	Specify materials to be used for pipe replacement (spot repairs).
4050, 3.08	Specify the installation process for DRP-HDPE or FFP-PVC, if other than manufacturer's recommendations.
4050, 3.08, C, 1	Specify the material used to replace pipe of the same nominal size as the existing pipe.

Section 4060 - Cleaning, Inspection, and Testing of Sewers

4060, 2.01, B, 3	Specify the type of recording media that will be used to record the inspection.
4060, 3.03, A, 1	Specify whenever video inspection of storm sewers is <u>not</u> desired.

Section 5010 - Pipe and Fittings

5010, 1.08, C	Specify whether measurement of fittings will be made by count or by weight.
5010, 2.01, A, 1, b	Specify the minimum wall thickness for PVC pipe sizes over 24 inches.
5010, 2.01, A, 2	Specify joint type for PVC pipe if other than push-on.
5010, 2.01, B, 1, b	Specify the minimum wall thickness for DIP sizes over 24 inches.
5010, 2.01, B, 4	Specify joint type for DIP if other than push-on.
5010, 2.04, C	Specify when thrust blocks will be used for pipe sizes greater than 16 inches in diameter.
5010, 2.07, B	Specify the materials to use for water service pipe and appurtenances.

I. Items to be Specified on Plans or in Contract Documents (Continued)

5010, 3.01, A, 3	Specify the lines and grades to install pipe with fittings.
5010, 3.01, A, 8	For pipes larger than 16 inches, specify when concrete thrust blocks are required in addition to restrained joints.
5010, 3.06, E	Specify the locations to install ground rods if other than adjacent to connections to existing piping.
5010, 3.07, B	Specify where to construct utility line supports.
5010, 3.08	Specify when the change of piping material is to be on the inside of the structure wall.
Figure 5010.101	Specify when to use the alternate method of thrust blocks at dead ends.

Section 5020 - Valves, Fire Hydrants, and Appurtenances

5020, 1.08, I, 3	Specify if the fire hydrant assembly is to be delivered to the Contracting Authority.
5020, 1.08, J, 3	Specify if the valve is to be delivered to the Contracting Authority.
5020, 1.08, K, 3	Specify if the valve box is to be delivered to the Contracting Authority.
5020, 2.01, A, 2	Specify whenever the opening direction for valves is clockwise.
5020, 2.01, D, 7	Specify the locations to use tapping valve assemblies.
5020, 2.02, B	Specify allowable manufacturer(s) of fire hydrant assemblies.
5020, 2.02, C, 5	Specify whenever the opening direction for fire hydrant assemblies is clockwise.
5020, 2.02, C, 6	For fire hydrant assemblies, specify the operating nut, pumper nozzle, nozzle threads, and main valve nominal opening sizes.
5020, 2.03, A	Specify the type of flushing device (blowoff) to be used.
5020, 2.03, B, 2	Specify the allowable manufacturer(s) for valve boxes.
5020, 3.02	Specify where to install and how to construct flushing device (blowoff).
5020, 3.04, D	Specify if exterior of a new fire hydrant barrel section will be painted a color other than matching the existing fire hydrant.

Section 6010 - Structures for Sanitary and Storm Sewers

6010, 2.05, B, 2, b	Specify the use of engineering fabric.
6010, 2.06, B	Specify when to use a concentric cone on sanitary sewer manholes.
6010, 2.11, B, 1	Specify if sanitary sewer manhole exterior is to be coated.

I. Items to be Specified on Plans or in Contract Documents (Continued)

6010, 2.11, B, 2	Specify whenever sanitary sewer manhole lining is required.
6010, 2.13, A	Specify if steps are to be provided for structures other than circular, precast manholes. Specify if steps are NOT to be provided in circular, precast manholes.
6010, 3.01, J	Specify the type of casting to use for manholes and intakes, except for intakes that have a specific casting type identified on the figures. Specify if casting frame is to be attached to the structure with bolts.
6010, 3.02, B, 2	Specify if reinforcing steel is to lap other than 36 diameters.
6010, 3.04, A, 1	Specify when to install casting extension rings.
6010, 3.04, B, 3	Specify when existing casting may be reinstalled for minor adjustment of existing manhole or intake.
6010, 3.04, C, 4	Specify when existing casting may be reinstalled for major adjustment of existing manhole or intake.
6010, 3.05, C, 1, a	Specify whenever a knockout opening is allowed in lieu of a cored opening.
6010, 3.05, C, 1, b	Specify if sanitary sewer service is NOT required to be maintained at all times when connecting a sanitary sewer to existing manhole or intake.
6010, 3.05, C, 3	Specify whenever a knockout opening is allowed in lieu of a cored opening.
6010, 3.06, A	Specify if removal of manhole or intake is other than to a minimum of 10 feet below top of subgrade in paved areas or 10 feet below finished grade in other areas.
6010, 3.06, B, 3	Specify when to fill abandoned pipe line with flowable mortar or controlled low strength material.
Figure 6010.501	Specify when Type Q grate is to be used in lieu of Type R.
Figure 6010.502	Specify when Type Q grate is to be used in lieu of Type R.
Figure 6010.603	Specify when Type Q grate is to be used in lieu of Type R.

Section 6020 - Rehabilitation of Existing Manholes

6020, 2.02, A	Specify the thickness of the in-situ manhole replacement wall.
6020, 2.02, C	Specify whenever the Contractor is required to provide a PVC or PE plastic liner for in-situ manhole replacement.
6020, 3.01, C	Specify when the use of a urethane chimney seal is allowed.
6020, 3.02, B, 3	Specify whenever a plastic liner is to be installed in an in-situ manhole replacement.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 6030 - Cleaning, Inspection, and Testing of Structures

6030, 3.04, A, 1	Specify when exfiltration testing is required for sanitary sewer manholes in lieu of vacuum testing.

Section 7010 - Portland Cement Concrete Pavement

7010, 2.01, E	Specify the use of an intermediate aggregate for concrete.
7010, 2.01, L, 2	Specify the type of performed expansion jointing filler or sealer to use if NOT using a resilient filler.
7010, 2.02, A, 1	Specify the type of Class C or Class M mix to use.
7010, 2.02, C, 2	Specify the type and amount of supplementary cementitious material in the mix.
7010, 3.01, C, 1, c	Specify the use of stringless paving.
7010, 3.02, H, 5, a	Specify when a textured finished surface other than an artificial turf or burlap drag is desired (i.e. surface tining).
7010, 3.02, H, 5, b	Specify when surface tining is required. *Note - longitudinal tining is listed as the default.*
7010, 3.02, I, 1, a	Specify when the use of a linseed oil solution is required.
7010, 3.02, J, 1, a	Specify the type and locations for construction of joints.
7010, 3.02, J, 2, i	Specify when to use wet sawing for dust control.
7010, 3.02, J, 3, a	Specify the location of longitudinal and transverse construction joints.
7010, 3.02, J, 4, a	Specify the location of expansion joints.
7010, 3.07, C, 2, a	Specify when the use of a profilograph for pavement smoothness is required.
Figure 7010.101, sheet 4	Specify when to use Detail D-1, D-2, or D-3.

Section 7011 - Portland Cement Concrete Overlays

7011, 2.01, L, 1	Specify the mass per unit area.
7011, 3.02, E, 3, a	Specify the high spots in the existing asphalt surface to be milled.

Section 7020 - Hot Mix Asphalt Pavement

7020, 1.08, A & B	Specify if measurement of HMA pavement is by ton or square yard.
7020, 1.08, C & D	Specify if measurement of HMA base widening is by ton or square yard.

I. Items to be Specified on Plans or in Contract Documents (Continued)

7020, 3.05, B, 1	Specify when the use of profilograph for pavement smoothness is required.
7020, Table 7020.05	Specify if the field laboratory air voids target value is other than 4%.

Section 7021 - Hot Mix Asphalt Overlays

7021, 2.04, A	Specify the asphalt binder grade.
7021, 3.01, A	Specify the milling depth, cross-section, or profile.

Section 7030 - Sidewalks, Shared Use Paths, and Driveways

7030, 1.08, H, 2	Specify whether granular surfacing for driveways will be computed in square yards or tons.
7030, 1.08, I, 1	Specify whenever the Contractor will be responsible for concrete compression or HMA density testing.
7030, 2.03, A	Specify color and surface texture of clay brick pavers, or select from samples submitted by the Contractor.
7030, 2.03, B	If concrete pavers are to be used, specify the material requirements.
7030, 2.04, B	Specify the use of a pre-mixed high performance cold mix in lieu of an HMA setting bed.
7030, 2.06	Specify the use of colored cement for brick/paver joint filler.
7030, 3.01, A-C	Specify removal limits of sidewalks, shared use paths, driveways, bricks, and curbs.
7030. 3.01, E	Specify the locations to grind or saw existing curbs to install sidewalks, shared use paths, and driveways.
7030, 3.04, D	Specify when curing is required.
7030, 3.04, F, 2, a, 1)	Specify the spacing for transverse joints in shared use paths, if other than equal to the width of the shared use paths.
7030, 3.06, A, 2	Specify the cross-section and patterns to use for brick sidewalks with a concrete base.
7030, 3.11, A	Specify when testing will be the Contractor's responsibility.
Figure 7030.101	Specify the radius for commercial and industrial driveways. Specify when a 'B' joint is to be provided at the back of curb. Specify the driveway width. Specify when a 5 foot sidewalk is to be constructed through the driveway.
Figure 7030.102	Specify the radius for commercial and industrial driveways. Specify the driveway width. Specify when a 5 foot sidewalk is to be constructed through the driveway.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Figure 7030.104	Specify parking grading slope and property slope if different than 4:1.
Figure 7030.201	If a special grade is required for parking slopes, specify the grade. Specify the width of the sidewalk.
Figure 7030.202	Specify one of the curb details for Class A sidewalk.
Figure 7030.203	Specify the brick sidewalk pattern. Specify the jointing of the concrete base.
Figure 7030.205	Specify the use of a BT-3, KT-2, or expansion joint.

Section 7040 - Pavement Rehabilitation

7040, 2.01, A, 1	Specify if patches are <u>not</u> constructed as standard patches.
7040, 2.01, A, 2	Specify the use of calcium chloride in high early strength patching.
7040, 2.01, B	Specify if an HMA mixture other than a minimum Low Traffic (LT) mixture is desired.
7040, 2.01, C, 5	Specify the use of soil sterilant for crack and joint filler material.
7040, 2.01, G	Specify if a subbase material other than modified subbase is desired.
7040, 2.01, K	Specify the length and diameter of epoxy coated dowel bars.
7040, 3.01, C	Specify the dimensions of full depth and partial depth patches.
7040, 3.01, F	Specify seeding or sodding the area outside the pavement.
7040, 3.02, A, 1	Specify when a second saw cut is required.
7040, 3.02, C, 6	Specify the locations of joints.
7040, 3.03, B, 2	Specify when to tool the joint.
7040, 3.04, J	Specify when pavement smoothness testing is required.
7040, 3.05, B	Specify the depth to mill the pavement area.
7040, 3.05, D	Specify if materials removed are <u>not</u> the property of the Contractor.
7040, 3.06, B, 3	Specify when to clean wet sawn joints.
7040, 3.06, C, 2	Specify the level to heat, handle, and apply joint filler material.
7040, 3.07, A, 3	Specify when to apply soil sterilant.
7040, 3.07, B, 2	For cracks wider than 1 inch, specify when to utilize additional methods to clean cracks of old crack filler.

I. Items to be Specified on Plans or in Contract Documents (Continued)

7040, 3.07, C, 2	For cracks 1/4 inch to 1 inch in width, specify when to utilize additional methods to clean cracks of old crack filler.
Figure 7040.102	Specify the use of a 'CD' joint.
Figure 7040.105	Specify the use of filter fabric. Specify the type of subbase.

Section 7050 - Asphalt Stabilization

7050, 1.02	Specify the crown of the pavement.
7050, 2.01, B	Specify the type of aggregate required.
7050, 3.03, A	Specify the depth of existing roadway surface to reclaim, if other than 4 inches.
7050, 3.07	Specify the type of surface treatment to apply.

Section 7060 - Bituminous Seal Coat

7060, 1.08 A & B	Specify measurement of bituminous seal coat is in area or units.
7060, 2.01, A	Specify the cover aggregate size.
7060, 2.01, B	Specify bituminous material if different than CRS-2P.
7060, 3.02, A, 1	Specify when to patch and joint fill hard surfaced streets.
7060, 3.04, B	Specify the application rate for spreading binder bitumen, if other than shown in the table.
7060, 3.04, D	Specify the application rate for spreading cover aggregate, if other than shown in the table.
7060, 3.06, B, 2	Specify the rate for spreading binder bitumen for two course seal coats.
7060, 3.06, B, 3	Specify the size of aggregate and the rate for spreading cover aggregate for two course seal coats.
7060, 3.07	Specify if sweeping of rural pavements is <u>not</u> necessary.

Section 7070 - Emulsified Asphalt Slurry Seal

7070, 1.02, B	Specify the application of fine or coarse slurry mixtures.
7070, 2.01, B	Specify when to use crushed aggregates.
7070, 2.02, A	Specify the amount of asphalt emulsion to blend with the aggregate.
7070, 3.01, B, 1, b	Specify the width of slurry mixture application.
7070, 3.02, A	Specify when to complete pavement patches and joint or crack filling for surface preparation.

I. Items to be Specified on Plans or in Contract Documents (Continued)

7070, 3.02, C	Specify if water flushing for surface preparation is not allowed.
7070, 3.03, C	Specify the rate of applying the slurry seal, if other than 10 to 18 pounds per square yard for fine aggregate and 15 to 22 pounds per square yard for coarse aggregate.
7070, 3.03, F	Specify when to apply a burlap drag.
7070, 3.05, E	Specify if strip slurry treatment is to be placed in two separate operations.
	Section 7080 - Permeable Interlocking Pavers
7080, 2.02, A	Specify either slotted or perforated underdrain pipes.
7080, 2.02, B	Specify the size of collector pipe if other than 6 inch diameter is desired.
7080, 2.03, C	Specify the size of lateral pipe if other than 4 inch diameter is desired.
7080, 3.02, A	Specify the elevation and grade for the excavation area.
7080, 3.02, B	Specify the use and location of underdrains.
7080, 3.03, A	Specify the use of engineering fabric over completed subgrade.
7080, 3.04, A, 5	Specify cleanout locations.
7080, 3.04, A, 7	Specify the use of underdrain cleanout pipes and observation wells.
7080, 3.04, B, 1	Specify underdrain lateral pipe locations.
7080, 3.05, A	Specify the thickness of storage aggregate.
7080, 3.05, C	Specify the storage aggregate elevation.
7080, 3.09	Specify the installation pattern of the pavers.
	Section 7090 - Cold-in-Place Pavement Recycling
7090, 2.02	Specify the required strength of the recycled pavement section.
7090, 3.01, B, 1	Specify the width and depth to mill the existing pavement material.
7090, 3.01, B, 2	Specify the use of an asphalt foaming system.
7090, 3.08, C	Specify if the compacted recycled roadway does not have to be within 6 inches of the established centerline.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 7091 - Full Depth Reclamation

7091, 2.02	Specify the required strength of the reclaimed pavement section as specified in the contract documents.
7091, 3.01, B, 1	Specify the width and depth to reclaim.
7091, 3.01, B, 2	Specify the use of an asphalt foaming system.
7091, 3.05, A	Specify if multiple passes are required.
7091, 3.09, C	Specify if the compacted, reclaimed roadway does not have to be within 6 inches of the established centerline.
7091, 3.11	Specify when to complete microcracking.
7091, 3.12	Specify the use of an HMA interlayer.

Section 8010 - Traffic Signals

8010, 2.01, A, 1, c	Specify if a message besides “TRAFFIC SIGNAL” will be required on the handhole cover.
8010, 2.01, B, 3, a, 2)	Specify solvent welded, socket type fittings for use other than PVC conduit and fittings.
8010, 2.01, C, 6, a	Specify the mode type, size, and number of fibers for fiber optic cable required.
8010, 2.01, C, 6, p	Specify the type of fiber distribution panel if a panel other than one capable of terminating a minimum of 24 fibers is desired.
8010, 2.01, C, 6, t	Specify the use of fusion splice continuous fiber runs or branch circuit connections in splice enclosures.
8010, 2.02, B, 2, c	Specify the voice message to be used for accessible pedestrian signal push button stations.
8010, 2.02, D, 9	Specify the type of mounting for microwave vehicle detectors.
8010, 2.03, A	Specify the use of traffic monitoring systems.
8010, 2.03, B	Specify the use of fiber optic hub cabinet.
8010, 2.03, C, 2, b	Specify the location to mount the antenna for a wireless interconnect network, if other than near the top of the signal pole nearest the controller cabinet.
8010, 2.04, A, 2, b	Specify dimensions and type of aluminum cabinet riser to be used.
8010, 2.04, A, 2, g	Specify accommodations of phasing and expansibility of cabinet back panel positions.

I. Items to be Specified on Plans or in Contract Documents (Continued)

8010, 2.04, C	Specify the use of emergency vehicle preemption system.
8010, 2.05, A, 1, a	Specify the color of vehicle traffic signal head assembly housing.
8010, 2.05, B, 1, a	Specify the color of pedestrian traffic signal head assembly housing.
8010, 2.05, C, 1, a	Specify the mast arm length and vertical pole height.
8010, 2.05, C, 1, f	Specify where to use a combination street lighting/signal pole. Specify if the luminaire arm is to be mounted somewhere other than the same vertical plane as the signal arm.
8010, 2.05, D, 1, a	Specify the vertical pole height of the traffic signal pedestal pole.
8010, 2.05, F, 3	Specify the street name sign dimensions, letter height and font, and sheeting.
8010, 3.01, B, 3, c	Specify if boring pits are allowed to be closer than 2 feet to the back of curb.
8010, 3.01, C, 9, c	Specify if the conduit cables could be pulled through intermediate junction boxes, handholes, pull boxes, pole bases, or any conduit opening.
8010, 3.01, C, 9, g	Specify how much cable slack to provide in each handhole, junction box, and cabinet.
8010, 3.01, C, 9, h	Specify installation of fiber optic accessories.
8010, 3.01, D, 1	Specify the foundation excavation size, shape, and depth.
8010, 3.02, C	Specify the installation of video detection camera system.
8010, 3.03, A	Specify the installation of traffic monitoring system.
8010, 3.03, B	Specify the installation of fiber optic hub cabinet.
8010, 3.04, A, 1	Specify the installation of controller cabinet and auxiliary equipment.
8010, 3.04, B	Specify the installation of controller.
8010, 3.04, C	Specify the installation of UPS battery backup system.
8010, 3.04, D	Specify the installation of emergency vehicle preemption system.
8010, 3.06	Specify construction of temporary traffic signal.
Figure 8010.104	Specify the length of rectangular detector loop.
Figure 8010.105	Specify the number of signals, signs, and spacing.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 8020 - Pavement Markings

8020, 3.02, A, 3, c	Specify lane widths.
8020, 3.02, B, 2	Specify if pavement surface will not be cleaned with a rotary broom or street sweeper.
8020, 3.02, D	Specify if pavement is to be grooved prior to placing marking tape.
8020, 3.02, G, 2	Specify when to place pavement markings in a groove cut into the pavement surface.

Section 8030 - Temporary Traffic Control

8030, 1.08, A, 3	Specify when to include portable dynamic message signs, temporary barrier rail, temporary flood lighting, and pilot cars in the traffic control lump sum bid item.
8030, 2.04, B	Specify if something other than precast concrete units are to be used for temporary barrier rail.
8030, 3.01, C	Specify the locations to place temporary barrier rail.
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 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, M	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.

I. Items to be Specified on Plans or in Contract Documents (Continued)

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, 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, 3.08, A	Specify when tree wrapping is required.
9030, 3.12, 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, B	Specify thickness for compost blankets.
9040, 1.08, E, 1	Specify the width of temporary RECP.
9040, 1.08, I	Specify if level spreaders are not to be removed.
9040, 1.08, L, 1, c	Specify the use of anti-seep collars.
9040, 1.08, O	Specify measurement for stabilized construction entrance in square yards or tons.
9040, 2.02, B	Specify the use of filter berms or compost blankets.
9040, 2.03	Specify the use of filter material in areas other than filter socks and filter berms.
9040, 2.06, A	Specify diameter for open weave, degradable netting if other than 9 inches is required.
9040, 2.07, A, 2	Specify if using RECP for permeable check dam.
9040, 2.08, A	Specify length of pressure-treated timber for level spreaders.
9040, 2.11, A	Specify class of concrete if not Class C.
9040, 2.11, B	Specify riser diameter for sediment basin outlet structures.
9040, 2.11, C, 1	Specify the number, diameter, and elevation of the holes in the riser of the dewatering device in sediment basin outlet structures.

I. Items to be Specified on Plans or in Contract Documents (Continued)

9040, 2.11, D	Specify barrel diameter of the sediment basin outlet structures.
9040, 2.11, E	Specify riser diameter for anti-vortex device.
9040, 3.02, D	Specify if weekly erosion and sediment control site inspections are not 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 not to be installed along the contour.
9040, 3.06, C	Specify when a vegetated berm is required.
9040, 3.07, A, 1	Specify the size and length of filter sock.
9040, 3.07, A, 3	Specify when the filter sock is not to be installed along the contour.
9040, 3.07, B	Specify when to remove the filter sock.
9040, 3.08, A, 2	Specify if placement of seed and fertilizer is to be accomplished before installation of temporary rolled erosion control products.
9040, 3.08, A, 3	Specify if placement of seed and fertilizer is to be accomplished on the anchor trench.
9040, 3.08, B, 1	Specify if placement of seed and fertilizer is to be accomplished before installation of temporary rolled erosion control products.
9040, 3.09, B	Specify when to remove the wattle.
9040, 3.10, A, 2	Specify when to provide an RECP under the check dam.
9040, 3.10, D	Specify when to remove check dams.
9040, 3.12, C	Specify the excavated depth behind the level spreader.
9040, 3.12, E	Specify the minimum depth of depression before accumulated sediment is removed.
9040, 3.15, B, 1	Specify the number, diameter, and configuration of holes in the riser section of sediment basin outlet structures.
9040, 3.17	Specify the size and elevations of sediment traps.
9040, 3.18, A, 1	Specify when the silt fence material is not to be installed along the contour.
9040, 3.19, E	Specify when to install subgrade stabilization fabric prior to placing crushed stone.
9040, 3.19, F	Specify the thickness and dimensions of crushed stone for stabilized construction entrance.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Figure 9040.101	Specify if compost blankets are vegetated or unvegetated.
Figure 9040.102	Specify size of berm if slope is steeper than 3:1. Specify berm placement locations in uncompacted windrow perpendicular to the slope. Specify filter sock diameter.
Figure 9040.105	Specify diameter of wattle. Specify space between wattles.
Figure 9040.107	Specify height between engineering fabric and crest on the rock check dam.
Figure 9040.108	Specify total height of diversion.
Figure 9040.109	Specify excavated depression depth.
Figure 9040.110	Specify the rock thickness (T), width (W), and length (L) for rip rap apron for pipe outlet onto flat ground.
Figure 9040.111	Specify the rock thickness (T), width (W), and length (L) for rip rap apron for pipe outlet into channel.
Figure 9040.112	Specify diameter of pipe for temporary pipe slope drain. Specify A, B, and C anchoring options.
Figure 9040.113	Specify barrel length and diameter for sediment basin without emergency spillway. Specify when anti-seep collars are required.
Figure 9040.114	Specify barrel length and diameter for sediment basin with emergency spillway. Specify when anti-seep collars are required.
Figure 9040.115	Specify elevations and dimensions for sediment basin dewatering device. Specify perforation configurations. Specify diameter of discharge pipe barrel.
Figure 9040.116	Specify riser diameter for anti-vortex device.
Figure 9040.117	Specify when anti-seep collars are required.
Figure 9040.118	Specify width of sediment trap.
Figure 9040.119	Specify spacing of post installation for silt fence.

Section 9050 - Gabions and Revet Mattresses

9050, 1.08, A, 3	Specify PVC coating for gabions.
9050, 1.08, B, 3	Specify PVC coating for revet mattresses.
9050, 2.01	Specify when double twisted wire baskets are <u>not</u> required.
9050, 2.02	Specify when to use welded wire baskets.
9050, 2.05	Specify when to use anchor stakes. Specify the length of anchor stakes.

I. Items to be Specified on Plans or in Contract Documents (Continued)

9050, 3.01, A	Specify when to cut and reshape the area behind a proposed gabion wall to allow for placement of the wall.
9050, 3.01, E	Specify the placement, compaction, and dimensions of granular subbase materials.
9050, 3.04, A	Specify special details of gabion wall installation including height, slope of wall, gabion setback, special backfill materials, and tieback requirements.

Section 9060 - Chain Link Fence

9060, 1.08, A, 3	Specify PVC coating for chain link fence.
9060, 1.08, B, 3	Specify the use of barbed wire for gates.
9060, 1.08, C, 3	Specify the type of barbed wire supporting arm.
9060, 2.01, D, 2	Specify the PVC coating color.
9060, 2.02, A, 2	Specify the nominal diameter of fence height for post use, if other than shown in the table.
9060, 2.05, A	Specify the type of arm configuration for barbed wire supporting arms.
9060, 2.07, A	Specify the type, height, and width of gates.
9060, 3.01, A	Specify fence location and height.
9060, 3.01, B, 2, a	Specify post holes dimensions.
9060, 3.01, B, 2, e	Specify the required brace-post assembly.
9060, 3.01, G	Specify when to use barbed wire.
9060, 3.01, G, 1	Specify the installation of barbed wire, if other than 3 parallel wires on each barbed wire supporting arm on the outside of the area being secured.
9060, 3.01, H	Specify the installation requirements for gates.
9060, 3.01, I, 1	Specify the installation of electrical grounds.
9060, 3.02	Specify when all fences, including posts and footings, are <u>not</u> to be removed from within work areas.
9060, 3.03, A	Specify the height of temporary fence.
Figure 9060.101	Specify the fence fabric width. Specify when to install fence on the roadway side of the right-of-way.
Figure 9060.103	Specify the length of the sidewalk.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 9070 - Landscape Retaining Walls

9070, 2.01, B	Specify the depth of limestone slabs, if other than 8 inches.
9070, 3.01, B	Specify the excavation line and grade.

Section 9071 - Segmental Block Retaining Walls

9071, 3.01, B	Specify the excavation line and grade.
9071, 3.02, B	Specify leveling pad materials.
9071, 3.02, C	Specify the elevation and orientation.
9071, 3.02, D, 1	Specify the use of subdrains.

Section 9072 - Combined Concrete Sidewalk and Retaining Wall

9072, 2.01, A, 3	Specify the type of expansion joint, if resilient filler is not desired.
9072, 3.01, B	Specify the excavation line and grade.
9072, 3.04	Specify the formation of rustications.

Section 9080 - Concrete Steps, Handrails, and Safety Rail

9080, 2.04, B	Specify when to galvanize handrail and safety rail.
9080, 2.04, C	Specify when to apply powder coat to steel, galvanized steel, or aluminum handrail and safety rail.
9080, 3.02, A, 1	Specify the length of rail.
Figure 9080.103	Specify the field painting of safety rail.

Section 10,010 - Demolition

10,010, 1.07, A	Specify when the use of explosives is allowed.
10,010, 3.08, D	Specify when the removal and disposal of all brush, shrubs, trees, logs, downed timber, and other yard waste on the site is not desired.
10,010, 3.08, E	Specify when the removal of all retaining walls is not desired.
10,010, 3.11	Specify what materials are required to be recycled from the demolition site.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 11,010 - Construction Survey

11,010, 1.02	Specify any additional items to be included in construction survey work.
11,010, 3.02, D	Specify if property limits are to be marked.
11,010, 3.04	Specify which land corners, property corners, permanent reference markers, and benchmarks are to be replaced.

Section 11,040 - Temporary Sidewalk Access

11,040, 3.02, A	Specify locations to construct temporary granular sidewalks.
11,040, 3.03, B	Specify locations to locate temporary longitudinal channelizing devices.
Figure 11,040.102	Specify when to install orange construction safety fence between the top of the bottom rail and the bottom of the top rail.

Section 11,050 - Concrete Washout

11,050, 3.02, A	Specify locations of temporary granular sidewalks.

J. 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 Standard 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, D, 2, c	Topsoil, Compost-amended Furnishing and incorporating compost.
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. e. Compaction testing, as specified in the contract documents.
2010, 1.08, F, 3	Below Grade Excavation (Core Out) 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.
2010, 1.08, G, 3	Subgrade Preparation Excavating, manipulating, replacing, compacting, and trimming to the proper grade.
2010, 1.08, H, 3	Subgrade Treatment Furnishing, placing, and incorporating the subgrade treatment material (cement, asphalt, fly ash, lime, geogrid, or geotextiles).
2010, 1.08, I, 3	Subbase Furnishing, placing, compacting, and trimming to the proper grade.
2010, 1.08, J, 1, c	Removal of Structures Removal and disposal of structures.
2010, 1.08, J, 2, a, 3)	Removal of Known Box Culverts Removal and disposal of known box culverts.

J. Incidental or Included Items (Continued)

2010, 1.08, J, 2, c, 3) Removal of Known Pipe Culverts
Removal and disposal of known pipe culverts.

2010, 1.08, J, 3, a, 3) Removal of Known Pipes and Conduits
Removal, disposal, and plugging, if specified, of pipes and conduits.

Section 3010 - Trench Excavation and Backfill

3010, 1.08, A General
1. Standard trench excavation.
2. Removal and disposal of unsuitable backfill material encountered during standard trench excavation.
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. Sheeting, shoring, and bracing.
8. Adjusting the moisture content of excavated backfill material to the range specified for placement and compaction.

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 Replacement of Unsuitable Backfill Material
Furnishing, hauling, and placing backfill material.

3010, 1.08, E, 3 Special Pipe Embedment or Encasement
Furnishing and placing all required special pipe embedment or encasement materials.

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 bedding material, placing 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; trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill material; pipe connections; testing; and inspection.

J. Incidental or Included Items (Continued)

4010, 1.08, B, 1, c	Sanitary Sewer Gravity Main with Casing Pipe, Trenched Furnishing and installing both carrier pipe and casing pipe, 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; trenchless installation materials and equipment; pit excavation, dewatering, and placing 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 bedding material, placing bedding and backfill material, 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, and placing 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 bedding material, placing 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, and placing 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 bedding material, placing 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 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 bedding material, placing bedding and backfill material, compaction, and testing.
4010, 1.08, H, 3	Removal of Sanitary Sewer Removal, disposal, and capping (if specified) of pipe; and furnishing and placing backfill material.

J. Incidental or Included Items (Continued)

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 backfill.
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 backfill.

Section 4020 - Storm Sewers

4020, 1.08, A, 1, c	Storm Sewer, Trenched Trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, joint wrapping, wyes and other fittings, pipe joints, pipe connections, testing, and inspection. The length of elbows and tees of the pipes installed will be included in the length of pipe measured.
4020, 1.08, A, 2, c	Storm Sewer, Trenchless Furnishing and installing pipe; trenchless installation materials and equipment; pit excavation, dewatering, and placing 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 bedding material, placing 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, and placing backfill material; casing spacers; furnishing and installing annular space fill material; pipe connections; testing; and inspection.
4020, 1.08, C, 3	Removal of Storm Sewer Removal, disposal, and capping (if specified) of pipe; and furnishing and placing backfill material.
4020, 1.08, E, 3	Storm Sewer Abandonment, Plug Trench excavation if necessary, cutting pipe if required, furnishing and placing plug materials, and placing backfill.
4020, 1.08, F, 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 backfill.

J. Incidental or Included Items (Continued)

Section 4030 - Pipe Culverts

4030, 1.08, A, 1, c	Pipe Culvert, Trenched Trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, connectors, testing, and inspection. The length of elbows and tees of the pipes installed will be included in the length of pipe measured.
4030, 1.08, A, 2, c	Pipe Culvert, Trenchless Furnishing and installing pipe; trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill materials; pipe connections; testing; and inspection.
4030, 1.08, B, 3	Pipe Apron Trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, connectors, and other appurtenances.
4030, 1.08, C, 3	Footings for Concrete Pipe Aprons Excavation, dewatering, reinforcing steel, concrete, and placing bedding and backfill material.

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, D, 3	Subdrain or 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 Rehabilitation

4050, 1.08, A, 3	Pipe Lining Removal of internal obstructions, pipe cleaning, inspection, and all costs associated with the public information and notification program.
4050, 1.08, B, 3	Building Sanitary Sewer Service Reconnection Removal of internal obstructions, pipe cleaning, and all costs associated with the public information and notification program.

J. Incidental or Included Items (Continued)

4050, 1.08, C, 1, c	Spot Repairs (by Pipe Replacement) Uncovering and removing existing pipe, placing backfill material for replacement pipe, and restoring the surface.
4050, 1.08, C, 2, c	Spot Repairs (by Linear Foot) Furnishing and installing replacement pipe and connections.

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 bedding material, placing 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, and placing 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 bedding material, placing 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, and placing 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) Restrained joints and thrust blocks.
5010, 1.08, C, 2, c	Fitting (by weight) Restrained joints 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 bedding material, installation of tracer wire system for non-metallic service pipe, and placing bedding and backfill material.
5010, 1.08, E, 1, c	Water Service Stub (by length), Water Service Pipe Trench excavation, dewatering, furnishing bedding material, installation of tracer wire system for non-metallic service pipe, and placing bedding and backfill material.

J. Incidental or Included Items (Continued)

Section 5020 - Valves, Fire Hydrants, and Appurtenances

5020, 1.08, A, 3	Valve (Butterfly or Gate) 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, E	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 Replacement Removal of existing valve box; excavation; furnishing and installing new valve box; backfill; compaction; and all other necessary appurtenances.
5020, 1.08, H, 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, I, 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, J, 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, K, 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.

J. Incidental or Included Items (Continued)

Section 6010 - Structures for Sanitary and Storm Sewers

6010, 1.08, A, 3	Manhole Excavation, furnishing bedding material, placing bedding and backfill material, compaction, 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 bedding material, placing bedding and backfill material, compaction, base, structural concrete, reinforcing steel, precast units (if used), concrete fillets, pipe connections, castings, and adjustment rings.
6010, 1.08, C, 3	Drop Connection The connection to the manhole and all pipe, fittings, concrete encasement, and bedding and backfill material.
6010, 1.08, E, 3	Manhole or Intake 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, F, 3	Manhole or 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; installing new infiltration barrier (sanitary sewer manholes only); placing backfill material; and compaction.
6010, 1.08, G, 3	Connection to Existing Manhole or Intake Coring or cutting into the existing manhole or intake, pipe connectors, grout, and waterstop (when required).
6010, 1.08, H, 3	Remove Manhole or 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	Infiltration Barrier, Rubber Chimney Seal All necessary compression or expansion bands and extension sleeves as necessary to complete chimney seal.
6020, 1.08, A, 2, c	Infiltration Barrier, Molded Shield Sealant.
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.

J. Incidental or Included Items (Continued)

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, 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, 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, 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, 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 installing fiber board barrier, furnishing and placing modified subbase material, furnishing and installing reinforcing steel and tie bars, furnishing and placing concrete, furnishing, placing, and compacting HMA.
7010, 1.08, I, 3	PCC Pavement Samples and Testing Certified plant inspection, pavement thickness cores, profilograph pavement smoothness measurement (when required by the contract documents), and maturity testing.

J. Incidental or Included Items (Continued)

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, safety fencing, concrete for rigid headers, boxouts for fixtures, and pavement smoothness.

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	HMA Separation Layer for Unbonded PCC Overlay HMA 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.

Section 7020 - Hot Mix Asphalt Pavement

7020, 1.08, A, 3	Pavement, HMA (by ton) Asphalt mix with asphalt binder, tack coats between layers, construction zone protection, and quality control.
7020, 1.08, B, 3	Pavement, HMA (by square yard) Asphalt mix with asphalt binder, tack coats between layers, construction zone protection, and quality control.
7020, 1.08, C, 3	HMA Base Widening (by ton) Asphalt mix with asphalt binder, tack coats between layers, construction zone protection, and quality control.
7020, 1.08, D, 3	HMA Base Widening (by square yard) Asphalt mix with asphalt binder, tack coats between layers, construction zone protection, and quality control.

J. Incidental or Included Items (Continued)

7020, 1.08, E, 3	HMA 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 installing fiber board barrier, furnishing and placing modified subbase material, furnishing and applying tack coat, furnishing, placing, and compacting HMA.
7020, 1.08, I, 3	HMA Pavement Samples and Testing Certified plant inspection, pavement thickness cores, density analysis, profilograph pavement smoothness measurement (when required by the contract documents), and air void testing.

Section 7021 - Hot Mix Asphalt Overlays

7021, 1.08, A, 3	HMA Overlay (by ton) Asphalt mix with asphalt binder, tack coats between layers, construction zone protection, and quality control.
7021, 1.08, B, 3	HMA 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, 3	Removal of Sidewalk, Shared Use Path, or 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 Paths Subgrade preparation, jointing, sampling, smoothness testing and correction, and testing.
7030, 1.08, D, 3	Special Subgrade Preparation for Shared Use Paths 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.

J. Incidental or Included Items (Continued)

7030, 1.08, H, 1, c	Driveway, Paved Excavation, subgrade preparation, jointing, sampling, and testing.
7030, 1.08, H, 2, c	Driveway, Granular 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	Hot Mix Asphalt for Crack Filling Cleaning, applying tack coat, and furnishing and placing HMA 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.

J. Incidental or Included Items (Continued)

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	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	Bituminous Seal Coat (by units), 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	Bituminous Seal Coat (by units), 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	Emulsified Asphalt Slurry Seal (by units), Aggregate Surface preparation and furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts.
7070, 1.08, B, 2, c	Emulsified Asphalt Slurry Seal (by units), 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.

J. Incidental or Included Items (Continued)

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, placement of bedding course, installing permeable interlocking pavers, 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

7091, 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.
7091, 1.08, B, 3	Bituminous Recycling Agents Furnishing and placing of materials and mixing the agent into the recycled mix.
7091, 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.

J. Incidental or Included Items (Continued)

7091, 1.08, D, 3	Chemical Stabilization Agents Furnishing and placing of materials and mixing the agent into the reclaimed mix.
7091, 1.08, F, 3	Interlayer for Cement Stabilized Base Surface cleaning, furnishing, and placing of the specified interlayer.

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.

J. Incidental or Included Items (Continued)

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. 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 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, 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, 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, wrapping, staking or guying, herbicide, maintenance during the establishment period, and replacements.

J. Incidental or Included Items (Continued)

9030, 1.08, B, 3	Plants (by count), With Warranty Delivery, excavation, installation, watering, placing backfill material, mulching, wrapping, staking or guying, herbicide, 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, D, 1, c	Filter Socks, Installation Anchoring stakes.
9040, 1.08, D, 2, c	Filter Socks, 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.

J. Incidental or Included Items (Continued)

9040, 1.08, F, 1, c	Wattles, Installation Anchoring stakes.
9040, 1.08, F, 2, c	Wattles, Removal Restoration of the area to finished grade and off-site disposal of wattle and accumulated sediment.
9040, 1.08, G, 1, c	Check Dams, Rock Engineering fabric.
9040, 1.08, G, 2, a, 3)	Check Dams, Manufactured, Installation Anchoring stakes.
9040, 1.08, G, 2, b, 3)	Check Dams, 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 Structures Removal of the structure upon completion of the project.
9040, 1.08, I, 3	Level Spreaders 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	Rip Rap Engineering fabric.
9040, 1.08, K, 3	Temporary Pipe Slope Drains 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	Sediment Basin, Outlet Structure Concrete base, dewatering device, anti-vortex device, outlet pipe, and anti-seep collars (if specified).
9040, 1.08, L, 2, c	Sediment Basin, Removal of Sediment Dewatering and removal and off-site disposal of accumulated sediment.
9040, 1.08, L, 3, c	Sediment Basin, Removal of Outlet Structure Dewatering and off-site disposal of the outlet structure, concrete base, emergency spillway, and accumulated sediment.
9040, 1.08, M, 1, c	Sediment Trap Outlet, Installation Engineering fabric.
9040, 1.08, M, 2, c	Sediment Trap Outlet, Removal of Sediment Dewatering and removal and off-site disposal of accumulated sediment.
9040, 1.08, M, 3, c	Sediment Trap Outlet, Removal of Device Dewatering and off-site disposal of sediment trap outlet and accumulated sediment.

J. Incidental or Included Items (Continued)

9040, 1.08, N, 1, c	Silt Fence or Silt Fence Ditch Check, Installation Anchoring posts.
9040, 1.08, N, 2, c	Silt Fence or Silt Fence Ditch Check, Removal of Sediment Anchoring posts.
9040, 1.08, N, 3, c	Silt Fence or Silt Fence Ditch Check, Removal of Device Restoration of the area to finished grade and off-site disposal of fence, posts, and accumulated sediment.
9040, 1.08, O, 1, c	Stabilized Construction Entrance (by Square Yard) Subgrade stabilization fabric.
9040, 1.08, O, 2, c	Stabilized Construction Entrance (by Ton) Subgrade stabilization fabric.
9040, 1.08, P, 1, c	Dust Control, Water Furnishing, transporting, and distributing water to the haul road.
9040, 1.08, R, 3	Turf Reinforcement Mats (TRM) Excavation, staples, anchoring devices, and material for anchoring slots.
9040, 1.08, T, 1, c	Inlet Protection Device, Installation 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.
	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, 3	Chain Link Fence 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).

J. Incidental or Included Items (Continued)

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.

J. Incidental or Included Items (Continued)

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, 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.

J. Incidental or Included Items (Continued)

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 11,040 - 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.

K. Bid Items

The following is a list of standard bid items listed in the SUDAS Standard Specifications. The following are suggested bid items. This list may not be all-inclusive. The Engineer may make modifications as necessary.

Item Number	Bid Item	Unit
	Section 2010 - Earthwork, Subgrade, and Subbase	
2010-108-A-0	Clearing and Grubbing	UNIT
2010-108-B-0	Clearing and Grubbing	AC
2010-108-C-0	Clearing and Grubbing	LS
2010-108-D-1	Topsoil, On-site	CY
2010-108-D-2	Topsoil, Compost-amended	CY
2010-108-D-3	Topsoil, Off-site	CY
2010-108-E-0	Excavation, Class 10, Class 12, or Class 13	CY
2010-108-G-0	Subgrade Preparation	SY
2010-108-H-0	Subgrade Treatment, ____ (Type)	SY
2010-108-I-0	Subbase, ____ (Type)	SY
2010-108-J-1	Removal of Structure, ____ (Type)	EA
2010-108-J-2-a	Removal of Known Box Culvert, ____ (Type), ____ (Size)	LF
2010-108-J-2-c	Removal of Known Pipe Culvert, ____ (Type), ____ (Size)	LF
2010-108-J-3-a	Removal of Known Pipe and Conduit, ____ (Type), ____ (Size)	LF
2010-108-K-1	Filling and Plugging of Known Pipe Culverts, Pipes, and Conduits, ____ (Type), ____ (Size)	LF
2010-108-L-0	Compaction Testing	LS
	Section 3010 - Trench Excavation and Backfill	
3010-108-B-0	Rock Excavation	CY
3010-108-C-0	Trench Foundation	TON
3010-108-D-0	Replacement of Unsuitable Backfill Material	CY
3010-108-E-0	Special Pipe Embedment or Encasement	LF
3010-108-F-0	Trench Compaction Testing	LS
	Section 4010 - Sanitary Sewers	
4010-108-A-1	Sanitary Sewer Gravity Main, Trenched, ____ (Type), ____ (Size)	LF
4010-108-A-2	Sanitary Sewer Gravity Main, Trenchless, ____ (Type), ____ (Size)	LF
4010-108-B-1	Sanitary Sewer Gravity Main with Casing Pipe, Trenched, ___ (Type), ___ (Size)	LF
4010-108-B-2	Sanitary Sewer Gravity Main with Casing Pipe, Trenchless, ___ (Type), ___ (Size)	LF
4010-108-C-1	Sanitary Sewer Force Main, Trenched, ____ (Type), ____ (Size)	LF
4010-108-C-2	Sanitary Sewer Force Main, Trenchless, ____ (Type), ____ (Size)	LF
4010-108-D-1	Sanitary Sewer Force Main with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
4010-108-D-2	Sanitary Sewer Force Main with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF

K. Bid Items (Continued)

Item Number	Bid Item	Unit
4010-108-E-0	Sanitary Sewer Service Stub, ____ (Type), ____ (Size)	LF
4010-108-F-0	Sanitary Sewer Service Relocation	EA
4010-108-G-0	Sewage Air Release Valve and Pit	EA
4010-108-H-0	Removal of Sanitary Sewer, ____ (Type), ____ (Size)	LF
4010-108-I-0	Sanitary Sewer Cleanout	EA
4010-108-K-0	Sanitary Sewer Abandonment, Plug	EA
4010-108-L-0	Sanitary Sewer Abandonment, Fill and Plug	LF
	Section 4020 - Storm Sewers	
4020-108-A-1	Storm Sewer, Trenched, ____ (Type), ____ (Size)	LF
4020-108-A-2	Storm Sewer, Trenchless, ____ (Type), ____ (Size)	LF
4020-108-B-1	Storm Sewer with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
4020-108-B-2	Storm Sewer with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
4020-108-C-0	Removal of Storm Sewer, ____ (Type), ____ (Size)	LF
4020-108-E-0	Storm Sewer Abandonment, Plug	EA
4020-108-F-0	Storm Sewer Abandonment, Fill and Plug	LF
	Section 4030 - Pipe Culverts	
4030-108-A-1	Pipe Culvert, Trenched, ____ (Type), ____ (Size)	LF
4030-108-A-2	Pipe Culvert, Trenchless, ____ (Type), ____ (Size)	LF
4030-108-B-0	Pipe Apron, ____ (Type), ____ (Size)	EA
4030-108-C-0	Footing for Concrete Pipe Apron, ____ (Type), ____ (Size)	EA
4030-108-D-0	Pipe Apron Guard	EA
	Section 4040 - Subdrains and Footing Drain Collectors	
4040-108-A-0	Subdrain, ____ (Type), ____ (Size)	LF
4040-108-B-0	Footing Drain Collector, ____ (Type), ____ (Size)	LF
4040-108-C-0	Subdrain Cleanout, ____ (Type), ____ (Size)	EA
4040-108-C-0	Footing Drain Cleanout, ____ (Type), ____ (Size)	EA
4040-108-D-0	Subdrain Outlets and Connections, ____ (Type), ____ (Size)	EA
4040-108-D-0	Footing Drain Outlets and Connections, ____ (Type), ____ (Size)	EA
4040-108-E-0	Storm Sewer Service Stub, ____ (Type), ____ (Size)	LF
	Section 4050 - Pipe Rehabilitation	
4050-108-A-0	Pipe Lining, ____ (Type), ____ (Size)	LF
4050-108-B-0	Building Sanitary Sewer Service Reconnection	EA
4050-108-C-1	Spot Repairs by Pipe Replacement	EA
4050-108-C-2	Spot Repairs by Pipe Replacement	LF
	Section 5010 - Pipe and Fittings	
5010-108-A-1	Water Main, Trenched, ____ (Type), ____ (Size)	LF
5010-108-A-2	Water Main, Trenchless, ____ (Type), ____ (Size)	LF

K. Bid Items (Continued)

Item Number	Bid Item	Unit
5010-108-B-1	Water Main with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
5010-108-B-2	Water Main with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
5010-108-C-1	Fitting, ____ (Type), ____ (Size)	EA
5010-108-C-2	Fitting, ____ (Type), ____ (Size)	LB
5010-108-D-0	Water Service Stub, ____ (Type), ____ (Size)	EA
5010-108-E-1	Water Service Pipe, ____ (Type), ____ (Size)	LF
5010-108-E-2	Water Service Corporation, ____ (Type), ____ (Size)	EA
5010-108-E-3	Water Service Curb Stop and Box, ____ (Type), ____ (Size)	EA
	Section 5020 - Valves, Fire Hydrants, and Appurtenances	
5020-108-A-0	Valve, ____ (Type), ____ (Size)	EA
5020-108-B-0	Tapping Valve Assembly, ____ (Size)	EA
5020-108-C-0	Fire Hydrant Assembly	EA
5020-108-D-0	Flushing Device (Blowoff), ____ (Size)	EA
5020-108-F-0	Valve Box Extension	EA
5020-108-G-0	Valve Box Replacement	EA
5020-108-H-0	Fire Hydrant Adjustment	EA
5020-108-I-0	Fire Hydrant Assembly Removal	EA
5020-108-J-0	Valve Removal	EA
5020-108-K-0	Valve Box Removal	EA
	Section 6010 - Structures for Sanitary and Storm Sewers	
6010-108-A-0	Manhole, ____ (Type), ____ (Size)	EA
6010-108-B-0	Intake, ____ (Type), ____ (Size)	EA
6010-108-C-0	Drop Connection	EA
6010-108-D-0	Casting Extension Ring	EA
6010-108-E-0	Manhole Adjustment, Minor	EA
6010-108-E-0	Intake Adjustment, Minor	EA
6010-108-F-0	Manhole Adjustment, Major	EA
6010-108-F-0	Intake Adjustment, Major	EA
6010-108-G-0	Connection to Existing Manhole	EA
6010-108-G-0	Connection to Existing Intake	EA
6010-108-H-0	Remove Manhole	EA
6010-108-H-0	Remove Intake	EA
	Section 6020 - Rehabilitation of Existing Manholes	
6020-108-A-0	Infiltration Barrier, ____ (Type)	EA
6020-108-B-0	In-situ Manhole Replacement, Cast-in-place Concrete	VF
6020-108-C-0	In-situ Manhole Replacement, Cast-in-place Concrete with Plastic Liner	VF
6020-108-D-0	Manhole Lining with Centrifugally Cast Cementitious Mortar Liner with Epoxy Seal	VF

K. Bid Items (Continued)

Item Number	Bid Item	Unit
	Section 7010 - Portland Cement Concrete Pavement	
7010-108-A-0	Pavement, PCC, ____ (Thickness)	SY
7010-108-E-0	Curb and Gutter, ____ (Width), ____ (Thickness)	LF
7010-108-F-0	Beam Curb	LF
7010-108-G-0	Concrete Median	SY
7010-108-H-0	PCC Railroad Crossing Approach	SY
7010-108-I-0	PCC Pavement Samples and Testing	LS
7010-108-K-0	PCC Pavement Widening, ____ (Thickness)	SY
	Section 7011 - Portland Cement Concrete Overlays	
7011-108-A-1	PCC Overlay, Furnish Only	CY
7011-108-A-2	PCC Overlay, Place Only	SY
7011-108-A-3	Surface Preparation for Bonded PCC Overlay	SY
7011-108-A-4	Surface Preparation for Unbonded PCC Overlay	SY
7011-108-A-5	HMA Separation Layer for Unbonded PCC Overlay	SY
7011-108-A-6	Geotextile Fabric Separation Layer for Unbonded PCC Overlay	SY
	Section 7020 - Hot Mix Asphalt Pavement	
7020-108-A-0	Pavement, HMA	TON
7020-108-B-0	Pavement, HMA, ____ (Thickness)	SY
7020-108-C-0	HMA Base Widening	TON
7020-108-D-0	HMA Base Widening, ____ (Thickness)	SY
7020-108-E-0	HMA Railroad Crossing Approach	SY
7020-108-I-0	HMA Pavement Samples and Testing	LS
	Section 7021 - Hot Mix Asphalt Overlays	
7021-108-A-0	HMA Overlay	TON
7021-108-B-0	HMA Overlay, ____ (Thickness)	SY
	Section 7030 - Sidewalks, Shared Use Paths, and Driveways	
7030-108-A-0	Removal of Sidewalk	SY
7030-108-A-0	Removal of Shared Use Path	SY
7030-108-A-0	Removal of Driveway	SY
7030-108-B-0	Removal of Curb	LF
7030-108-C-0	Shared Use Path, ____ (Type), ____ (Thickness)	SY
7030-108-D-0	Special Subgrade Preparation for Shared Use Path	SY
7030-108-E-0	Sidewalk, PCC, ____ (Thickness)	SY
7030-108-F-0	Brick/Paver Sidewalk with Pavement Base	SY
7030-108-G-0	Detectable Warnings	SF
7030-108-H-1	Driveway, Paved, ____ (Type), ____ (Thickness)	SY
7030-108-H-2	Driveway, Granular	SY or TON
7030-108-I-0	Sidewalk Assurance Testing	LS
7030-108-I-0	Shared Use Path Assurance Testing	LS
7030-108-I-0	Driveway Assurance Testing	LS

K. Bid Items (Continued)

Item Number	Bid Item	Unit
	Section 7040 - Pavement Rehabilitation	
7040-108-A-0	Full Depth Patches	SY
7040-108-B-0	Subbase Over-excavation	TON
7040-108-C-0	Partial Depth Patches	SF
7040-108-D-0	Crack and Joint Cleaning and Filling, Hot Pour	LF
7040-108-E-1	Crack Cleaning and Filling, Emulsion	LF
7040-108-E-2	Hot Mix Asphalt for Crack Filling	TON
7040-108-F-0	Diamond Grinding	SY
7040-108-G-0	Milling	SY
7040-108-H-0	Pavement Removal	SY
7040-108-I-0	Curb and Gutter Removal	LF
7040-108-J-0	Dowel Bar Retrofit	EA
	Section 7050 - Asphalt Stabilization	
7050-108-A-0	Asphalt Stabilization	SY
	Section 7060 - Bituminous Seal Coat	
7060-108-A-0	Bituminous Seal Coat	SY
7060-108-B-1	Cover Aggregate, ____ (Size)	TON
7060-108-B-2	Binder Bitumen	GAL
	Section 7070 - Emulsified Asphalt Slurry Seal	
7070-108-A-0	Emulsified Asphalt Slurry Seal	SY
7070-108-B-1	Aggregate, ____ (Size)	TON
7070-108-B-2	Asphalt Emulsion	GAL
	Section 7080 - Permeable Interlocking Pavers	
7080-108-B-0	Engineering Fabric	SY
7080-108-C-0	Underdrain, ____ (Type), ____ (Size)	LF
7080-108-D-0	Storage Aggregate	TON
7080-108-E-0	Filter Aggregate	TON
7080-108-F-0	Permeable Interlocking Pavers, ____ (Type)	SY
7080-108-G-0	PCC Edge Restraint, ____ (Type), ____ (Size)	LF
	Section 7090 - Cold-in-Place Pavement Recycling	
7090-108-A-0	Cold-in-Place Recycling	SY
7090-108-B-0	Bituminous Recycling Agents	GAL
7090-108-C-0	Chemical Recycling Additives	TON

K. Bid Items (Continued)

Item Number	Bid Item	Unit
	Section 7091 - Full Depth Reclamation	
7091-108-A-0	Full Depth Reclamation	SY
7091-108-B-0	Mechanical Stabilization Agents	TON
7091-108-C-0	Bituminous Stabilization Agents	GAL
7091-108-D-0	Chemical Stabilization Agents	TON
7091-108-E-0	Microcracking	SY
7091-108-F-0	Interlayer for Cement Stabilized Base, ____ (Type), ____ (Thickness)	SY
	Section 8010 - Traffic Control	
8010-108-A-0	Traffic Signal	LS
8010-108-B-0	Temporary Traffic Signal	LS
	Section 8020 - Pavement Markings	
8020-108-B-0	Painted Pavement Markings, Solvent/Waterborne	STA
8020-108-C-0	Painted Pavement Markings, Durable	STA
8020-108-D-0	Painted Pavement Markings, High-Build	STA
8020-108-E-0	Permanent Tape Markings	STA
8020-108-F-0	Wet, Retroreflective Removable Tape Markings	STA
8020-108-G-0	Painted Symbols and Legends	EA
8020-108-H-0	Precut Symbols and Legends	EA
8020-108-I-0	Temporary Delineators	EA
8020-108-J-0	Raised Pavement Markers	EA
8020-108-K-0	Pavement Markings Removed	STA
8020-108-L-0	Symbols and Legends Removed	EA
8020-108-M-0	Grooves Cut for Pavement Markings	STA
8020-108-N-0	Grooves Cut for Symbols and Legends	EA
	Section 8030 - Temporary Traffic Control	
8030-108-A-0	Temporary Traffic Control	LS
	Section 9010 - Seeding	
9010-108-A-0	Conventional Seeding, Seeding, Fertilizing, and Mulching	AC
9010-108-B-0	Hydraulic Seeding, Seeding, Fertilizing, and Mulching	AC
9010-108-C-0	Pneumatic Seeding, Seeding, Fertilizing, and Mulching	AC
9010-108-D-0	Watering	MGAL
9010-108-E-0	Warranty	LS
	Section 9020 - Sodding	
9020-108-A-0	Sod	SQ
	Section 9030 - Plant Material and Planting	
9030-108-A-0	Plants, ____ (Type)	EA
9030-108-B-0	Plants with Warranty, ____ (Type)	EA
9030-108-C-0	Plants	LS

K. Bid Items (Continued)

Item Number	Bid Item	Unit
9030-108-D-0	Plants with Warranty	LS
9030-108-E-0	Tree Drainage Wells	EA
	Section 9040 - Erosion and Sediment Control	
9040-108-A-1	SWPPP Preparation	LS
9040-108-A-2	SWPPP Management	LS
9040-108-B-0	Compost Blanket, ____ (Thickness)	SF
9040-108-C-0	Filter Berm, ____ (Size)	LF
9040-108-D-1	Filter Sock, ____ (Size)	LF
9040-108-D-2	Filter Sock, Removal	LF
9040-108-E-0	Temporary RECP, ____ (Type)	SY
9040-108-F-1	Wattle, ____ (Type), ____ (Size)	LF
9040-108-F-2	Wattle, Removal	LF
9040-108-G-1	Check Dam, Rock	TON
9040-108-G-2-a	Check Dam, Manufactured, ____ (Type), ____ (Size)	LF
9040-108-G-2-b	Check Dam, Manufactured, Removal, ____ (Type)	LF
9040-108-H-0	Temporary Earth Diversion Structure, ____ (Type), ____ (Size)	LF
9040-108-I-0	Level Spreader	LF
9040-108-J-0	Rip Rap, ____ (Type)	TON
9040-108-K-0	Temporary Pipe Slope Drain, ____ (Type), ____ (Size)	LF
9040-108-L-1	Sediment Basin, Outlet Structure, ____ (Size)	EA
9040-108-L-2	Sediment Basin, Removal of Sediment	EA
9040-108-L-3	Sediment Basin, Removal of Outlet Structure	EA
9040-108-M-1	Sediment Trap Outlet	TON
9040-108-M-2	Sediment Trap Outlet, Removal of Sediment	EA
9040-108-M-3	Sediment Trap Outlet, Removal of Device	EA
9040-108-N-1	Silt Fence or Silt Fence Ditch Check	LF
9040-108-N-2	Silt Fence or Silt Fence Ditch Check, Removal of Sediment	LF
9040-108-N-3	Silt Fence or Silt Fence Ditch Check, Removal of Device	LF
9040-108-O-1	Stabilized Construction Entrance	SY
9040-108-O-2	Stabilized Construction Entrance	TON
9040-108-P-1	Dust Control, Water	MGAL
9040-108-P-2	Dust Control, Product	SY
9040-108-Q-1	Erosion Control Mulching, Conventional	AC
9040-108-Q-2	Erosion Control Mulching, Hydromulching	AC
9040-108-R-0	Turf Reinforcement Mats, ____ (Type)	SQ
9040-108-S-0	Surface Roughening	SF
9040-108-T-1	Inlet Protection Device, ____ (Type)	EA
9040-108-T-2	Inlet Protection Device, Maintenance	EA
9040-108-U-0	Flow Transition Mat	SF

K. Bid Items (Continued)

Item Number	Bid Item	Unit
	Section 9050 - Gabions and Revet Mattresses	
9050-108-A-0	Gabions, ____ (Type)	CY
9050-108-B-0	Revet Mattresses, ____ (Type)	CY
	Section 9060 - Chain Link Fence	
9060-108-A-0	Chain Link Fence, ____ (Type), ____ (Size)	LF
9060-108-B-0	Gates, ____ (Type), ____ (Size)	EA
9060-108-C-0	Barbed Wire, ____ (Type of Supporting Arm)	LF
9060-108-D-0	Removal and Reinstallation of Existing Fence, ____ (Type), ____ (Size)	LF
9060-108-E-0	Removal of Fence	LF
9060-108-F-0	Temporary Fence, ____ (Type), ____ (Size)	LF
	Section 9070 - Landscape Retaining Walls	
9070-108-A-0	Modular Block Retaining Wall	SF
9070-108-B-0	Limestone Retaining Wall	SF
9070-108-C-0	Landscape Timbers	SF
	Section 9071 - Segmental Block Retaining Walls	
9071-108-A-0	Segmental Block Retaining Wall	SF
9071-108-C-0	Granular Backfill Material	TON
	Section 9072 - Combined Concrete Sidewalk and Retaining Wall	
9072-108-A-0	Combined Concrete Sidewalk and Retaining Wall	CY
	Section 9080 - Concrete Steps, Handrails, and Safety Rail	
9080-108-A-0	Concrete Steps, ____ (Type)	SF
9080-108-B-0	Handrail, ____ (Type)	LF
9080-108-C-0	Safety Rail	LF
	Section 10,010 - Demolition	
10,010-108-A	Demolition Work	LS
10,010-108-B	Plug or Abandon Well	EA
	Section 11,010 - Construction Survey	
11,010-108-A	Construction Survey	LS
11,010-108-B	Monument Preservation and Replacement	LS
	Section 11,020 - Mobilization	
11,020-108-A	Mobilization	LS

K. Bid Items (Continued)

Item Number	Bid Item	Unit
	Section 11,030 - Temporary Services During Construction	
11,030-108-A-0	Maintenance of Postal Service	LS
11,030-108-B-0	Maintenance of Solid Waste Collection	LS
	Section 11,040 - Temporary Sidewalk Access	
11,040-108-A-0	Temporary Pedestrian Residential Access	SY
11,040-108-B-0	Temporary Granular Sidewalk	SY
11,040-108-C-0	Temporary Longitudinal Channelizing Device	LF
	Section 11,050 - Concrete Washout	
11,050-108-A-0	Concrete Washout	LS

Public Improvement Contracts

A. General

Public improvements contracts should be used to ensure construction of all public improvements to the standards provided by the Jurisdiction. These contracts may also be used between the developer, contractor, and the Jurisdiction for private subdivision or site developments. After the plans and the contract have been given Jurisdictional approval, changes should not be made in the design or scope of work without addenda or a change order approved by the Jurisdiction.

If the change involves engineering details shown on the plans, the original plans (depending on the Jurisdiction's requirements, plans may be held by the Project Engineer or Jurisdiction) should be modified by the Project Engineer and should accompany a change order. Work on portions of the project involved in the change order should not be performed until the change order is approved by the Jurisdiction.

B. Contract Documents

The Project Engineer should use the contract documents required by the Jurisdiction. Sample contract document forms are available on the SUDAS website at www.iowasudas.org.

The following items are typically included in the contract documents:

1. Notice to Bidders and Notice to Public Hearing

2. Instructions to Bidders

3. Proposal
   - Part A - Scope of Work
   - Part B - Acknowledgement of Addenda
   - Part C - Bid Items, Quantities, and Prices
   - Part D - General
   - Part E - Additional Requirements
   - Part G - Identity of Bidder
   - Proposal Attachments

4. Bid Bond

5. Contract and Contract Attachment

6. Performance, Payment, and Maintenance Bond

2) Discuss design calculations. Depending on the complexity of the design, these may range from a single steady-state equation (i.e. Manning's) to a step calculation including several channel cross-sections, culverts, and bridges.
3) Discuss the overall grading plan in terms of controlling runoff along lot lines and preventing runoff from adversely flowing onto adjacent lots.
4) The limits of swale and ditch easements will be established based upon the required design frequency. This includes 100 year overflow easements from stormwater controlled structures.

e. Storm Drainage Outlets and Downstream Analysis:

1) Discuss soil types, permissible and calculated velocity at outlets, energy dissipater design, and drainage impacts on downstream lands. Provide calculations for the energy dissipater dimensions, size, and thickness of rip rap revetment (or other material) and filter layer.
2) Include a plan and cross-sections of the drainage way downstream of the outlet, indicating the flow line slope and bank side slopes. Identify soil types on the plan.
3) Perform downstream analysis. The downstream analysis will show what impacts, if any, a project will have on the drainage systems downstream of the project site. The analysis consists of three elements: review of resources, inspection of the affected area, and analysis of downstream effects.
    a) During the review of resources, review any existing data concerning drainage of the project area. This data will commonly include area maps, floodplain maps, wetland inventories, stream surveys, habitat surveys, engineering reports concerning the entire drainage basin, known drainage problems, and previously completed downstream analyses.
    b) Physically inspect the drainage system at the project site and downstream of it. During the inspection, investigate any problems or areas of concern that were noted during the review of resources. Identify any existing or potential capacity problems in the drainage system, flood-prone areas, areas of channel destruction, erosion and sediment problems, or areas of significant destruction of natural habitat.
    c) Analyze the information gathered during the review of resources and field inspection, to determine if the project will create any drainage problems downstream or will make any existing problems worse. Note there are situations that even when minimum design standards are met the project will still have negative downstream impacts. Whenever this situation occurs, mitigation measures must be included in the project to correct for the impacts.

f. Hydraulic Model: If the design warrants hydraulic modeling, state the method used. Typical modeling programs include:

1) HEC-RAS - River Analysis Systems
2) HEC-2 - Water Surface Profiles
3) SWMM - Storm Water Management Model
4) WSPRO - Water Surface Profiles
5) HY-8 - Hydraulic Design of Highway Culverts
6) Other commercial or public domain programs approved by the Jurisdiction.

4. Stormwater Facilities Design:

a. Design Standards: All stormwater management facilities will be designed according to these design standards at a minimum. The following references may provide helpful design information for stormwater detention and water quality issues.

1) *Urban Drainage Design Manual* (Hydraulic Engineering Circular No. 22).

2) *Design and Construction of Urban Stormwater Management Systems*. Manual of Practice No.77
3) *Urban Runoff Quality Management*. Manual of Practice No. 87
4) *Stormwater Detention for Drainage, Water Quality, and CSO Management*

b. Detention Basin Location: Describe basin site. Discuss existing topography and relationship to basin grading. Determine if construction will be affected by rock deposits. Also determine if a high water table precludes basin storage. Floodplain locations should be avoided.

c. Detention Basin Performance: The following summarize the recommended detention requirements. The Jurisdiction may adopt different standards or modify these requirements on a case by case basis depending on existing drainage conditions, flooding problems, or future development. The designer should verify the detention requirements with the Jurisdiction for each proposed project.

1) After development, the release rate of runoff for rainfall events having an expected return frequency of 2 years should not exceed the existing, pre-developed peak runoff rate from that same storm.
2) For rainfall events having an expected return frequency of 5, 10, 25, 50, and 100 years, the rate of runoff from the developed site should not exceed the existing, pre-developed peak runoff rate from a 5 year frequency storm of the same duration unless limited by downstream conveyance. Provide a table summarizing these release rates. Also provide a stage-storage-discharge table. These tables are also to be shown in Table 2A-4.03. State the minimum freeboard provided and at what recurrence interval the basin overtops.
3) Discuss the effects on the overall stormwater system by detention basins in contributing offsite areas. If contributing offsite areas are presently undeveloped, discuss assumptions about future development and stormwater detention.
4) Calculate the basin overflow release rate. This equals the onsite 100 year post-developed peak discharge plus the contributing offsite 100 year post developed peak discharge. Include this calculation with Table 2A-4.03.

d. Detention Basin Outlet:

1) The single-stage outlet (i.e. one culvert pipe) is not recommended because of its inability to detain post-developed runoff from storms less than the 5 year interval. In many cases, runoff from storm events less than the 5 year recurrence interval has created erosion and sedimentation problems downstream of the detention basin.
2) A more desirable outlet has two or more stages. An orifice structure serves to detain runoff for water quality purposes and release runoff for low-flow events of a 2 year storm. Greater storm events are usually discharged by a separate outlet.
3) Discuss the basin outlet design in terms of performance during low- and high-flows, and downstream impact.

e. Spillway and Embankment Protection:

1) Design the spillway for high flows using weir and/or spillway design methods. The steady-state open channel flow equation is not intended for use in spillway design.
2) Describe methods to protect the basin during overtopping flow.

f. TR-55 Design Limitations: TR-55 includes a method for estimating required storage volume based upon peak inflow, peak outflow, and total runoff volume. This method may result in storage errors of 25% and should not be used in final design. The detention basin size in final design should be based upon actual hydrograph routing utilizing methods such as WINTR-55 or TR-20.

5. **Permits:** Indicate what permits have been applied for and received. Submit Iowa DNR approval letter and report for sites affecting unnumbered A-zones, as delineated on Flood Insurance Rate Maps.

6. **References:** Provide a list of all references cited, in bibliographical format.

7. **Appendix:** Drawings and calculations in the Appendix should include, but are not limited to, the following items.

   a. Drawings:
   1) A preliminary plat (pre-and post-topography) may be used to show the proposed development. Minimum scale of 1 inch = 500 feet or larger to ensure legibility should be used for all drainage areas. (Drawings no larger than 24 inches by 36 inches should be inserted in 8 1/2 inch by 11 inch sleeves in the back of the bound report). The plat is to show street layout and/or building location on a contour interval not to exceed 2 feet. The map must show on- and off-site conditions. Label flow patterns used to determine times of concentration.
   2) Drainage plans (preliminary plat or topography map) must extend a minimum of 250 feet from the edge of the proposed preliminary plat boundary, or a distance specified by Jurisdiction. The limits of swale and ditch easements should be established based upon the required design frequency. This includes 100 year overflow easements from stormwater controlled structures.
   3) Overall drainage basin (or sub-basin) and location of proposed site within the basin.
   4) Soil map or geotechnical information.
   5) Location and elevations of jurisdictional benchmarks. All elevations should be on jurisdictional datum.
   6) Proposed property lines (if known).
   7) If the preliminary plat does not include proposed grades, submit a grading and erosion control plan showing existing and proposed streets, names, and approximate grades.
   8) Existing drainage facilities and structures, including existing roadside ditches, drainageways, gutter flow directions, culverts, etc. All pertinent information such as size, shape, slope location, 100 year flood elevation, and floodway fringe line (where applicable) should also be included to facilitate review and approval of drainage plans.
   9) Proposed storm sewers and open drainageways, right-of-way and easement width requirements, 100 year overland flow easement, proposed inlets, manholes, culverts, erosion and sediment control, water quality (pollution) control and energy dissipation devices, and other appurtenances.
   10) Proposed outfall point for runoff from the study area.
   11) The 100 year flood elevation and major storm floodway fringe (where applicable) are to be shown on the plans, report drawings, and plats (preliminary and final). In addition, the report should demonstrate that the stormwater system has adequate capacity to handle a 100 year storm event, or provisions are made for overland flow.
   12) Show the critical minimum lowest opening elevation of a building for protection from major and minor storm runoff. This elevation is to be reviewed with the Jurisdiction to confirm if previous changes were made to the minimum lowest opening elevation for major storm event.

   b. Calculations:
   1) Determine runoff coefficients and curve numbers
   2) Determine times of concentration
   3) Calculations for intake capacity, sewer design, and culvert design
   4) Peak discharge calculations - show results in tabular format and pre- and post-developed hydrographs

5) Detention basin design - show tabular stage-storage-discharge results and inflow/outflow hydrographs
6) Detention basin outlet design
7) Open channel flow calculations
8) Erosion protection design

Table 2A-4.01: Hydrology Summary

	Area 1				**Area 2**			
	Onsite		***Offsite***		***Onsite***		***Offsite***	
	Pre	***Post***	***Pre***	***Post***	***Pre***	***Post***	***Pre***	***Post***
Size (Acres)								
Predominant Land Use								
Watershed Length								
Time of Concentration								
Runoff Coefficient								
Runoff (Q)								
2 yr								
5 yr								
10 yr								
25 yr								
50 yr								
100 yr								

Table 2A-4.02: Hydrology Summary (Critical Points)

Design Flows	**Critical Point 1**	**Critical Point 2**	**Critical Point 3**	**Critical Point 4**
2 yr				
5 yr				
10 yr				
25 yr				
50 yr				
100 yr				

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5L Access Management

5M Complete Streets

5N Traffic Impact Studies

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Asphalt Pavement Mixture Selection

A. Scope

This section is intended for the engineers and technicians who specify asphalt paving material criteria for urban projects, generally ranging from low to medium volume, up to 10M ESALs. Vehicle volumes exceeding 10M $ESAL_{20}$, or projects outside of these design standards, may require more detailed design and/or expert consultation. The section provides a step-by-step process for determining the appropriate mixture criteria and gives the designer additional background information on specific mixture criteria. The section is intended to assist in selecting the mixture criteria that best satisfy the project demands and limitations. Statewide use of this section will improve the standard application of current accepted gyratory mix design technology. In accordance with AASHTO and Iowa DOT Materials I.M. 510, mixture selection involves the use of a 20 year design life whereas pavement thickness design is based on a 50 year design life.

B. Definitions

Equivalent Single Axle Load (ESAL): A standard unit of pavement damage created by a single pass of a vehicle axle.

Car axle = 0.0002 ESAL 18kip truck axle = 1.0 ESAL 24kip truck axle = 3.0 ESAL

$ESAL_{20}$: Estimated cumulative ESALs over a 20 year period.

N: The number of gyratory compaction revolutions at which HMA mixture properties are measured. N_{des} represents 20 years of traffic loading.

Gyratory Mix Design: A laboratory process for achieving desired pavement performance by determining the optimum proportions of aggregates and asphalt binder for hot mix asphalt using a SHRP Superpave gyratory compactor.

Lift Designation (Surface, Intermediate, Base): The terms for the lifts in the hot mix asphalt pavement structure. The surface lift is the top lift, about 1 1/2 inches thick. The intermediate lift(s) is one or more lifts placed under the surface lift, generally 2 to 4 inches thick. The base lift(s) is all mixture placed below the intermediate lift, generally limited to full depth construction.

Modified Asphalt Binders: For design traffic levels greater than 1,000,000 ESALs (High, Very High, and Extremely High), the binders may need to be modified and thus may be more costly.

Nominal Maximum Aggregate Size (NMAS): The mixture size designation used for the combined aggregate gradation. Defined as one sieve size larger than the first sieve to retain more than 10%.

Performance Graded (PG): National asphalt binder grading system, developed by AASHTO, based on high and low pavement operating temperatures (°C). A PG binder is identified using a nomenclature of PG XXYY, followed by an ESAL designation (L, S, H, V, E). The XX is the high pavement temperature in degrees Celsius in which the binder should resist rutting. The YY, in negative Celsius, is the low pavement temperature in which the binder should resist cracking. For example a PG 58-28S should resist rutting to 58 °C and cracking of the pavement to a temperature of -28 °C under standard (0.3 M to 1 M ESALs) traffic loading.

C. Design Checklist

Designers should follow the steps below to ensure that the material criteria selected will best meet the needs of the project and the constraints of the owner agency.

1. **Determine the Level of Traffic Forecasted for the Next 20 Years:** Both current and future traffic levels are needed to determine the appropriate asphalt mixture for the project. Even if the project is not expected to remain in place for 20 years, the material selection levels are based on 20 year values. Common values are average daily traffic (ADT) for the current year, ADT for the 20 year forecast, and percent trucks. In addition to these annualized daily values, the designer should consider potential seasonal high truck volumes, and give particular attention to point sources and future development areas that may generate heavy truck volumes, like quarries, industrial parks, and bus lanes. Seasonal truck volumes may reflect a rate of pavement loading well in excess of the annualized values.

2. **Understand the Pavement Section Design or Rehabilitation Strategy:** In order to make the proper mixture selection, the designer must have knowledge of the proposed pavement construction or rehabilitation and intended pavement performance. The thickness of the pavement will also affect the material and mixture selection. Particular parameters include required structural thickness, existing pavement cross section and condition (dominant distress patterns), traffic patterns and speed, and past maintenance.

3. **Determine the Regional Climate Conditions:** Iowa's 1 day low pavement temperature ranges approximately 5°C from north to south. Adjusted for 98% reliability, the values range from -28 °C to -24 °C. The 7 day high pavement temperature across the state only varies by 3 °C. These values are computed from daily high air temperatures. Adjusted for 98% reliability, the pavement temperature values range from 56 °C to 59 °C. Climate details for a specific location can be obtained from the LTPPB software package available on the FHWA website (https://infopave.fhwa.dot.gov/). See Figures 5D-1.01 and 5D-1.02.

4. **Compute the Anticipated 20 Year Pavement Loading:** The design pavement loading is the starting point for selecting the material and mixture selection criteria. The design pavement loading is measured in ESALs, not ADT. To determine the design ESALs on the project, use the traffic conditions from Step 1 and compute the $ESAL_{20}$. Use the examples outlined in Examples 5D-1.01 and 5D-1.02, for two lane, two way traffic; use Example 5D-1.03 for urban multi-lane situations. Design ESAL levels for asphalt criteria selection are divided into relatively large brackets. While a firm understanding of the traffic and pavement loading is important, good approximations of truck traffic are normally sufficient to determine the design requirements.

5. **Identify Any Special Conditions that Impact the Pavement:** The standard selection process is based on high speed traffic with a broad distribution of vehicle types. There are numerous special conditions that may, through engineering judgement, require changes in the standard pavement materials/mixture selection. These special conditions are outlined below.

    a. **Heavy Trucks:** If the pavement's history has regularly been impacted by heavy trucks, the designer may consider increasing either the binder grade through the designation of a higher design traffic loading, the mix designation (ESAL level), or both. Typical examples of this condition are routes adjacent to quarries, grain elevators, or regional commercial freight distribution centers.

b. Slow/Stop/Turning: Urban roadways normally require slower running speeds and often include signed or signaled intersections. The pavement loading condition significantly increases at slower speeds (less than 45 MPH) and stopped vehicles at intersections. The designer may consider increasing the binder grade through the designation of a higher design traffic loading and/or the percent of crushed aggregate to account for this condition. Economics will determine if the higher grade of binder can be applied to the whole project, or just the impacted length of pavement (i.e. intersection and approaches).

c. Durability: Many low-volume asphalt pavements are more susceptible to failure due to long term aging than to rutting or fatigue. For pavements with good maintenance histories the designer may want to ensure that the mixture selection will provide adequate durability and, if economically necessary, sacrifice some reliability against rutting or fatigue. This can be accomplished through the selection of a lower compaction level and/or the selection of a softer grade of binder.

d. Urban vs. Rural: Separate from the issue of traffic speed, rural projects that pass through urban locations should consider mix sizes (NMAS) that will appeal to the pedestrian traffic. In general, smaller mix sizes will have a better surface appearance than larger mix sizes. The designer can specify smaller mix sizes than those provided in the material selection guide table, but should also consider the availability of the aggregates when making that decision. Similarly, the designer may choose to use a larger mix size on rural sections for the purpose of reducing the asphalt binder content in the mixture.

e. New Construction vs. Rehabilitation: The design guide takes into account the major pavement performance factors including rutting, fatigue, and low temperature cracking. When an overlay is placed directly on a slab to be rehabilitated, the existing pavement distress influences the overlay performance and thus the design. If the underlying pavement is PCC or asphalt with thermocracking, the reflective cracking in the overlay will dominate over low temperature cracking so the design parameters related to low temperature cracking for the overlay become less of a factor in the design. If a stress relief layer is included in the overlay design, low temperature cracking should be considered.

f. Seasonal Traffic: Seasonal traffic occurs over a relatively short period of time and may create pavement damage in excess of the normal traffic. For example, grain harvest, Iowa State Fair, festivals, etc. may generate higher volumes (in terms of ESALs) of traffic for a short period of time. This does not only take into account traffic volumes, but also pavement loads.

g. Mixture Workability: Smaller mixture sizes are easier to use for hand work.

6. Select the HMA Mixture Criteria for Each Pavement Layer: Using the information developed in steps 1 through 5, select the PG binder grade, mixture size, mix design level, and aggregate properties.

a. PG Asphalt Binder Grade: Engineers should evaluate the initial costs, traffic loadings, historical experience, and potential maintenance costs when selecting the appropriate binder for a project. The designer should select a binder that nominally satisfies 98% temperature reliability for both the 7 day high pavement temperature and the 1 day low pavement temperature (see 5D-1, C, 3). The 98% reliability level described by LTPP Bind designates the areas that are covered to the most extreme high and low temperatures in Iowa. When evaluating the binder to select, the engineer should balance initial costs for the binder and the likelihood of maintenance requirements caused by rutting/shoving for high pavement temperatures and low temperature cracking during the 1 day cold temperatures. In Iowa, PG 58-28S binders will provide full 98% reliability.

Engineers may designate an "H" binder, such as PG58-28H, to accommodate higher truck traffic and/or slower stop and go traffic. For the very highest volume roadways, a PG-58-28V should be considered.

For all base and intermediate layers that are 3 to 4 inches below the surface, PG 58-28S is the recommended binder. The surface binders will insulate the lower layers from the severe one day low temperature event. For projects in the central and southern parts of the state that involve overlays, it may be appropriate to use PG 64-22S. If no method is used to retard the reflective cracking, such as an interlayer, rubblization, or crack and seat, the resistance to low temperature cracking is not critical. If there are methods employed to retard the reflective cracking, a PG 58-28S or PG 58-28H should be used.

Agencies in the central and southern part of the state who have had historical success using PG 64-22S may continue use of that binder grade.

Table 5D-1.01: Asphalt Binder for Local Agencies

Asphalt Mixture		**Criteria**			
Design Traffic (1×10^6 ESALs)	**Mix Designation**	**Design Traffic (1×10^6 ESALs)**		**Design Speed (MPH)**	**PG Binder**
≤ 0.3 M	LT	≤ 0.3 M	and	≤ 45	58-28S
0.3 M to 1 M	ST	0.3 M to 1 M	and	> 45	58-28S
0.3 M to 1 M	ST	0.3 M to 1 M	and	15 to 45	58-28S[1]
1 to 10 M	HT	1 to 10 M	and	15 to 45	58-28H
Overlays	LT/ST/HT	≤ 10M	and	15 to 45	64-22S[2] or 58-28S or H

L = Low S = Standard H = High

[1] Use of PG 58-28H should be considered if heavy truck or bus traffic is present.
[2] If methods are used to retard reflective cracking, PG 58-28S or H is recommended.

b. HMA Mixture Size: Each mixture size (NMAS) is a function of the available aggregates, project conditions, and lift thickness. Minimum lift thickness is a function of density and mixture constructability. The following table shows the minimum lift thickness for the following mix sizes:

Mix Size	**Minimum Lift Thickness**
3/8"	1"
1/2"	1 1/2"
3/4"	2 1/4"
1"	3"

c. Mix Design Level: Based on the projected $ESAL_{20}$ value, seasonal traffic loading and current pavement distress, the designer must select a mix design level. The boundaries of the design levels are not absolute, so the designer should take into consideration the assumptions used to compute the ESAL value.

d. Aggregate Properties: The mixture design criteria (Table 5D-1.03) is derived from Iowa DOT Materials I.M. 510. Table 5D-1.03 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.

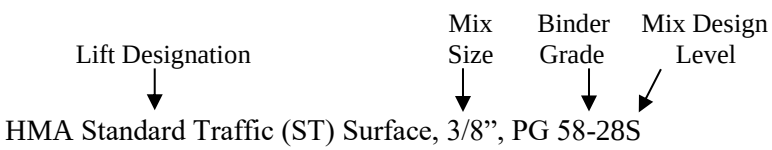
8. Place Mix Criteria in the Project Plans and Proposal: The following information should be placed in the plans and proposal:

a. Traffic and $ESAL_{20}$ Projections: The traffic and $ESAL_{20}$ projections should be listed on the title sheet of the plans. The $ESAL_{20}$ value should coincide with the selected mix design level. If seasonal ESALs are used for design, the title sheet should note that the $ESAL_{20}$ value is based on seasonal loading. The following is an example title sheet.

Traffic	
Current ADT	_____
Future ADT	_____
Present Trucks	_____
$ESAL_{20}$	_____

b. HMA 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 Table 5D-1.03. 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 58-34E+ 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 Table 5D-1.03 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 Table 5D-1.03 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 Table 5D-1.03, 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 (Table 5D-1.03) 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 (Table 5D-1.03) 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 Table 5D-1.03.

F. Example Plans

1. **Title Page:** The traffic and $ESAL_{20}$ projections should be listed on the title sheet of the plans. The $ESAL_{20}$ value should coincide with the selected mix design level. If seasonal ESALs are used for design, the title sheet should note that the $ESAL_{20}$ value is based on seasonal loading.

2. **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 $ESAL_{20}$ level should not be added to the typical section (it is specified in the bid item).

3. **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 Table 5D-1.03.

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 $ESAL_{20}$ 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 HMA mixture design level *[from Table 5D-1.02, HMA 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 HMA mixture design level *[from Table 5D-1.02, HMA 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 HMA mixture design level *[from Table 5D-1.02, HMA Mixture Selection Guide]*	**1 to 10 M**

H. Tables and Figures

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]
		min	*rec*	*max*			
≤ 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.

Table 5D-1.03: Mixture Design Criteria
(derived from Iowa DOT Materials I.M. 510)

Mix	Layer Designation	Gyratory Density		Film Thickness	Aggregate[2]			
		N_{des}	Design % G_{mm} (target)		Quality Type	Crush (min)	FAA (min)	Sand Equivalent (min)
LT	0.3 M S	50	96.0	8.0 - 15.0	A[1]	60[1]	---	40
	0.3 M I							
	0.3 M B		97.0		A[1]	45		
ST	1M S	50	96.0	8.0 - 15.0	A	75[1]	40	40
	1M I				A[1]	60[1]		
	1M B		97.0				---	
HT	10M S	75	96.0	8.0 - 15.0	A	75	43	45
	10M I							
	10M B		96.5		A[1]	60		
For mix design levels exceeding 10M ESALs, see Iowa DOT Materials I.M. 510.								

[1] Requirements differing from Iowa DOT Materials I.M. 510; for base mixes, aggregate quality improved from B to A and percent crushed aggregate increased by 15%.
[2] Flat & Elongated 10% maximum at a 5:1 ratio

c. SUDAS Concrete Mix Proportioning Specifications: The concrete mixes currently used in Iowa were developed in the 1950s. Classes A, B, and C were specified for concrete paving. As originally developed, Classes A and B, with minimum design compressive strengths of 3,500 psi and 3,000 psi respectively, were utilized for rural county paving. Class C concrete, with a higher compressive strength of a minimum of 4,000 psi and a w/cm ratio of less than 0.45, was the standard for primary roads. With its history of proven performance, Class C concrete is now the standard for all concrete road paving in Iowa. In areas where early opening strength is desired, such as intersections and driveways, an M mix can be substituted for C mix. M mix has a higher cement content, which accelerates the heat of hydration and set time of the concrete.

Unless the designer otherwise specifies, the contractor can choose any of the Iowa DOT Class C mixes and the materials that are allowed within the specifications. Generally, economy, workability, and availability of materials are key factors in the decision making process of the contractor and the concrete supplier.

Iowa DOT Materials I.M. 529 establishes the mix proportions for the various concrete mixes used by the Iowa DOT and SUDAS. Each mixture has specific requirements for the coarse and fine aggregates as well as the type of cement, including SCMs. The mix proportions include unit volumes for all materials.

If the concrete mix for a project is specifically needed to address joint durability, consideration should be given to the C-SUD mixes that are included in Table 4 of I.M. 529. Two main differences highlight these mixes. The first is the water-cement ratio. Using a lower water-cement ratio will create lower paste permeability and higher strength. The basic w/c ratio is 0.40 with the maximum set at 0.42. In addition to the w/c ratio, use of pozzolanic materials (SCMs) for substitution of cement will improve freeze-thaw durability in the presence of deicers. Consideration should be given to provide cement replacement rates of 20-25% Class F fly ash or 30-35% Class C fly ash or a combination of 20% slag and 20% Class C fly ash.

1) Mix Designation:

Example: C-4WR-S35

- The first letter indicates the class of concrete
- The first number indicates the percentages of fine aggregate and coarse aggregate
  - 2 is composed of 40% fine and 60% coarse
  - 3 is composed of 45/55
  - 4 is composed of 50/50
  - 5 is composed of 55/45
  - 6 is composed of 60/40
  - 7 is composed of 65/35
  - 8 is composed of 70/30
  - 57 is composed of 50/50
- The WR indicates water reducer is used in the mixture
- SCMs are then indicated with their percentage of cementitious material substitution. C and F fly ashes are indicated with a C and F, respectively. GGBF slag is indicated with an S. The percentage of substitution is indicated after the SCM letter.
- The example designates a Class C concrete mix, a combined aggregate composed of 50% fine aggregate and 50% coarse aggregate, water reducer admixture, and 35% GGBF slag cementitious material substitution.

2) **Mix Proportions:** Iowa DOT Materials I.M. 529 provides material proportioning for the various Iowa DOT concrete mixes and includes basic absolute volumes of cement, water, air, and fine and coarse aggregate per unit volume of concrete (cy/cy). Target and maximum w/cm ratios are provided for each of the mix classes. Also included is guidance for calculation of fly ash and GGBF slag cementitious material substitution of cement.
3) **Admixtures:** Sources of Iowa DOT approved admixtures are provided in Iowa DOT Materials I.M. 403, along with their maximum dosages. Generally, the maximum dosages are as recommended by the manufacturers. Do not exceed the maximum dosages according to the manufacturer's recommendations.

3. **Modification of the Standard Concrete Mix Specifications:** While care should be exercised, achieving the required properties in the concrete may require making adjustments to the materials selected, to materials proportions, or even to other factors such as temperature, as follows.

a. Workability: Water content, proportion of aggregate and cement, aggregate properties, cement characteristics, admixtures, and time and temperature can be adjusted to achieve the desired workability. The slump test (ASTM C 143 / AASHTO T 119) is most often used to measure the workability of fresh concrete.

b. Stiffening and Setting: The rates of stiffening and setting of a concrete mixture are important because they affect its ability to be placed, finished, and sawed. Stiffening and setting can be affected by the following in the concrete mixture: cementitious materials, chemical admixtures, aggregate moisture, temperature, and water-cementitious materials (w/cm) ratios.

c. Bleeding: Techniques can be used to prevent and minimize bleeding. These techniques (Kosmatka 1994) include reducing the water content, w/cm, and slump; increasing the amount of cement or supplementary cementitious materials in the mix; increasing the fineness of the cementitious materials; using properly graded aggregate; and using certain chemical admixtures such as air-entraining agents may reduce bleeding.

d. Air-void System: The air-void system is important to concrete durability in environments subject to freezing and thawing. It includes total air content, spacing factors, and specific surface. The air-void system can be controlled with cement, supplementary cementitious materials, aggregates, and workability. The air-void system in the field will be affected by changes in the grading of the aggregate, water, admixture dosage, delays, and temperature.

e. Density: Conventional concrete used in pavements has a density in the range of 137 to 150 lb/yd^3. Density varies depending on the amount and density of the aggregates, the amount of entrained air, the amount of water, and the cement content. Density is affected by the following factors: density of the material in the mixture, mostly from coarse aggregates; moisture content of the mixture; and relative proportions of the materials, mainly water.

f. Strength: Strength and rate of strength gain are influenced by water-cementitious materials ratio, cement chemistry, SCMs, chemical admixtures, aggregates, and temperature. Changes in the environmental conditions and variation in materials, consolidation, and curing affect the strength at a specified age and affect strength development with age. Increased temperatures will increase early strength but may decrease long-term strength gain.

g. Volume Stability: Concrete experiences volume changes as a result of temperature and moisture variations. To minimize the risk of cracking, it is important to minimize the tendency to change in volume by considering paste content, aggregates, and curing.

Pavement Thickness Design

A. General

The AASHO road test (completed in the 1950s) and subsequent AASHTO *Guide for the Design of Pavement Structures* (AASHTO Design Guide) provide the basis for current pavement design practices. To design a pavement by the AASHTO method, a number of design parameters must be determined or assumed. This section will explain the parameters required to design the pavement thickness of both concrete and hot mix asphalt roadways. The same parameters can be used for input data in computer programs on pavement determinations. The program used should be based on AASHTO design methods.

Even though the AASHTO Design Guide is several years old, it is still used throughout the industry for pavement thickness design. A newer design program called the Mechanistic-Empirical Pavement Design Guide (MEPDG) is available, however, it is costly and requires a great deal of data to be effective. The MEPDG does not generate a pavement thickness, it is set up to analyze the failure potential for a given thickness design. It is not generally used by local agencies. Each of the paving associations provides software programs for calculating pavement thickness. The programs can be accessed through the respective websites of the paving associations. Users should be aware of the required inputs for the software programs, as well as the specific system defaults that cannot be changed or do not fit the project design criteria. If the program defaults do not match the project circumstances, the software program should not be used.

Historically municipalities have resorted to a one-size-fits-all approach by constructing standard pavement thicknesses for certain types of roadways without regard to traffic volumes or subgrade treatments. In an effort to show the effect of varying traffic loads and subgrade treatments on pavement thickness, this section provides comparison tables showing the various rigid and flexible pavement thicknesses calculated according to the AASHTO pavement design methodology. The ESAL and pavement thickness values shown in the tables are dependent upon the design parameters used in the calculations. The assumed parameters are described in the corresponding tables. The pavement designer should have a thorough understanding of the parameters and their reflection of actual site conditions prior to using them to select a pavement thickness. Projects that have traffic or site conditions that differ significantly from the values assumed herein should be evaluated with a site specific pavement design.

Engineers need to examine their agency's standard pavement foundation support system based on good engineering practices and the level of service they desire for the life of both HMA and PCC pavements. It is important to understand the characteristics of the soil and what cost-effective soil manipulation can be achieved, whether an aggregate subbase is used or not. If different soil types are encountered, and an aggregate subbase is not used, properly blending and compacting the soil will help reduce differential movement and help prevent cracking. Good designs, followed by good construction practices with a proper inspection/observation program, are critical to realize the full performance potential of either pavement type.

Designs that improve the foundation will extend the pavement life, improve the level of service throughout the life of the pavement, and provide more economical rehabilitation strategies at the end of the pavement's life for both HMA and PCC pavements. Although the initial cost to construct the pavement will undoubtedly be higher than placing the pavement on natural subgrade, the overall life cycle costs will be greatly improved.

Definitions of the pavement thickness design parameters are contained in Section 5F-1, B. Section 5F-1, C defines the process for calculating ESAL values. Section 5F-1, D provides the comparison tables discussed in the previous paragraph. Finally, example calculations are shown in Section 5F-1, E.

The pavement designer should be aware of the parameters that are required for the project under design. If those project design parameters differ from the parameters used to calculate the typical pavement thicknesses provide in this section, then a specific design set to meet the specific project parameters should be undertaken.

B. Pavement Thickness Design Parameters

Some of the pavement thickness design parameters required for the design of a rigid pavement differ from those for a flexible pavement. Table 5F-1.01 summarizes the parameters required for the design of each pavement structure.

Table 5F-1.01: Summary of Design Parameters for Pavement Thickness

Section	Description	Flexible HMA	Rigid JPCP/JRCP
5F-1, B, 1	**Performance Criteria**		
	a. Initial Serviceability Index	X	X
	b. Terminal Serviceability Index	X	X
5F-1, B, 2	**Design Variables**		
	a. Analysis Period	X	X
	b. Design Traffic	X	X
	c. Reliability	X	X
	d. Overall Standard Deviation	X	X
5F-1, B, 3	**Material Properties for Structural Design**		
	a. Soil Resilient Modulus	X	
	b. Modulus of Subgrade Reaction		X
	c. Concrete Properties		X
	d. Layer Coefficients	X	
5F-1, B, 4	**Pavement Structural Characteristics**		
	a. Coefficient of Drainage	X	X
	b. Load Transfer Coefficients for Jointed		X
	c. Loss of Support		X

The following considerations should be used when designing pavement thickness for flexible and rigid pavements.

1. **Performance Criteria (Serviceability Indexes):** Condition of pavements are rated with a present serviceability index (PSI) ranging from 5 (perfect condition) to 0 (impossible to travel).

   a. **Initial Serviceability Index (Po):** The initial serviceability index (P_o) is the PSI immediately after the pavement is open. At the AASHO road test, values of 4.5 for rigid pavement and 4.2 for flexible pavement were assumed. These values are listed in the 1993 AASHTO Design Guide.

   b. **Terminal Serviceability Index (P_t):** The terminal serviceability index (P_t) is considered to be the PSI that represents the lowest acceptable level before resurfacing or reconstruction becomes necessary.

      The following values are recommended for terminal serviceability index.

      Table 5F-1.02: Terminal Serviceability Indexes (P_t) for Street Classifications

P_t	Classifications
2.00	Secondary Roads and Local Residential Streets
2.25	Minor Collectors, Industrial, and Commercial Streets
2.50	Major Collectors and Arterials

   c. **Serviceability Loss:** The predicted loss or drop in serviceability (ΔPSI) is the difference between initial and terminal serviceability ($P_o - P_t$). The ΔPSI is the basis for the pavement design.

2. **Design Variables:**

   a. **Analysis Period:** This refers to the period of time for which the analysis is to be conducted. The recommended analysis period is 50 years for both concrete and asphalt pavements.

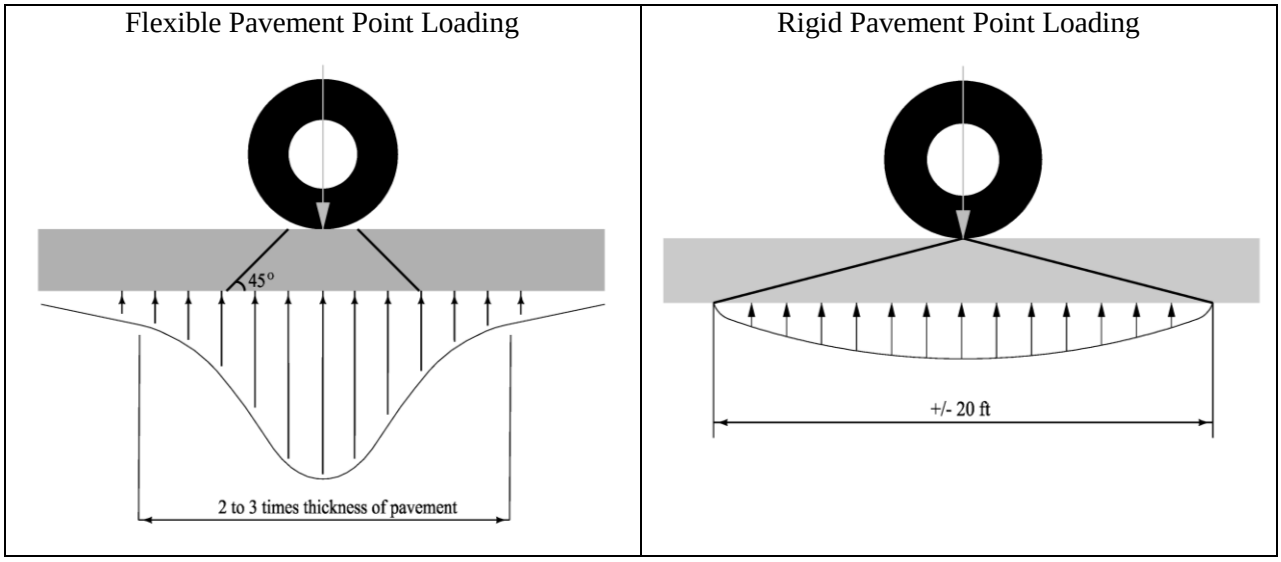
   b. **Design Traffic:** An estimate of the number of Equivalent 18,000 pound Single Axle Loads (ESALs) during the analysis period is required. This value can be estimated based on:
      - the Average Annual Daily Traffic (AADT) in the base year,
      - the average percentage of trucks expected to use the facility,
      - the average annual traffic growth rate, and
      - the analysis period.

      It should be noted that it is not the wheel load but rather the damage to the pavement caused by the wheel load that is of particular concern. As described above, the ESAL is the standard unit of pavement damage and represents the damage caused by a single 18,000 pound axle load. Therefore, a two-axle vehicle with both axles loaded at 18,000 pounds would produce two ESALs. However, since vehicle configurations and axle loads vary, AASHTO has established a method to convert different axle loads and configurations to ESALs. For example, a 34,000 pound tandem axle produces approximately 1.9 ESALs for rigid pavement (1.1 for flexible pavement). Summing the different ESAL values for each axle combination on a vehicle provides a vehicle's Load Equivalency Factor (LEF). The LEF can then be applied to the assumed truck mix and the AADT to determine ESALs.

      Section 5F-1, C details the steps involved in ESAL calculations and provides examples for both rigid and flexible pavements. ESAL tables for rigid and flexible pavements, and the corresponding assumptions used to create them, are provided for both two lane and four lane facilities.

The need for separate ESAL tables for flexible and rigid pavements is based on the inherent ability of each type of pavement to distribute a point loading. Rigid pavements have the ability to distribute the load across the slab. A point loading on a flexible pavement is more localized. This results in different ESAL factors for the two types of pavements. This is shown graphically in Figure 5F-1.01.

Figure 5F-1.01: Flexible vs. Rigid Point Loading Distribution



c. Reliability [R (%)]: Reliability is the probability that the design will succeed for the life of the pavement. Because higher roadway classification facilities are considered more critical to the transportation network, a higher reliability is used for these facilities. The following reliability values were assumed for the calculations.

Table 5F-1.03: Reliability for Flexible and Rigid Pavement Design

Street Classification	Reliability
Local Streets	80%
Collector Streets	88%
Arterial Streets	95%

d. Overall Standard Deviation (S_o): The Overall Standard Deviation is a coefficient that describes how well the AASHO Road Test data fits the AASHTO Design Equations. The lower the overall deviation, the better the equations models the data. The following ranges are recommended by the AASHTO Design Guide.

Table 5F-1.04: Overall Standard Deviation (S_o) for Rigid and Flexible Pavements

Pavement Type	Range of Values		Value Used
	Low	***High***	
Rigid Pavements	0.30	0.40	0.35
Flexible Pavements	0.40	0.50	0.45

3. Material Properties for Structural Design:

a. Soil Resilient Modulus (M_R): The important variable in describing the foundation for pavement design is the Soil Resilient Modulus (M_R). M_R is a property of the soil that indicates the stiffness or elasticity of the soil under dynamic loading.

The Soil Resilient Modulus measures the amount of recoverable deformation at any stress level for a dynamically loaded test specimen. The environment can affect pavement performance in several ways. Temperature and moisture changes can have an effect on the strength, durability, and load-carrying capacity of the pavement and roadbed materials. Another major environmental impact is the direct effect roadbed swelling, pavement blowups, frost heave, disintegration, etc. can have on loss of riding quality and serviceability. If any of these environmental effects have the potential to be present during the life cycle of the pavement, the MR should be evaluated on a season by season basis, and a seasonal modulus developed.

The purpose of using seasonal modulus is to qualify the relative damage a pavement is subject to during each season of the year and treat it as part of the overall design. An effective soil modulus is then established for the entire year, which is equivalent to the combined effects of all monthly seasonal modulus values.

For the purposes of this section, the MR value was calculated based on the proposed CBR values of 3 and 5. Previous editions of this section have included CBR values of 3, 5, and 10. The normal soils in Iowa have in situ CBR values of 1 to 3. In order to attain a soil strength of CBR of 3, it is necessary to construct a subgrade of at least 12 inches of soil mechanically compacted to a minimum of 95% Standard Proctor Density. The Iowa DOT uses a MR value of 3,000 to 3,500. That value is reasonably close to the value used in this section for a CBR of 3 when adjusted for seasonal variations (2,720).

The design charts in this section include values for CBR of 5. It is possible to reach a CBR of 5 with Iowa soils through diligent mechanical compaction of the top 12 inches of the subgrade. Generally, soils that have 45% or less silt content and plasticity indexes greater than 10 can be mechanically compacted and reach CBR of 5. Due to the fine grained nature of some Iowa soils, it may be necessary to stabilize these soils through the use of agents such as lime, fly ash, cement, and asphalt in order to achieve a CBR of 5 or greater. Stabilization requires the agent to be thoroughly distributed into the soil matrix and the soil matrix must be well pulverized to prevent clumps from remaining isolated in the soil mass. The application of the stabilizing agent will usually increase the strength properties of the soil.

It is critical that the appropriate level of construction quality control be completed that will verify the increase in soil strength matches the value used in the thickness design.

In order to successfully develop a foundation CBR of 10, it is also going to involve use of a subgrade that is stabilized with cement, fly ash, or other product. If the designer determines that a foundation will be constructed to reach a CBR of 10, then a specific pavement design should be undertaken rather than using the standard designs presented in this section. AASHTO recommends that the following correlation be used to relate the resilient modulus to the CBR. Using this equation, the corresponding MR values for CBR values of 3 and 5 are shown. For further information regarding the relationship between soil types and bearing values, see Sections 6E-1 and 6H-1. Once a CBR is selected for design, it is absolutely critical to ensure the value is reached in the field.

Without the formalized construction process of enhancing the subgrade through stabilization, it is critical to not use subgrade support values higher than a CBR of 3 or 5 for thickness design.

$$M_R = 1{,}500 \times CBR$$

CBR Value	M_R Value
3	4500
5	7500

For flexible pavement design, 1993 AASHTO Guide, Part II, Tables 4.1 and 4.2 with AASHTO Wet-Freeze Zone III criteria were used to estimate the effective M_R value taking into account seasonal variability. Frozen conditions were assumed for one-half the month of December and the months of January and February. Due to spring wetness and thawing conditions, the M_R value for the month of March and one-half of April were assumed to be 30% of normal conditions. Half of April, and all of May, October, November, and one-half of December were assumed to be wet with the support value set at 67% of normal. The remaining months of June, July, August, and September were dry months.

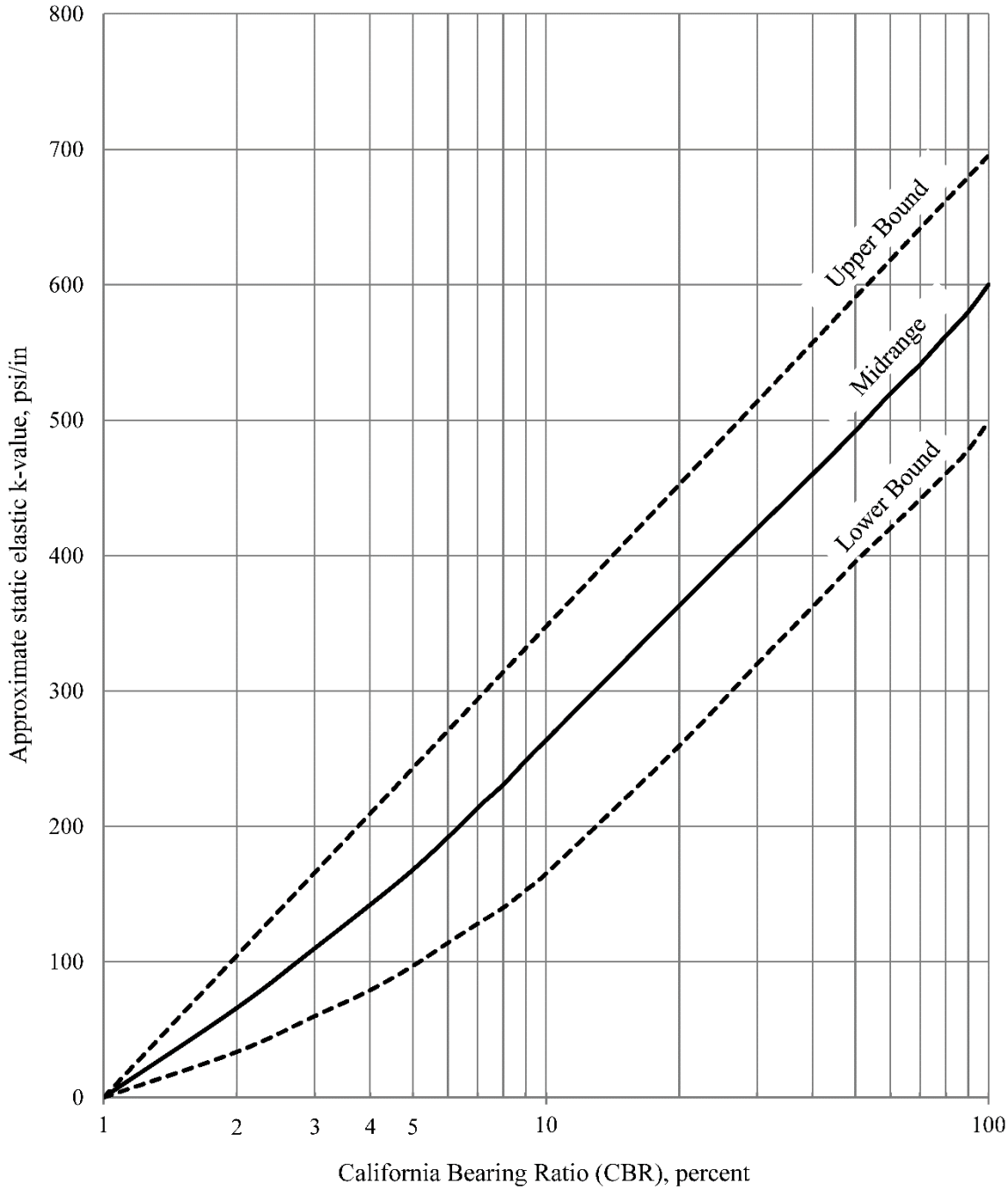
For rigid pavement design, the M_R value is used to calculate the modulus of subgrade reaction, k.

b. Modulus of Subgrade Reaction (k, k_c): Several variables are important in describing the foundation upon which the pavement rests:

- k - The modulus of subgrade reaction for the soil;
- k_c - A composite k that includes consideration of subbase materials under the new pavement
- M_R - Soil resilient modulus

1) Modulus of Subgrade Reaction, k: For concrete pavements, the primary requirement of the subgrade is that it be uniform. This is the fundamental reason for specifications on subgrade compaction. In concrete pavement design, the strength of the soil is characterized by the modulus of subgrade reaction or, as it is more commonly referred to, "k".

Figure 5F-1.01: Relationship Between CBR and k Value



Source: Adapted from *Phase I: Validation of Guidelines for k-Value Selection and Concrete Pavement Performance Prediction*, Publication No. FHWA-RD-96-198

2) Composite Modulus of Subgrade Reaction, k_c: In many highway applications the pavement is not placed directly on the subgrade. Instead, some type of subbase material is used. When this is done, the k value actually used for design is a "composite k" (k_c), which represents the strength of the subgrade corrected for the additional support provided by the subbase.

The analysis of field data completed as a part of the Iowa Highway Research Board (IHRB) Project TR-640 showed that the modulus of subgrade reaction and the drainage coefficient for 16 PCC sites, which ranged in ages between 1 and 42 years, were variable and found to be lower in-situ than typical parameters used in thickness design. This indicates a loss of support over time. This change in support is already partially reflected in the AASHTO serviceability index to a degree.

Similar to the procedures used to estimate the effective M_R value for flexible pavement design, the AASHTO Design Guide provides procedures for estimating the k_c value taking into account potential seasonal variability. The same seasonal variability assumptions used for flexible pavements were used to calculate k_c values for rigid pavements.

c. Concrete Properties: PCC - Modulus of Elasticity (E_c) and Modulus of Rupture (S'_c).

The Modulus of Rupture (S'_c) used in the AASHTO Design Guide equations is represented by the average flexural strength of the pavement determined at 28 days using third-point loading (ASTM C 78).

The Modulus of Elasticity for concrete (E_c) depends largely on the strength of the concrete. Typical values are from 2 to 6 million psi. The following equation provides an approximate value for E_c:

$$E_c = 6{,}750\ (S'_c)$$

where:

S'_c = modulus of rupture [28 day flexural strength of the concrete using third point loading (psi)]

The approximate relation between modulus of rupture (S'_c) and compressive strength (f_c) is

$$S'_c = 2.3\ f_c^{0.667} (\text{psi})$$

d. Layer Coefficients: Structural layer coefficients (a_i values) are required for flexible pavement structural design. A value for these coefficients is assigned to each layer material in the pavement structure in order to convert actual layer thickness into the structural number (SN). These historical values have been used in the structural calculations. If specific elements, such as a Superpave mix or polymer modified mix are used, the designer should adjust these values to reflect differing quality of materials.

The following table shows typical values for layer coefficients.

Table 5F-1.05: Layer Coefficients

Component	Coefficient	Minimum Thickness Allowed
Surface / Intermediate Course		
HMA with Type A Aggregate	0.44*	1.5
Base Course		
HMA with Type A Aggregate	0.44	2
Cement Treated Granular (Aggregate) Base	0.20*	6
Soil-Cement Base	0.15	6
Crushed (Graded) Stone Base	0.14*	6
Macadam Stone Base	0.12	6
PCC Base (New)	0.50	
Old PCC	0.40**	
Crack and Seated PCC	0.25 to 0.30	
Rubblized PCC	0.24	
Cold-in-Place Recycled Asphalt Pavement	0.22 to 0.27	
Full Depth Reclamation	0.18	
Subbase Course		
Soil-Cement Subbase (10% cement)	0.10	6
Soil-Lime Subbase (10% lime)	0.10	6
Modified Subbase	0.14	4
Soil-Aggregate Subbase	0.05*	4

* Indicates coefficients taken from AASHTO Interim Guide for the Design of Flexible Pavement Structures.

** This value is for reasonably sound existing concrete. Actual value used may be lower, depending on the amount of deterioration that has occurred.

Source: AASHTO, Kansas State University, and Iowa DOT

4. Pavement Structural Characteristics:

a. Coefficient of Drainage: Water under the pavement is one of the primary causes of pavement failure. Water, either from precipitation or groundwater, can cause the subgrade to become saturated and weaken. This can contribute to pavement pumping under heavy loads.

C_d - The coefficient of drainage for rigid pavement design used to account for the quality of drainage.

M_i - The coefficient of drainage for flexible pavement design used to modify layer coefficients.

At the AASHO road test, the pavements were not well drained as evidenced by the heavy pumping that occurred on some of the test sections. The cross-sections were elevated and drainage ditches were provided. However, edge drains, which are used frequently in today's street and highway construction, were not evaluated at the AASHO road test. Edge drains are an effective deterrent to pumping and associated pavement distress.

In selecting the proper C_d or M_i value, consideration must be given to two factors: 1) how effective is the drainage, and 2) how much of the time is the subgrade and subbase in a saturated condition? For example, pavements in dry areas with poor drainage may perform as well as pavements built in wet areas with excellent drainage.

The following definitions are offered as a guide.

- Excellent Drainage: Material drained to 50% of saturation in 2 hours.
- Good Drainage: Material drained to 50% of saturation in 1 day.
- Fair Drainage: Material drained to 50% of saturation in 7 days.
- Poor Drainage: Material drained to 50% of saturation in 1 month.
- Very Poor Drainage: Material does not drain.

Based on these definitions, the C_d or M_i value for the road test conditions would be 1.00. A value of 1.00 would have no impact on pavement thickness or the number of ESALs a section would carry. Lower values increase the recommended pavement thickness; higher values decrease the recommended pavement thickness. Based on Tables 2.4 and 2.5 from the 1993 AASHTO Design Guide, the analysis assumed a fair quality of drainage and 1% to 5% exposure to saturation for the drainable base sections.

b. Load Transfer Coefficients for Jointed and Jointed Reinforced Pavements: One item that distinguishes PCC pavement is the type of joint used to control cracking and whether or not steel dowels are used in the joint for load transfer. Each of these designs provides a different level of transfer of load from one side of a pavement joint to the other. To adjust projected pavement performance for these various designs, the load transfer coefficient or "J" factor is used.

c. Loss of Support: The 1993 AASHTO Design Guide indicates that the loss of support factor is included in the design of concrete pavements to account for the potential impact arising from the erosion of the subgrade material and/or differential soil movements. Values of the factor range from 0 to 3. Application of these factors impacts the k value used in thickness design. According to the 1993 AASHTO Design Guide, Part II, Figure 3.6, with a value of 0, the k value does not change. With a value of 3, corresponding to fine grained subgrade soils, a k value of 100 becomes an effective k value of 8. From a practical standpoint, a k value less than 50 represents conditions where a person's weight would produce noticeable deformations in the subgrade. Thus a subgrade with this level of support would never pass a proof roll test.

The use of loss of support values has a very significant impact on the thickness design for concrete pavements. In almost all cases at the AASHO road test where the concrete pavements fell below the minimum serviceability level, the cause of the failure was due to loss of support. Because the design equations were derived from this data, the reduction in serviceability is already accounted for in the design procedure. The 1993 AASHTO Design Guide, Part II, Section 2.4.3 states that experience should be the key element in the selection and use of an appropriate loss of support value.

The use of a loss of support value of 1 reduces a subgrade k value of 100 (equivalent to a CBR of 3) to an effective k value of 40 to be used in the thickness design. Since this creates a subgrade quality lower than experienced engineers would allow pavement to be placed, the design tables were developed using a loss of support value of 0. Research conducted by the Federal Highway Administration (FHWA-RD-96-198) supports using zero for the loss of support value.

Pavement design parameters within the PCC thickness design software programs often do not adequately reflect actual pavement foundation conditions except immediately after initial construction. Field data from testing completed at 16 Iowa sites showed lower coefficient of drainage values than those assumed in design, indicating that a potential migration of natural soils into the aggregate subbase over time may cause some loss of support. This in turn lowers the overall modulus of subgrade reaction. The results of the field testing indicating this loss of support due to mixing of the subgrade and subbase will need to be further validated by additional research. In order to maintain a high drainage coefficient, it is important to maintain separation between the soil subgrade and the aggregate subbase. One method of providing the separation is with a geotextile layer.

In most cases for local, low volume PCC roads, aggregate subbases do not influence thickness design to any measurable degree. According to MEPDG analysis for low volume PCC roadways (less than 1,000 ADT and 10% trucks), aggregate subbase thicknesses greater than 5 inches do not appear to improve the International Roughness Index (IRI) or reduce slab cracking.

Based on the IHRB TR-640 research with a limited data set of 16 Iowa sites, it was noted that a PCC pavement with an optimized foundation of granular subbase, subdrains, and a geotextile separation layer between the subgrade and subbase is likely to maintain a higher pavement condition index (PCI) over time than a PCC pavement on natural subgrade. The lower the variability and the higher the coefficient of drainage with an optimized foundation, the higher the pavement condition will be for a given period of time. Since the PCI prediction model from the IHRB research was developed based on a limited data set, it must be further validated with a larger pool of data. However, designers should consider the benefits of optimizing the foundations under their pavements to improve long-term serviceability.

C. Calculating ESAL Values

To estimate the design ESALs, the following procedure may be used. A more thorough analysis may also be performed using the procedures found in Appendix D of the 1993 AASHTO Design Guide or computer programs based on that procedure.

1. Obtain an estimate of the design AADT for the beginning, or base year of the analysis period.

2. Obtain an estimate of the average percentage of the AADT that will be trucks.

3. Three independent truck mix types are provided. The designer should match the truck mix type with the general characteristics of their project area's actual truck mix. The three types are:
   - Type A: The truck mix within this type is typical for local city streets in residential or other land uses that do not include large trucks.
   - Type B: This type would typically represent the truck mix on higher volume streets. The truck type is predominantly Class 5 with lesser volumes of Class 8 and Class 9 trucks.
   - Type C: The truck mix in this type would generally involve higher volumes with the truck types being larger with a higher percentage of Class 8 and Class 9 trucks.

4. Select the base year design lane ESALs from Tables 5F-1.07 through 5F-1.10, depending upon whether the facility is two lane, four lane, rigid, or flexible. The designer may want to interpolate between the table values and the actual values of base year AADT and percent trucks, although the final pavement thickness is not often impacted by such calculations.

5. Select the growth factor from Table 5F-1.11 based on the average annual traffic growth rate and the analysis period.

6. Multiply the base year design lane ESALs, by the growth factor to obtain the total ESALs for the analysis period.

Table 5F-1.06 summarizes the inputs and calculations that went into creating Tables 5F-1.07 through 5F-1.10.

Table 5F-1.06: Truck Mixture for Urban Roadways and Determination of Truck ESAL Factor

Type A Truck Mix: Primarily buses and single axle trucks often found on low volume streets

Truck Class (Vehicle Description)	Percent of Total Trucks	Loading	Percent of Truck Class	Vehicle Weight (lbs)	Axle Type S-Single TA-Tandem	Axle Load (lbs)	ESAL Factor (per axle) Rigid	ESAL Factor (per axle) Flexible	LEF (by Vehicle) Rigid	LEF (by Vehicle) Flexible
 Class 4 (2-axle busses, BUS)	10%	Partial Load (80% capacity)	100%	25000	Front-S	9000	0.053	0.066		
					Rear-S	16000	0.607	0.631	0.660	0.697
 Class 5 (2-axle, 6-tire trucks & busses, SU-2)	75%	Partial Load (50% capacity)	100%	20000	Front-S	6500	0.014	0.018		
					Rear-S	13500	0.294	0.326	0.308	0.344
 Class 6 (3-axle trucks, SU-3)	5%	Empty	50%	22000	Front-S	7000	0.019	0.024		
					Rear-TA	15000	0.064	0.044	0.041	0.034
		Fully Loaded	50%	46000	Front-S	12000	0.178	0.206		
					Rear-TA	34000	1.900	1.099	1.039	0.653
 Class 8 (4-axle (or less) single trailer truck, Comb-4)	5%	Empty	20%	24000	Front-S	9000	0.053	0.066		
					Rear-TA	9000	0.009	0.006		
					Trailer-S	6000	0.010	0.013	0.014	0.017
		Partial Load (50% capacity)	40%	44000	Front-S	9500	0.067	0.082		
					Rear-TA	22000	0.310	0.202		
					Trailer-S	12500	0.212	0.242	0.236	0.210
		Fully Loaded	40%	64000	Front-S	10000	0.083	0.101		
					Rear-TA	34000	1.900	1.099		
					Trailer-S	20000	1.558	1.520	1.416	1.088
 Class 9 (5-axle single trailer truck, Comb-5)	5%	Empty	20%	36000	Front-S	11000	0.124	0.147		
					Rear-TA	14000	0.048	0.033		
					Trailer-TA	11000	0.019	0.013	0.038	0.039
		Partial Load (50% capacity)	40%	58000	Front-S	11500	0.149	0.175		
					Rear-TA	24000	0.447	0.284		
					Trailer-TA	22500	0.341	0.220	0.375	0.272
		Fully Loaded	40%	80000	Front-S	12000	0.178	0.206		
					Rear-TA	34000	1.900	1.099		
					Trailer-TA	34000	1.900	1.099	1.592	0.962
								Composite LEF for Type A Truck Mix =	**0.535**	**0.492**

Table 5F-1.06 (Continued): Truck Mixture for Urban Roadways and Determination of Truck ESAL Factor

Type B Truck Mix: Predominantly single axle with some multi-axle trucks

Truck Class (Vehicle Description)	Percent of Total Trucks	Loading	Percent of Truck Class	Vehicle Weight (lbs)	Axle Type S-Single TA-Tandem	Axle Load (lbs)	ESAL Factor (per axle) Rigid	ESAL Factor (per axle) Flexible	LEF (by Vehicle) Rigid	LEF (by Vehicle) Flexible
 Class 4 (2-axle busses, BUS)	5%	Partial Load (80% capacity)	100%	25000	Front-S	9000	0.053	0.066		
					Rear-S	16000	0.607	0.631	0.660	0.697
 Class 5 (2-axle, 6-tire trucks & busses, SU-2)	55%	Partial Load (50% capacity)	100%	20000	Front-S	6500	0.014	0.018		
					Rear-S	13500	0.294	0.326	0.308	0.344
 Class 6 (3-axle trucks, SU-3)	10%	Empty	50%	22000	Front-S	7000	0.019	0.024		
					Rear-TA	15000	0.064	0.044	0.041	0.034
		Fully Loaded	50%	46000	Front-S	12000	0.178	0.206		
					Rear-TA	34000	1.900	1.099	1.039	0.653
 Class 8 (4-axle (or less) single trailer truck, Comb-4)	5%	Empty	20%	24000	Front-S	9000	0.053	0.066		
					Rear-TA	9000	0.009	0.006		
					Trailer-S	6000	0.010	0.013	0.014	0.017
		Partial Load (50% capacity)	40%	44000	Front-S	9500	0.067	0.082		
					Rear-TA	22000	0.310	0.202		
					Trailer-S	12500	0.212	0.242	0.236	0.210
		Fully Loaded	40%	64000	Front-S	10000	0.083	0.101		
					Rear-TA	34000	1.900	1.099		
					Trailer-S	20000	1.558	1.520	1.416	1.088
 Class 9 (5-axle single trailer truck, Comb-5)	25%	Empty	20%	36000	Front-S	11000	0.124	0.147		
					Rear-TA	14000	0.048	0.033		
					Trailer-TA	11000	0.019	0.013	0.038	0.039
		Partial Load (50% capacity)	40%	58000	Front-S	11500	0.149	0.175		
					Rear-TA	24000	0.447	0.284		
					Trailer-TA	22500	0.341	0.220	0.375	0.272
		Fully Loaded	40%	80000	Front-S	12000	0.178	0.206		
					Rear-TA	34000	1.900	1.099		
					Trailer-TA	34000	1.900	1.099	1.592	0.962
					Composite LEF for Type B Truck Mix =				**0.895**	**0.677**

Table 5F-1.06 (Continued): Truck Mixture for Urban Roadways and Determination of Truck ESAL Factor

Type C Truck Mix: Mixed truck traffic with both single axle and multi-axle trucks

Truck Class (Vehicle Description)	Percent of Total Trucks	Loading	Percent of Truck Class	Vehicle Weight (lbs)	Axle Type S-Single TA-Tandem	Axle Load (lbs)	ESAL Factor (per axle) Rigid	ESAL Factor (per axle) Flexible	LEF (by Vehicle) Rigid	LEF (by Vehicle) Flexible
 Class 4 (2-axle busses, BUS)	5%	Fully Loaded	100%	25000	Front-S	9000	0.053	0.066		
					Rear-S	16000	0.607	0.631	0.660	0.715
 Class 5 (2-axle, 6-tire trucks & busses, SU-2)	30%	Fully Loaded	100%	20000	Front-S	6500	0.014	0.018		
					Rear-S	13500	0.294	0.326	0.308	0.368
 Class 6 (3-axle trucks, SU-3)	10%	Empty	50%	22000	Front-S	7000	0.019	0.024		
					Rear-TA	15000	0.064	0.044	0.041	0.034
		Fully Loaded	50%	46000	Front-S	12000	0.178	0.206		
					Rear-TA	34000	1.900	1.099	1.039	0.653
 Class 8 (4-axle (or less) single trailer truck, Comb-4)	10%	Empty	20%	24000	Front-S	9000	0.053	0.066		
					Rear-TA	9000	0.009	0.006		
					Trailer-S	6000	0.010	0.013	0.014	0.017
		Partial Load (50% capacity)	40%	44000	Front-S	9500	0.067	0.082		
					Rear-TA	22000	0.310	0.202		
					Trailer-S	12500	0.212	0.242	0.236	0.210
		Fully Loaded	40%	64000	Front-S	10000	0.083	0.101		
					Rear-TA	34000	1.900	1.099		
					Trailer-S	20000	1.558	1.520	1.416	1.088
 Class 9 (5-axle single trailer truck, Comb-5)	45%	Empty	20%	36000	Front-S	11000	0.124	0.147		
					Rear-TA	14000	0.048	0.033		
					Trailer-TA	11000	0.019	0.013	0.038	0.039
		Partial Load (50% capacity)	40%	58000	Front-S	11500	0.149	0.175		
					Rear-TA	24000	0.447	0.284		
					Trailer-TA	22500	0.341	0.220	0.375	0.272
		Fully Loaded	40%	80000	Front-S	12000	0.178	0.206		
					Rear-TA	34000	1.900	1.099		
					Trailer-TA	34000	1.900	1.099	1.592	0.962
					Composite LEF for Type C Truck Mix =				**1.302**	**0.919**

The following assumptions were made in the calculation of the ESALs and LEFs shown in Table 5F-1.06:

- The truck mix data was obtained from the Iowa DOT 2014 traffic counts using FHWA vehicle classes. Class 7, 10, 11, 12, and 13 were not included since they do not make up any significant volumes on Iowa urban roadways.
- ESAL factors for individual axles were calculated using manufacturer's vehicle weights and typical loadings.
- Concrete thickness of 8 inches, asphalt structural number of 3.25, terminal serviceability index of 2.25.
- ESAL tables were calculated with WinPas using the AASHTO equations and verified against the AASHTO design tables.

For the base year ESAL tables, the directional split for two lane facilities was set at 50/50 and for four-lane facilities, it was assumed that 60% of the trucks were in the design lane.

Table 5F-1.07: Base Year Design ESALs for Two Lane *Rigid Pavement*

% Trucks	Truck Mix Type	Two-Way Base Year AADT							
		1,000	**2,000**	**3,000**	**4,000**	**5,000**	**10,000**	**15,000**	**20,000**
1	A	1,000	2,000	3,000	4,000	5,000	10,000	14,500	19,500
	B	1,500	3,500	5,000	6,500	8,000	16,500	24,500	32,500
	C	2,500	5,000	7,000	9,500	12,000	24,000	35,500	47,500
2	A	2,000	4,000	6,000	8,000	10,000	19,500	29,500	39,000
	B	3,500	6,500	10,000	13,000	16,500	32,500	49,000	65,500
	C	5,000	9,500	14,500	19,000	24,000	47,500	71,500	95,000
3	A	3,000	6,000	9,000	11,500	14,500	29,500	44,000	58,500
	B	5,000	10,000	14,500	19,500	24,500	49,000	73,500	98,000
	C	7,000	14,500	21,500	28,500	35,500	71,500	107,000	142,500
4	A	4,000	8,000	11,500	15,500	19,500	39,000	58,500	78,000
	B	6,500	13,000	19,500	26,000	32,500	65,500	98,000	130,500
	C	9,500	19,000	28,500	38,000	47,500	95,000	142,500	190,000
5	A	5,000	10,000	14,500	19,500	24,500	49,000	73,000	97,500
	B	8,000	16,500	24,500	32,500	41,000	81,500	122,500	163,500
	C	12,000	24,000	35,500	47,500	59,500	119,000	178,000	237,500
6	A	6,000	11,500	17,500	23,500	29,500	58,500	88,000	117,000
	B	10,000	19,500	29,500	39,000	49,000	98,000	147,000	196,000
	C	14,500	28,500	43,000	57,000	71,500	142,500	214,000	285,000
7	A	7,000	13,500	20,500	27,500	34,000	68,500	102,500	136,500
	B	11,500	23,000	34,500	45,500	57,000	114,500	171,500	228,500
	C	16,500	33,500	50,000	66,500	83,000	166,500	249,500	332,500
8	A	8,000	15,500	23,500	31,000	39,000	78,000	117,000	156,000
	B	13,000	26,000	39,000	52,500	65,500	130,500	196,000	261,500
	C	19,000	38,000	57,000	76,000	95,000	190,000	285,000	380,000
9	A	9,000	17,500	26,500	35,000	44,000	88,000	132,000	175,500
	B	14,500	29,500	44,000	59,000	73,500	147,000	220,500	294,000
	C	21,500	43,000	64,000	85,500	107,000	214,000	321,000	427,500
10	A	10,000	19,500	29,500	39,000	49,000	97,500	146,500	195,000
	B	16,500	32,500	49,000	65,500	81,500	163,500	245,000	326,500
	C	24,000	47,500	71,500	95,000	119,000	237,500	356,500	475,000
12	A	11,500	23,500	35,000	47,000	58,500	117,000	175,500	234,000
	B	19,500	39,000	59,000	78,500	98,000	196,000	294,000	392,000
	C	28,500	57,000	85,500	114,000	142,500	285,000	427,500	570,500
14	A	13,500	27,500	41,000	54,500	68,500	136,500	205,000	273,500
	B	23,000	45,500	68,500	91,500	114,500	228,500	343,000	457,500
	C	33,500	66,500	100,000	133,000	166,500	332,500	499,000	665,500
16	A	15,500	31,000	47,000	62,500	78,000	156,000	234,000	312,500
	B	26,000	52,500	78,500	104,500	130,500	261,500	392,000	522,500
	C	38,000	76,000	114,000	152,000	190,000	380,000	570,500	760,500
18	A	17,500	35,000	52,500	70,500	88,000	175,500	263,500	351,500
	B	29,500	59,000	88,000	117,500	147,000	294,000	441,000	588,000
	C	43,000	85,500	128,500	171,000	214,000	427,500	641,500	855,500
20	A	19,500	39,000	58,500	78,000	97,500	195,000	293,000	390,500
	B	32,500	65,500	98,000	130,500	163,500	326,500	490,000	653,500
	C	47,500	95,000	142,500	190,000	237,500	475,000	713,000	950,500

Assumes two lane roadway with 50/50 directional split of base year AADT

Table 5F-1.08: Base Year Design ESALs for Two Lane *Flexible Pavement*

% Trucks	Truck Mix Type	Two-Way Base Year AADT							
		1,000	**2,000**	**3,000**	**4,000**	**5,000**	**10,000**	**15,000**	**20,000**
1	A	1,000	2,000	2,500	3,500	4,500	9,000	13,500	18,000
	B	1,000	2,500	3,500	5,000	6,000	12,500	18,500	24,500
	C	1,500	3,500	5,000	6,500	8,500	17,000	25,000	33,500
2	A	2,000	3,500	5,500	7,000	9,000	18,000	27,000	36,000
	B	2,500	5,000	7,500	10,000	12,500	24,500	37,000	49,500
	C	3,500	6,500	10,000	13,500	17,000	33,500	50,500	67,000
3	A	2,500	5,500	8,000	11,000	13,500	27,000	40,500	54,000
	B	3,500	7,500	11,000	15,000	18,500	37,000	55,500	74,000
	C	5,000	10,000	15,000	20,000	25,000	50,500	75,500	100,500
4	A	3,500	7,000	11,000	14,500	18,000	36,000	54,000	72,000
	B	5,000	10,000	15,000	20,000	24,500	49,500	74,000	99,000
	C	6,500	13,500	20,000	27,000	33,500	67,000	100,500	134,000
5	A	4,500	9,000	13,500	18,000	22,500	45,000	67,500	89,500
	B	6,000	12,500	18,500	24,500	31,000	61,500	92,500	123,500
	C	8,500	17,000	25,000	33,500	42,000	84,000	126,000	167,500
6	A	5,500	11,000	16,000	21,500	27,000	54,000	80,500	107,500
	B	7,500	15,000	22,000	29,500	37,000	74,000	111,000	148,000
	C	10,000	20,000	30,000	40,000	50,500	100,500	151,000	201,000
7	A	6,500	12,500	19,000	25,000	31,500	63,000	94,000	125,500
	B	8,500	17,500	26,000	34,500	43,000	86,500	129,500	173,000
	C	11,500	23,500	35,000	47,000	58,500	117,500	176,000	234,500
8	A	7,000	14,500	21,500	28,500	36,000	72,000	107,500	143,500
	B	10,000	20,000	29,500	39,500	49,500	99,000	148,000	197,500
	C	13,500	27,000	40,000	53,500	67,000	134,000	201,000	268,500
9	A	8,000	16,000	24,000	32,500	40,500	80,500	121,000	161,500
	B	11,000	22,000	33,500	44,500	55,500	111,000	166,500	222,000
	C	15,000	30,000	45,500	60,500	75,500	151,000	226,500	302,000
10	A	9,000	18,000	27,000	36,000	45,000	89,500	134,500	179,500
	B	12,500	24,500	37,000	49,500	61,500	123,500	185,000	247,000
	C	17,000	33,500	50,500	67,000	84,000	167,500	251,500	335,500
12	A	11,000	21,500	32,500	43,000	54,000	107,500	161,500	215,500
	B	15,000	29,500	44,500	59,500	74,000	148,000	222,000	296,500
	C	20,000	40,000	60,500	80,500	100,500	201,000	302,000	402,500
14	A	12,500	25,000	37,500	50,000	63,000	125,500	188,500	251,000
	B	17,500	34,500	52,000	69,000	86,500	173,000	259,500	345,500
	C	23,500	47,000	70,500	94,000	117,500	234,500	352,000	469,500
16	A	14,500	28,500	43,000	57,500	72,000	143,500	215,500	287,000
	B	20,000	39,500	59,500	79,000	99,000	197,500	296,500	395,000
	C	27,000	53,500	80,500	107,500	134,000	268,500	402,500	536,500
18	A	16,000	32,500	48,500	64,500	80,500	161,500	242,000	323,000
	B	22,000	44,500	66,500	89,000	111,000	222,000	333,500	444,500
	C	30,000	60,500	90,500	120,500	151,000	302,000	452,500	603,500
20	A	18,000	36,000	54,000	72,000	89,500	179,500	269,000	359,000
	B	24,500	49,500	74,000	99,000	123,500	247,000	370,500	494,000
	C	33,500	67,000	100,500	134,000	167,500	335,500	503,000	670,500

Assumes two lane roadway with 50/50 directional split of base year AADT

Table 5F-1.09: Base Year Design ESALs for Four Lane *Rigid Pavement*

% Trucks	Truck Mix Type	Two-Way Base Year AADT							
		2,000	**5,000**	**10,000**	**15,000**	**20,000**	**25,000**	**30,000**	**35,000**
1	A	1,000	3,000	6,000	9,000	11,500	14,500	17,500	20,500
	B	2,000	5,000	10,000	14,500	19,500	24,500	29,500	34,500
	C	3,000	7,000	14,500	21,500	28,500	35,500	43,000	50,000
2	A	2,500	6,000	11,500	17,500	23,500	29,500	35,000	41,000
	B	4,000	10,000	19,500	29,500	39,000	49,000	59,000	68,500
	C	5,500	14,500	28,500	43,000	57,000	71,500	85,500	100,000
3	A	3,500	9,000	17,500	26,500	35,000	44,000	52,500	61,500
	B	6,000	14,500	29,500	44,000	59,000	73,500	88,000	103,000
	C	8,500	21,500	43,000	64,000	85,500	107,000	128,500	149,500
4	A	4,500	11,500	23,500	35,000	47,000	58,500	70,500	82,000
	B	8,000	19,500	39,000	59,000	78,500	98,000	117,500	137,000
	C	11,500	28,500	57,000	85,500	114,000	142,500	171,000	199,500
5	A	6,000	14,500	29,500	44,000	58,500	73,000	88,000	102,500
	B	10,000	24,500	49,000	73,500	98,000	122,500	147,000	171,500
	C	14,500	35,500	71,500	107,000	142,500	178,000	214,000	249,500
6	A	7,000	17,500	35,000	52,500	70,500	88,000	105,500	123,000
	B	12,000	29,500	59,000	88,000	117,500	147,000	176,500	206,000
	C	17,000	43,000	85,500	128,500	171,000	214,000	256,500	299,500
7	A	8,000	20,500	41,000	61,500	82,000	102,500	123,000	143,500
	B	13,500	34,500	68,500	103,000	137,000	171,500	206,000	240,000
	C	20,000	50,000	100,000	149,500	199,500	249,500	299,500	349,500
8	A	9,500	23,500	47,000	70,500	93,500	117,000	140,500	164,000
	B	15,500	39,000	78,500	117,500	157,000	196,000	235,000	274,500
	C	23,000	57,000	114,000	171,000	228,000	285,000	342,000	399,000
9	A	10,500	26,500	52,500	79,000	105,500	132,000	158,000	184,500
	B	17,500	44,000	88,000	132,500	176,500	220,500	264,500	308,500
	C	25,500	64,000	128,500	192,500	256,500	321,000	385,000	449,000
10	A	11,500	29,500	58,500	88,000	117,000	146,500	175,500	205,000
	B	19,500	49,000	98,000	147,000	196,000	245,000	294,000	343,000
	C	28,500	71,500	142,500	214,000	285,000	356,500	427,500	499,000
12	A	14,000	35,000	70,500	105,500	140,500	175,500	211,000	246,000
	B	23,500	59,000	117,500	176,500	235,000	294,000	353,000	411,500
	C	34,000	85,500	171,000	256,500	342,000	427,500	513,000	599,000
14	A	16,500	41,000	82,000	123,000	164,000	205,000	246,000	287,000
	B	27,500	68,500	137,000	206,000	274,500	343,000	411,500	480,000
	C	40,000	100,000	199,500	299,500	399,000	499,000	599,000	698,500
16	A	18,500	47,000	93,500	140,500	187,500	234,000	281,000	328,000
	B	31,500	78,500	157,000	235,000	313,500	392,000	470,500	549,000
	C	45,500	114,000	228,000	342,000	456,000	570,500	684,500	798,500
18	A	21,000	52,500	105,500	158,000	211,000	263,500	316,000	369,000
	B	35,500	88,000	176,500	264,500	353,000	441,000	529,000	617,500
	C	51,500	128,500	256,500	385,000	513,000	641,500	770,000	898,000
20	A	23,500	58,500	117,000	175,500	234,000	293,000	351,500	410,000
	B	39,000	98,000	196,000	294,000	392,000	490,000	588,000	686,000
	C	57,000	142,500	285,000	427,500	570,500	713,000	855,500	998,000

Assumes four lane roadway with 50/50 directional split of two-way base year AADT and 60% of trucks in the design lane.

Table 5F-1.10: Base Year Design ESALs for Four Lane *Flexible Pavement*

% Trucks	Truck Mix Type	Two-Way Base Year AADT							
		2,000	5,000	10,000	15,000	20,000	25,000	30,000	35,000
1	A	1,000	2,500	5,500	8,000	11,000	13,500	16,000	19,000
	B	1,500	3,500	7,500	11,000	15,000	18,500	22,000	26,000
	C	2,000	5,000	10,000	15,000	20,000	25,000	30,000	35,000
2	A	2,000	5,500	11,000	16,000	21,500	27,000	32,500	37,500
	B	3,000	7,500	15,000	22,000	29,500	37,000	44,500	52,000
	C	4,000	10,000	20,000	30,000	40,000	50,500	60,500	70,500
3	A	3,000	8,000	16,000	24,000	32,500	40,500	48,500	56,500
	B	4,500	11,000	22,000	33,500	44,500	55,500	66,500	78,000
	C	6,000	15,000	30,000	45,500	60,500	75,500	90,500	105,500
4	A	4,500	11,000	21,500	32,500	43,000	54,000	64,500	75,500
	B	6,000	15,000	29,500	44,500	59,500	74,000	89,000	103,500
	C	8,000	20,000	40,000	60,500	80,500	100,500	120,500	141,000
5	A	5,500	13,500	27,000	40,500	54,000	67,500	80,500	94,000
	B	7,500	18,500	37,000	55,500	74,000	92,500	111,000	129,500
	C	10,000	25,000	50,500	75,500	100,500	126,000	151,000	176,000
6	A	6,500	16,000	32,500	48,500	64,500	80,500	97,000	113,000
	B	9,000	22,000	44,500	66,500	89,000	111,000	133,500	155,500
	C	12,000	30,000	60,500	90,500	120,500	151,000	181,000	211,500
7	A	7,500	19,000	37,500	56,500	75,500	94,000	113,000	132,000
	B	10,500	26,000	52,000	78,000	103,500	129,500	155,500	181,500
	C	14,000	35,000	70,500	105,500	141,000	176,000	211,500	246,500
8	A	8,500	21,500	43,000	64,500	86,000	107,500	129,000	150,500
	B	12,000	29,500	59,500	89,000	118,500	148,000	178,000	207,500
	C	16,000	40,000	80,500	120,500	161,000	201,000	241,500	281,500
9	A	9,500	24,000	48,500	72,500	97,000	121,000	145,500	169,500
	B	13,500	33,500	66,500	100,000	133,500	166,500	200,000	233,500
	C	18,000	45,500	90,500	136,000	181,000	226,500	271,500	317,000
10	A	11,000	27,000	54,000	80,500	107,500	134,500	161,500	188,500
	B	15,000	37,000	74,000	111,000	148,000	185,000	222,000	259,500
	C	20,000	50,500	100,500	151,000	201,000	251,500	302,000	352,000
12	A	13,000	32,500	64,500	97,000	129,000	161,500	194,000	226,000
	B	18,000	44,500	89,000	133,500	178,000	222,000	266,500	311,000
	C	24,000	60,500	120,500	181,000	241,500	302,000	362,000	422,500
14	A	15,000	37,500	75,500	113,000	150,500	188,500	226,000	263,500
	B	20,500	52,000	103,500	155,500	207,500	259,500	311,000	363,000
	C	28,000	70,500	141,000	211,500	281,500	352,000	422,500	493,000
16	A	17,000	43,000	86,000	129,000	172,000	215,500	258,500	301,500
	B	23,500	59,500	118,500	178,000	237,000	296,500	355,500	415,000
	C	32,000	80,500	161,000	241,500	322,000	402,500	483,000	563,500
18	A	19,500	48,500	97,000	145,500	194,000	242,000	290,500	339,000
	B	26,500	66,500	133,500	200,000	266,500	333,500	400,000	466,500
	C	36,000	90,500	181,000	271,500	362,000	452,500	543,500	634,000
20	A	21,500	54,000	107,500	161,500	215,500	269,000	323,000	377,000
	B	29,500	74,000	148,000	222,000	296,500	370,500	444,500	518,500
	C	40,000	100,500	201,000	302,000	402,500	503,000	603,500	704,000

Assumes four lane roadway with 50/50 directional split of two-way base year AADT and 60% of trucks in the design lane.

Table 5F-1.11: Growth Factor

Design Period Years (n)	Average Annual Traffic Growth Rate, Percent					
	No Growth	1%	2%	3%	4%	5%
1	1.0	1.0	1.0	1.0	1.0	1.0
2	2.0	2.0	2.0	2.0	2.0	2.1
3	3.0	3.0	3.1	3.1	3.1	3.2
4	4.0	4.1	4.1	4.2	4.2	4.3
5	5.0	5.1	5.2	5.3	5.4	5.5
6	6.0	6.2	6.3	6.5	6.6	6.8
7	7.0	7.2	7.4	7.7	7.9	8.1
8	8.0	8.3	8.6	8.9	9.2	9.5
9	9.0	9.4	9.8	10.2	10.6	11.0
10	10.0	10.5	10.9	11.5	12.0	12.6
11	11.0	11.6	12.2	12.8	13.5	14.2
12	12.0	12.7	13.4	14.2	15.0	15.9
13	13.0	13.8	14.7	15.6	16.6	17.7
14	14.0	14.9	16.0	17.1	18.3	19.6
15	15.0	16.1	17.3	18.6	20.0	21.6
16	16.0	17.3	18.6	20.2	21.8	23.7
17	17.0	18.4	20.0	21.8	23.7	25.8
18	18.0	19.6	21.4	23.4	25.6	28.1
19	19.0	20.8	22.8	25.1	27.7	30.5
20	20.0	22.0	24.3	26.9	29.8	33.1
21	21.0	23.2	25.8	28.7	32.0	35.7
22	22.0	24.5	27.3	30.5	34.2	38.5
23	23.0	25.7	28.8	32.5	36.6	41.4
24	24.0	27.0	30.4	34.4	39.1	44.5
25	25.0	28.2	32.0	36.5	41.6	47.7
26	26.0	29.5	33.7	38.6	44.3	51.1
27	27.0	30.8	35.3	40.7	47.1	54.7
28	28.0	32.1	37.1	42.9	50.0	58.4
29	29.0	33.5	38.8	45.2	53.0	62.3
30	30.0	34.8	40.6	47.6	56.1	66.4
31	31.0	36.1	42.4	50.0	59.3	70.8
32	32.0	37.5	44.2	52.5	62.7	75.3
33	33.0	38.9	46.1	55.1	66.2	80.1
34	34.0	40.3	48.0	57.7	69.9	85.1
35	35.0	41.7	50.0	60.5	73.7	90.3
36	36.0	43.1	52.0	63.3	77.6	95.8
37	37.0	44.5	54.0	66.2	81.7	101.6
38	38.0	46.0	56.1	69.2	86.0	107.7
39	39.0	47.4	58.2	72.2	90.4	114.1
40	40.0	48.9	60.4	75.4	95.0	120.8
41	41.0	50.4	62.6	78.7	99.8	127.8
42	42.0	51.9	64.9	82.0	104.8	135.2
43	43.0	53.4	67.2	85.5	110.0	143.0
44	44.0	54.9	69.5	89.0	115.4	151.1
45	45.0	56.5	71.9	92.7	121.0	159.7
46	46.0	58.0	74.3	96.5	126.9	168.7
47	47.0	59.6	76.8	100.4	132.9	178.1
48	48.0	61.2	79.4	104.4	139.3	188.0
49	49.0	62.8	81.9	108.5	145.8	198.4
50	50.0	64.5	84.6	112.8	152.7	209.3

Growth Factor = $\frac{[(1+r)^n]-1}{r}$ for values of n > 0

D. Determining Pavement Thickness

Once the ESALs have been determined, the pavement thickness may be determined by comparing the calculated ESAL value to Tables 5F-1.13 through 5F-1.18. These tables provide recommended pavement thicknesses for various subgrade conditions, roadway types, and pavement types. Use of the roadway classification (local, collector, and arterial) is included in Tables 5F-1.13 to 5F-1.18 in order to provide the values for terminal serviceability and reliability that are used in the pavement thickness calculations. Due to established policies in many jurisdictions across the state, the minimum pavement thickness for streets on natural subgrade was set at 7 inches for rigid pavement and 8 inches for flexible pavement. For pavements with a granular subbase, the minimum thickness was set at 6 inches for both pavement types. As noted in the thickness tables, whenever a thickness was calculated that was less than the minimum, the minimum was used.

Tables 5F-1.13 through 5F-1.18 were developed according to the guidelines of the AASHTO Design Guide. The AASHTO pavement design methodology is based upon the results of the AASHO Road Test, which was a series of full scale experiments conducted in Illinois in the 1950s. The design methodology that grew out of the Road Test considers numerous factors that affect the performance of a pavement. Table 5F-1.12 describes the assumptions used in the development of the pavement thickness tables. An explanation of each variable, as well as a recommended range, is provided in the AASHTO Guide.

For projects with unique conditions such as unusual soils, high truck volumes, significant drainage problems, or where specialized subgrade or subbase treatments are utilized, a special design may be warranted. The values in the tables above have been selected to represent typical conditions. An effort has been made not to be overly conservative in the establishment of the design parameters. For this reason, the designer is cautioned against deviating from the values presented in the tables above unless materials testing and/or project site conditions warrant such deviation.

Table 5F-1.12: Parameter Assumptions Used for Pavement Thickness Design Tables

Subbase:	**Natural**		**4" Subbase**		**6" Subbase**		**8" Subbase**		**10" Subbase**		**12" Subbase**	
CBR Value:	**3**	**5**	**3**	**5**	**3**	**5**	**3**	**5**	**3**	**5**	**3**	**5**
Rigid Pavement Parameters												
Initial Serviceability Index, P_o	4.5											
Terminal Serviceability Index, P_t	Local Roads = 2.00 Collector Roads = 2.25 Arterials = 2.50											
Reliability, R	Local Roads = 80% Collector Roads = 88% Arterials = 95%											
Overall Standard Deviation, S_o	0.35											
Loss of Support, LS	0											
Soil Resilient Modulus, M_R 1500 x CBR	4,500	7,500	4,500	7,500	4,500	7,500	4,500	7,500	4,500	7,500	4,500	7,500
Subbase Resilient Modulus, E_{SB} *Assumed	Not Applicable		30,000*									
Modulus of Subgrade Reaction k, and Composite Modulus of Subgrade Reaction, k_c Use AASHTO Chapter 3, Table 3.2 and Figures 3.3 - 3.6 to determine	105	148	228	342	239	359	254	380	269	404	285	428
Coefficient of Drainage, C_d	1.00		1.10									
Modulus of Rupture, S'_c $S'_c = 2.3 \times f_c^{0.667}$ *Assumed 4,000 psi concrete	580											
Modulus of Elasticity, E_c $E_c = 6{,}750 \times S'_c$ *Assumed 4,000 psi concrete	3,915,000											
Load Transfer, J	J = 3.1 (Pavement Thickness <8") J = 2.7 (Pavement Thickness ≥ 8")											
Flexible Pavement Parameters												
Initial Serviceability Index, P_o	4.2											
Terminal Serviceability Index, P_t	Local Roads = 2.00 Collector Roads = 2.25 Arterials = 2.50											
Reliability, R	Local Roads = 80% Collector Roads = 88% Arterials = 95%											
Overall Standard Deviation, S_o	0.45											
Layer Coefficients	Surface / Intermediate = 0.44 Base = 0.44 Granular Subbase = 0.14											
Soil Resilient Modulus, M_R 1500 x CBR	4,500	7,500	4,500	7,500	4,500	7,500	4,500	7,500	4,500	7,500	4,500	7,500
Effective Soil Resilient Modulus, MR Use AASHTO Chapter 2, Figure 2.3 to determine	2,720	4,520	2,720	4,520	2,720	4,520	2,720	4,520	2,720	4,520	2,720	4,520
Coefficient of Drainage, C_d	1.00		1.15									

The following flowchart depicts a summary of the analysis process.

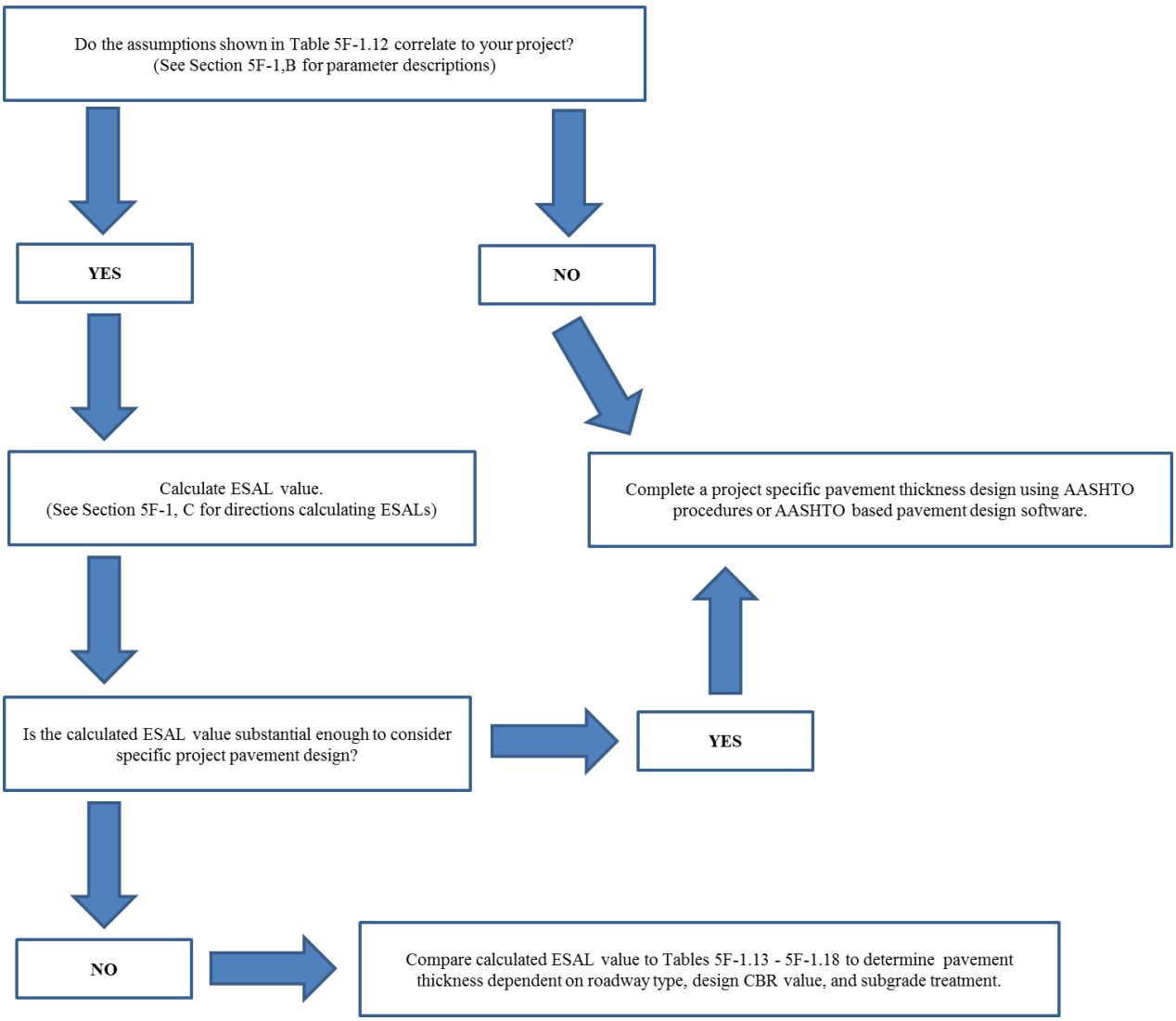


Table 5F-1.13: Recommended Thickness for Rigid Pavement - *Local Roads*

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
300,000	7*	6*	6*	6*	6*	6*	7*	6*	6*	6*	6*	6*
500,000	7*	6*	6*	6*	6*	6*	7*	6*	6*	6*	6*	6*
750,000	7*	6	6	6*	6*	6*	7*	6*	6*	6*	6*	6*
1,000,000	7	6	6	6	6	6	7	6	6*	6*	6*	6*
1,500,000	7.5	6.5	6.5	6.5	6.5	6.5	7.5	6.5	6	6	6	6
2,000,000	8	7	7	7	7	7	7.5	6.5	6.5	6.5	6.5	6.5
3,000,000	8	7.5	7.5	7.5	7.5	7.5	8	7	7	7	7	7

* Represents the minimum thickness based on established policies of local jurisdictions; the calculated value is less.

Table 5F-1.14: Recommended Thickness for Rigid Pavement - *Collector Roads*

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
750,000	7	6	6	6	6	6	7	6	6*	6*	6*	6*
1,000,000	7.5	6.5	6.5	6.5	6.5	6.5	7	6	6	6	6	6
1,500,000	8	7	7	7	7	7	7.5	6.5	6.5	6.5	6.5	6.5
2,000,000	8	7.5	7.5	7.5	7.5	7	8	7	7	7	7	7
3,000,000	8	8	8	8	8	8	8	7.5	7.5	7.5	7.5	7.5
4,000,000	8.5	8	8	8	8	8	8.5	8	8	8	8	8
5,000,000	9	8	8	8	8	8	8.5	8	8	8	8	8
7,500,000	9.5	8.5	8.5	8.5	8.5	8.5	9.5	8.5	8	8	8	8
10,000,000	10	9	9	9	9	9	9.5	8.5	8.5	8.5	8.5	8.5

* Represents the minimum thickness based on established policies of local jurisdictions; the calculated value is less.

Table 5F-1.15: Recommended Thickness for Rigid Pavement - *Arterial Roads*

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
1,000,000	7.5	7	7	7	7	6.5	7.5	6.5	6.5	6.5	6.5	6.5
1,500,000	8	7.5	7.5	7.5	7.5	7	8	7	7	7	7	7
2,000,000	8	8	7.5	7.5	7.5	7.5	8	7.5	7.5	7.5	7.5	7.5
3,000,000	8.5	8	8	8	8	8	8.5	8	8	8	8	8
4,000,000	9	8	8	8	8	8	8.5	8	8	8	8	8
5,000,000	9	8.5	8.5	8.5	8	8	9	8	8	8	8	8
7,500,000	10	9	9	9	9	9	9.5	8.5	8.5	8.5	8.5	8.5
10,000,000	10	9.5	9.5	9.5	9	9	10	9	9	9	9	9
12,500,000	10.5	9.5	9.5	9.5	9.5	9.5	10.5	9.5	9.5	9.5	9.5	9
15,000,000	11	10	10	10	10	10	10.5	9.5	9.5	9.5	9.5	9.5
17,500,000	11	10	10	10	10	10	11	10	10	10	10	10
20,000,000	11.5	10.5	10.5	10.5	10.5	10.5	11	10	10	10	10	10

Table 5F-1.16: Recommended Thickness for Flexible Pavement - *Local Roads*

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
300,000	8.5	7	6.5	6*	6*	6*	8*	6	6*	6*	6*	6*
500,000	9.5	8	7	6.5	6*	6*	8	6.5	6*	6*	6*	6*
750,000	10	8.5	7.5	7	6	6*	8.5	7	6	6*	6*	6*
1,000,000	10	8.5	8	7.5	6.5	6	8.5	7	6.5	6*	6*	6*
1,500,000	11	9.5	8.5	8	7	6.5	9	7.5	7	6	6*	6*
2,000,000	11	9.5	9	8.5	7.5	7	9.5	8	7.5	6.5	6	6*
3,000,000	12	10.5	9.5	9	8	7.5	10	8.5	8	7	6.5	6*

* Represents the minimum thickness based on established policies of local jurisdictions; the calculated value is less.

Table 5F-1.17: Recommended Thickness for Flexible Pavement - *Collector Roads*

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
750,000	10.5	9	8.5	7.5	7	6	9	7.5	6.5	6	6*	6*
1,000,000	11	9.5	9	8	7.5	6.5	9.5	8	7	6.5	6*	6*
1,500,000	11.5	10	9.5	8.5	8	7.5	10	8.5	7.5	7	6	6*
2,000,000	12	10.5	10	9	8.5	7.5	10.5	9	8	7.5	6.5	6
3,000,000	13	11.5	10.5	10	9	8.5	11	9.5	8.5	8	7	6.5
4,000,000	13.5	12	11	10.5	9.5	9	11.5	10	9	8.5	7.5	7
5,000,000	13.5	12	11.5	10.5	10	9.5	11.5	10	9.5	9	8	7.5
7,500,000	---	13	12	11.5	10.5	10	12.5	11	10	9.5	8.5	8
10,000,000	---	13.5	12.5	12	11	10.5	13	11.5	10.5	10	9	8.5

* Represents the minimum thickness based on established policies of local jurisdictions; the calculated value is less.

Table 5F-1.18: Recommended Thickness for Flexible Pavement - *Arterial Roads*

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
1,000,000	12	11	10	9.5	8.5	8	10.5	9	8	7.5	6.5	6
1,500,000	13	11.5	10.5	10	9	8.5	11	9.5	9	8	7.5	6.5
2,000,000	13.5	12	11	10.5	10	9	11.5	10	9	8.5	8	7
3,000,000	14	12.5	12	11	10.5	9.5	12	10.5	10	9	8.5	7.5
4,000,000	---	13	12.5	11.5	11	10.5	12.5	11	10.5	9.5	9	8
5,000,000	---	13.5	13	12	11.5	10.5	13	11.5	11	10	9.5	8.5
7,500,000	---	---	13.5	13	12	11.5	13.5	12	11.5	10.5	10	9.5
10,000,000	---	---	---	13.5	13	12	14	12.5	12	11.5	10.5	10
12,500,000	---	---	---	14	13.5	12.5	---	13	12.5	11.5	11	10
15,000,000	---	---	---	---	13.5	13	---	13.5	12.5	12	11.5	10.5
17,500,000	---	---	---	---	14	13	---	14	13	12.5	11.5	11
20,000,000	---	---	---	---	---	13.5	---	14	13.5	12.5	12	11

E. Pavement Thickness Design Calculations

Example #1 - Two Lane Roadway, PCC
AADT = 1,000
Trucks = 2%, Type A truck mix
Annual Growth Rate = 2%
Design Period = 50 years

Base Year Design ESALs (from Table 5F-1.07) = 2,000
Growth Factor (from Table 5F-1.11) = 84.6
2,000 ESALs X 84.6 = 169,200 ESALs

By referring to Table 5F-1.13 and rounding up the ESAL calculation to 300,000 (see below), the pavement thickness alternatives are either 6 inches or 7 inches depending on the CBR value and the subbase treatment selected.

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
300,000	7*	6*	6*	6*	6*	6*	7*	6*	6*	6*	6*	6*
500,000	7*	6*	6*	6*	6*	6*	7*	6*	6*	6*	6*	6*
750,000	7*	6	6	6*	6*	6*	7*	6*	6*	6*	6*	6*

* Represents the minimum thickness based on established policies of local jurisdictions; the calculated value is less.

Example #1 - Two Lane Roadway, HMA
AADT = 1,000
Trucks = 2%, Type A truck mix
Annual Growth Rate = 2%
Design Period = 50 years

Base Year Design ESALs (from Table 5F-1.08) = 2,000
Growth Factor (from Table 5F-1.1) = 84.6
2,000 ESALs X 84.6 = 169,200 ESALs

By referring to Table 5F-1.16 and rounding up the ESAL calculation to 300,000 (see below), the pavement thickness alternatives range from 6 inches to 8.5 inches depending on the CBR value and subbase treatment selected.

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
300,000	8.5	7	6.5	6*	6*	6*	8*	6	6*	6*	6*	6*
500,000	9.5	8	7	6.5	6*	6*	8	6.5	6*	6*	6*	6*
750,000	10	8.5	7.5	7	6	6*	8.5	7	6	6*	6*	6*

* Represents the minimum thickness based on established policies of local jurisdictions; the calculated value is less.

Example #2 - Two Lane Roadway, PCC
AADT = 5,000
Trucks = 4%, Type B truck mix
Annual Growth Rate = 2%
Design Period = 50 years

Base Year Design ESALs (from Table 5F-1.07) = 32,500
Growth Factor (from Table 5F-1.11) = 84.6
32,500 ESALs X 84.6 = 2,749,500 ESALs

By referring to Table 5F-1.14 and rounding up the ESAL calculation to 3,000,000 (see below), the pavement thickness alternatives range from 7.5 inches to 8 inches depending on the CBR value and subbase treatment selected.

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
750,000	7	6	6	6	6	6	7	6	6*	6*	6*	6*
1,000,000	7.5	6.5	6.5	6.5	6.5	6.5	7	6	6	6	6	6
1,500,000	8	7	7	7	7	7	7.5	6.5	6.5	6.5	6.5	6.5
2,000,000	8	7.5	7.5	7.5	7.5	7	8	7	7	7	7	7
3,000,000	8	8	8	8	8	8	8	7.5	7.5	7.5	7.5	7.5
4,000,000	8.5	8	8	8	8	8	8.5	8	8	8	8	8
5,000,000	9	8	8	8	8	8	8.5	8	8	8	8	8

* Represents the minimum thickness based on established policies of local jurisdictions; the calculated value is less.

Example #2 - Two Lane Roadway, HMA
AADT = 5,000
Trucks = 4%, Type B truck mix
Annual Growth Rate = 2%
Design Period = 50 years

Base Year Design ESALs (from Table 5F-1.08) = 24,500
Growth Factor (from Table 5F-1.11) = 84.6
24,500 ESALs X 84.6 = 2,072,700 ESALs

By referring to Table 5F-1.17 and rounding down the ESAL calculation to 2,000,000 (see below), the pavement thickness alternatives range from 6 inches to 12 inches depending on the CBR value and subbase treatment selected.

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
750,000	10.5	9	8.5	7.5	7	6	9	7.5	6.5	6	6*	6*
1,000,000	11	9.5	9	8	7.5	6.5	9.5	8	7	6.5	6*	6*
1,500,000	11.5	10	9.5	8.5	8	7.5	10	8.5	7.5	7	6	6*
2,000,000	12	10.5	10	9	8.5	7.5	10.5	9	8	7.5	6.5	6
3,000,000	13	11.5	10.5	10	9	8.5	11	9.5	8.5	8	7	6.5
4,000,000	13.5	12	11	10.5	9.5	9	11.5	10	9	8.5	7.5	7

* Represents the minimum thickness based on established policies of local jurisdictions; the calculated value is less.

Example #3 - Four Lane Roadway, PCC
AADT = 15,000
Trucks = 5%, Type C truck mix
Annual Growth Rate = 2%
Design Period = 50 years

Base Year Design ESALs (from Table 5F-1.09) = 107,000
Growth Factor (from Table 5F-1.11) = 84.6
107,000 ESALs X 84.6 = 9,052,200 ESALs

By referring to Table 5F-1.15 and rounding up the ESAL calculation to 10,000,000 (see below), the pavement thickness alternatives range from 9 inches to 10 inches depending on the CBR value and subbase treatment selected.

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
1,000,000	7.5	7	7	7	7	6.5	7.5	6.5	6.5	6.5	6.5	6.5
1,500,000	8	7.5	7.5	7.5	7.5	7	8	7	7	7	7	7
2,000,000	8	8	7.5	7.5	7.5	7.5	8	7.5	7.5	7.5	7.5	7.5
3,000,000	8.5	8	8	8	8	8	8.5	8	8	8	8	8
4,000,000	9	8	8	8	8	8	8.5	8	8	8	8	8
5,000,000	9	8.5	8.5	8.5	8	8	9	8	8	8	8	8
7,500,000	10	9	9	9	9	9	9.5	8.5	8.5	8.5	8.5	8.5
10,000,000	10	9.5	9.5	9.5	9	9	10	9	9	9	9	9
12,500,000	10.5	9.5	9.5	9.5	9.5	9.5	10.5	9.5	9.5	9.5	9.5	9

Example #3 - Four Lane Roadway, HMA
AADT = 15,000
Trucks = 5%, Type C truck mix
Annual Growth Rate = 2%
Design Period = 50 years

Base Year Design ESALs (from Table 5F-1.10) = 75,500
Growth Factor (from Table 5F-1.11) = 84.6
75,500 ESALs X 84.6 = 6,387,300 ESALs

By referring to Table 5F-1.18 and rounding the ESAL calculation to 7,500,000 (see below), the pavement thickness alternatives range from 9.5 inches to 13.5 inches depending on the CBR value and subbase treatment selected.

CBR	3						5					
ESAL/ Subbase	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular	Natural	4" Granular	6" Granular	8" Granular	10" Granular	12" Granular
1,000,000	12	11	10	9.5	8.5	8	10.5	9	8	7.5	6.5	6
1,500,000	13	11.5	10.5	10	9	8.5	11	9.5	9	8	7.5	6.5
2,000,000	13.5	12	11	10.5	10	9	11.5	10	9	8.5	8	7
3,000,000	14	12.5	12	11	10.5	9.5	12	10.5	10	9	8.5	7.5
4,000,000	---	13	12.5	11.5	11	10.5	12.5	11	10.5	9.5	9	8
5,000,000	---	13.5	13	12	11.5	10.5	13	11.5	11	10	9.5	8.5
7,500,000	---	---	13.5	13	12	11.5	13.5	12	11.5	10.5	10	9.5
10,000,000	---	---	---	13.5	13	12	14	12.5	12	11.5	10.5	10

F. References

American Association of State Highway Transportation Officials (AASHTO). *Guide for Design of Pavement Structures.* 1993.

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Cold-in-Place Recycling

A. General

Cold-in-place recycling (CIR) is the process of recycling an asphalt pavement in-place with a train of equipment that can range from a single unit to a multi-unit train. In CIR, the existing asphalt pavement is cold milled to produce recycled asphalt pavement (RAP), which is then further processed, placed, and compacted in one continuous operation on the roadway.

The advantages of CIR over other rehabilitation/reconstruction techniques include:

- Conservation of resources
- Energy conservation compared to other rehabilitation/reconstruction processes
- Surface irregularities are corrected
- A portion of existing cracks are removed and reflective cracks mitigated
- Rutting, potholes, and raveling are eliminated
- Base and subgrades are not disturbed
- Pavement cross-slope and profile are improved
- Reduced traffic disruptions and user inconvenience compared to other rehabilitation/reconstruction techniques
- Reduced or no edge drop-offs
- Cost savings compared to other rehabilitation/reconstruction options

B. Pavement Assessment

When determining whether the appropriate rehabilitation method is a CIR project the following information should be evaluated:

- Age of the pavement
- Thickness of the existing pavement
- Delamination or evidence of stripped aggregates
- Grade and type of existing binder
- Gradation of existing aggregate
- Presence of any fabric or other geosynthetic interlayers
- Past pavement condition surveys
- Subbase/subgrade support quality
- Utility interference

Age of the existing pavement is a good indicator of the stiffness of the existing binder and the expected hardness during cold planning. It is also an indicator of the quality of the underlying support structure.

The thickness of the existing pavement affects treatment depth. Generally CIR projects involve depths of 3 to 4 inches with some as thin as 2 inches and some up to 5 inches provided good compaction can be accomplished. Treatment depths should be a minimum of three times the maximum size of the aggregate to aid compaction. CIR treatment depths should extend through delaminated or poorly bonded lifts to prevent those sections from being loosened and removed during the cold planning process thus creating uneven treatment depths.

Knowledge of the existing binder grades affects the mix design for the CIR product. Soft binders or binders containing solvents tend to be less stable, which may signal the need for additives such as cement, lime, or new aggregate. Harder binders may call for additional recycling agents since less activation of the existing binder occurs. Specialty mixtures such as open-graded drainage layers, open-graded friction courses, and stone matrix asphalt will affect the mix design and construction techniques.

If fabric or other geosynthetic interlayers are present, the recycled depth must either extend below the interlayer so that it is removed, or be a minimum of 1 inch above it to prevent tearing of the fabric and delamination of the pavement above the fabric.

In addition to record information, a field inspection is needed to determine the condition of the existing pavement. The current type, severity, and frequency of pavement distress should be documented. Pavements that have structurally sound bases but surface distresses, such as cracking, rutting, and raveling are prime candidates for CIR. The CIR process can be effective in mitigating cracking if the new layer removes about 70% of the depth of the cracks

Two elements of structural capacity need to be evaluated. The first is what pavement thickness should be developed to address the needs of the anticipated traffic mix over the life of the rehabilitation project. Generally, the new CIR layer has structural coefficients of 0.30 to 0.35 per inch. The actual structural coefficient is based on the amount and type of recycling agents and if additives are used. If the traffic mix calls for additional pavement, an asphalt or concrete overlay can be added to address the structural needs.

The second structural element relates to the ability of the remaining pavement structure to support the recycling equipment during the construction process. Pavements with extensive base failures are not good candidates for CIR. The assessment of the load carrying capacity of the remaining pavement and underlying subbase and subgrade becomes more important for thinner sections. Equipment used for CIR is generally heavy and without sufficient structure; the equipment can punch through the remaining material and into the subgrade.

Three means of determining the strength of the remaining pavement include ground penetrating radar (GPR), dynamic cone penetrometer (DCP), and falling weight deflectometer (FWD). It is important to undertake this testing at the same time of year when moisture conditions in the remaining pavement base, subbase, and subgrade are similar to those at the anticipated time of construction.

Field samples from the existing pavement should be collected to obtain representative material throughout the project area. The gradation of the RAP and properties of the mineral aggregate will affect the amounts of recycling agent, additives, and on final mix performance.

The final assessment includes accessibility for the equipment, especially in urban areas. Although the exact equipment to be used by the successful bidder is not known, an evaluation using typical equipment should be made. Such things as small radii, T-intersections, bridges, overhanging vegetation, and many surface utility structures will influence whether CIR is the appropriate rehabilitation technique to apply. Small cold planers may be needed to facilitate the recycling of the entire roadway.

The presence, frequency, and elevation of utility structures needs to be evaluated. Manholes, valves and other structures should be lowered to a point a minimum of 2 inches below the CIR treatment depth; generally involving removal of the casting. A steel plate should then be installed over the manholes. After the CIR treatment and placement of any overlay, the manholes can be adjusted to match the surface elevations. Special treatment of utility structures that cannot be lowered may involve milling the material around the structure with smaller equipment.

C. Mix Design

The mix design is a laboratory procedure that establishes the job mix formula (JMF) to meet the project requirements for long-term service life of the recycled pavement. Mix design procedures that use Superpave principles are the most widely used. The procedures use either Superpave Gyratory Compactor or 75-blow Marshall Compaction. Mixture evaluations should address initial and cured strength, resistance to moisture-induced damage, raveling resistance, and resistance to thermal cracking.

The mix design should include the following steps:

- Obtain samples from the existing pavement
- Determine binder content and gradation of the extracted aggregate
- Crush the materials and determine gradation
- Select type and grade of bituminous recycling agent
- Select type and grade of recycling additive, if required
- Prepare and test specimens
- Establish job mix formula

The JMF should specify the type and grade of bituminous recycling agent, optimum recycling agent content, mix water content, any additive type and quantity, if used, and laboratory compacted maximum density at the optimum moisture content.

D. Recycling Agents and Additives

1. **Recycling Agents:** The correct selection of the type and grade of recycling agent is critical for proper performance of the CIR project. The most common types of recycling agents are emulsified asphalts and foamed asphalts.

   Emulsified asphalt consists of an asphalt binder, water, and an emulsifier. They can be formulated with ingredients to enhance specific mixture properties, to aid production and/ or constructability. Ingredients added can include solvents, cutters, rejuvenating agents, accelerants, retarders, water reducers, polymers, and peptizers. The chemistry of the emulsified asphalt and the reclaimed materials (RAP, granular materials, and water) has a major influence on the stability and breaking-time of the emulsified asphalt. Thus, it is important to confirm the compatibility of the emulsified asphalt with the remaining materials in the mix design process. Emulsified asphalt content typically ranges from 2% to 4% by dry weight of RAP.

   Foamed asphalt is a mixture of air, water, and hot asphalt. It occurs when a small amount of cold water is introduced into hot asphalt binder inside an expansion chamber. The water causes the asphalt binder to expand rapidly into millions of bubbles resulting in a foam. The foaming occurs as the water changes states from a liquid to a vapor and expands from 8 to 15 times its original volume. In the foam state, the asphalt binder's viscosity is greatly reduced and its surface area is greatly increased enabling it to be readily dispersed throughout the recycled materials. Foamed asphalt content typically ranges from 1.5% to 3% by dry weight of RAP.

2. **Recycling Additives:** Chemical additives are used with recycling agents to improve early strength gain, increase rutting resistance, and improve the moisture resistance of CIR mixes. Chemical additives such as cement or lime have been successfully used. Cement can be added in dry or slurry form. Cement contents should be kept low to prevent shrinkage cracking. The typical cement content should be 0.25% to 1.0% with a minimum ratio of asphalt residue to cement at 3 to 1.

   Quicklime or hydrated lime is usually added in slurry form, although hydrated lime can be added in dry form. Lime is typically added at 1.0 to 1.5% by dry weight of RAP.

E. Construction

Prior to initiation of recycling work, the existing roadway should be prepared by removing any excess dirt, mud, vegetation, standing water, combustible materials, oils, raised roadway markings, and other objectionable materials by sweeping, blading, or other approved methods. Paint stripes are typically just recycled into the material.

Traffic loop wires, rubberized crack fill materials, thermoplastic marking materials, and concrete patches should be removed. Utilities should be lowered to minimize stopping of the CIR train.

Depending on the RAP gradation, bulking of the material can be 10% to 15%. If the roadway has vertical constraints, such as meeting the existing curb and gutter elevations, and will involve additional surface thickness, it may be necessary to pre-mill a wedge at the curb or remove and haul from the site material milled across the entire surface width.

Once construction begins, the recycling agent should be metered by weight of RAP using a meter calibrated to within 0.5% of the specified rate. Complete coating of the RAP with emulsified asphalt is not necessary at the time of mixing. Further coating takes place during spreading and compaction.

If foamed asphalt is used, the CIR equipment must contain a heating system capable of maintaining the temperature of the asphalt flow components in order to maintain the expansion ratio. The binder injection system should contain two independent pumping systems and spray bars to apply the foamed asphalt separately from the water needed for compaction.

CIR is a variable process. The JMF provides a starting point but changes in gradation of RAP can occur, resulting in workability impacts. The appearance of the mixture after initial compaction can indicate if adjustments are necessary. Adjustments to mix water, recycling agents, and additive contents may be necessary. These changes should only be made by experienced personnel.

Compaction of CIR mixtures requires more energy than hot or warm mix asphalt. This is due to the high internal friction developed between mix particles, the higher viscosity of the binder due to aging, and cold compaction temperatures. Typically two or three rollers are used with at least one pneumatic roller weighing 22 to 25 tons and at least one double drum vibratory roller weighing 10 to 12 tons. Main compaction rollers should have a drum width of at least 5.5 feet and have working water spray bars to prevent material pickup. When foamed asphalt is used, the compaction commences immediately after placement. Emulsified asphalt mixtures should be compacted as the mixture begins to break, turning from brown to black.

To determine optimum compaction operations, a control strip between 500 and 1,000 feet long should be established. Many contractors begin breakdown rolling with one or two passes of a static drum roller. Pneumatic rollers and vibratory rollers follow up and then the finish rolling is completed with the static double drum roller. The rolling pattern established on the test strip should compact the mixture between 95% and 105% of the target density. The final compacted surface should be free of ruts, bumps, indentations, and segregation of aggregates while conforming to the designed profile and cross-section.

Minimum temperatures for construction are typically set at 55° F. Construction should not proceed if rainy weather is forecasted.

The CIR mixture must adequately cure before secondary compaction is completed, if needed, or the surface course is placed. Curing periods can be as short as a few hours or as long as several weeks depending on temperature, rainfall, humidity levels, type of recycling additive, if used, and which recycling agent was used. The most common curing period is 2 to 3 days.

A light fog seal may be required to prevent raveling of the CIR surface prior to placing the surface course. The fog seal should be composed of emulsified asphalt diluted up to 60% by volume with water. Typical application rates are 0.05 to 0.12 gallons per square yard. If a sand blotter is needed, it should be applied at 2 to 3 pounds per square yard.

If the recycling agent is emulsified asphalt, secondary compaction may be necessary after curing to remove minor consolidation in the wheel path caused by traffic. Secondary compaction is best completed on warmer days when the pavement temperature is above 80° F.

Due the high void content, a surface course is required to be placed over the CIR mixture to protect the mixture from moisture intrusion. For low traffic roadways, seal coats, slurry seals, and microsurfacing can be used. For higher traffic facilities, overlays of either concrete or asphalt are typically used. Prior to placement of any surface treatment, the surface should be cleaned with a power broom or sweeper to remove all loose materials. If the overlay uses asphalt, a tack coat of emulsified asphalt should be applied to provide for good bond. If an unbonded concrete overlay is used an asphalt or geosynthetic fabric interlayer must be used.

F. References

Asphalt Recycling and Reclaiming Association (ARRA). *Basic Asphalt Recycling Manual.* FHWA. Second Edition, 2015.

Full Depth Reclamation

A. General

Full depth reclamation (FDR) is a pavement rehabilitation technique in which the full depth asphalt pavement section and a predetermined amount of the underlying materials are uniformly crushed, pulverized, or blended, resulting in a stabilized base course that may be further enhanced through the use of additives.

FDR conserves existing sources since the existing pavement materials are incorporated into the base materials to form a new base. In some instances, a portion of the blended materials will need to be removed from the site if elevation restrictions are involved. FDR is distinguished from other pavement rehabilitation methods by the fact that the cutting head penetrates completely through the asphalt pavement section into the underlying subgrade or subbase. FDR can be utilized to depths up to 18 inches, but reclaimed depths of 6 to 12 inches are more typical.

Pavement distresses that can be addressed by FDR include:

- Excessive cracking of all types
- Surface deformations such as rutting, shoving, depressions, and patches
- Inadequate structural capacity and subgrade instability
- Loss of bond between pavement layers
- Corrections to roadway geometry
- Flexural distress in the wheel paths

By pulverizing the existing asphalt pavement and the underlying materials to build and strengthen the base, FDR rehabilitates the roadway without the need to change elevations or increase right-of-way widths. The reclaimed pavement alone can often serve as the base for the new surface course. If there is a need to improve the reclaimed materials, there are three methods of stabilization that can be used:

- Mechanical
- Chemical
- Bituminous

Mechanical stabilization is accomplished through the addition of new aggregates or recycled asphalt or crushed concrete pavements. Bituminous stabilization involves the addition of emulsified asphalt or foamed asphalt. Chemical stabilization adds cement, lime, Class C fly ash, cement kiln dust, lime kiln dust, calcium chloride, magnesium chloride, or proprietary products. FDR performance may be enhanced with a combination of stabilizing materials.

Full depth reclamation is an effective rehabilitation strategy if the asphalt roadway exhibits the following conditions:

- Problems with subbase/subgrade to the point of cracking and rutting are occurring
- Damaged pavement that is beyond resurfacing
- Repair strategy would involve in excess of 20% of the pavement requiring full depth patching
- Current pavement is inadequate for future traffic loading
- Corrections to geometrics are needed and can be accomplished within vertical constraints present in the roadway

B. Pavement Assessment

Basic information about the existing pavement is important to the FDR process. This includes the thickness of the asphalt pavement, the type and content of the asphalt binder, the aggregate gradation, the soil plasticity, and presence of any unusual elements such as fabrics in the existing pavement.

The presence of larger surface patches is also critical since it may affect the consistency of the reclaimed material. Patches may also indicate locations of poor drainage or poor subgrade support that may need to be specifically addressed as part of the rehabilitation project.

Two elements of structural capacity must be determined. The first relates to the ability to support the future traffic loading. The second relates to the ability of the underlying subgrade to support the construction equipment. In the thickness design process, the reclaimed material is considered a stabilized base. The structural layer coefficients for a bituminous stabilized base range from 0.20 to 0.30. If a combination of bituminous and cement or Class C fly ash are used as stabilizers, the layer coefficient will be higher. Cementitious materials if used as stabilizers alone will have layer coefficients ranging from 0.20 to 0.27 depending on the product and amount used. Lime will be on the lower end of the range.

In order to determine the strength of the underlying subgrade to support the construction processes, the existing subgrade needs to be analyzed with either a dynamic cone penetrometer (DCP) or a falling weight deflectometer (FWD). These test results should be obtained when conditions are similar to when the construction is expected to take place so they will be representation of the actual support values for the equipment.

Some of the underlying materials should be incorporated into the reclaimed mixture as a means of limiting wear on the equipment, improving productivity, and controlling costs. The determination of how much of the underlying materials to include in the pulverized material is dependent upon the following items:

- Thickness of the asphalt layers compared to the underlying materials
- Gradation of the pulverized asphalt layers
- Gradation of the pulverized underlying materials
- Whether or not a stabilizing agent will be used
- Which stabilizing agent, if any, is to be used
- Desired structural properties of the FDR section
- Subgrade stability

Field cores or block sampling of the existing asphalt pavement should be completed for each area of similar materials. Those materials should be crushed to produce gradations similar to expectations during the FDR process. The crushed materials will be evaluated during the mix design process.

The roadway geometry should be evaluated to determine if any realignment, lane changes, medians, or other modifications are needed to meet future traffic projections.

A summary flow chart for the project selection process can be found in Figure 3.4 of the *Guide to Full Depth Reclamation (FDR) with Cement.* The designer may chose other stabilizing materials besides cement.

In urban areas especially it is important to identify manholes, vaults, water valves and other structures in the pavement. The critical element is to determine if these structures can be lowered at least 4 inches below the FDR treatment depth. This will allow the reclaiming process to be uninterrupted and the material consistency maintained. If the structures cannot be lowered, the material around the structures must be pulled away and placed so the reclaiming process can be applied to that material. It can later be brought back and placed around the structure.

C. Mix Design

A laboratory mix design should be developed in order to optimize the quantity of stabilizing agent and the physical properties of the reclaimed mixture to meet the project requirements. The mix design will identify the need for a stabilizing agent, the type and percent of stabilizing agent, the recommended water content, and the type and amount of additives, if any is needed. From this information, a job mix formula is developed.

Currently there are no national standards for design of FDR mixtures. If mechanical stabilizers such as recycled asphalt pavements (RAP) are to be added, no mix design is necessary. The only thing needed to be determined is the optimum moisture content and the maximum dry density of the modified reclaimed material.

FDR mix designs should include the following:

- Obtain field samples of the existing asphalt pavement, base and underlying subgrade materials, and crush to generate RAP
- Determine gradation and plasticity index for the RAP materials
- Determine need for stabilizing agents and additives needed to meet structural requirements
- Determine dry density and optimum moisture content
- Mix, compact, and cure samples with varying amounts of stabilizing agent
- Test mixtures for strength and durability
- Establish job mix formula

The top size of the mixture gradation should not exceed 25% of the depth of the compacted reclaimed layer.

The properties of the FDR layer are highly dependent on the properties of the asphalt pavement layer, the subgrade, the stabilization materials used, and the thoroughness of mixing, compaction, and curing.

D. Stabilization Methods

If pulverization and compaction of the existing pavement and underlying materials does not meet the structural needs of the project, addition methods of stabilization will be necessary. There are three different types of stabilization.

1. **Mechanical:** If the pulverized material is either too coarse or has too many fines, then the appropriately sized granular material can be added to the mix to create a well-graded material. The granular material can be virgin crushed aggregates, asphalt grindings, or crushed concrete.

   The existing roadway geometry, including curb heights and bridge elevations may limit the amount of granular material that can be added. If elevation restrictions are encountered, additional work to remove some of the pulverized material prior to adding the granular material should be undertaken. If pulverized material is to be removed, it may be necessary to undertake additional gradation evaluations prior to adding finally the granular material.
   The mechanical stabilizer material can be added by spreading ahead of the pulverization pass or incorporated into the blending pass after pulverization and shaping. Spreading prior to pulverizing will likely create a more uniformly blended FDR.

2. **Chemical:** Chemical stabilization includes the use of cementitious products to increase the strength of the reclaimed mix. Typically these mixes use cement, lime, Class C fly ash, Class F fly ash with other additives, cement kiln dust, lime kiln dust, calcium chloride, magnesium chloride, or proprietary products.

Although most subgrade materials have very little chemical impact on the performance of the FDR, soils with certain characteristics can disrupt the hydration process. When the pH is lower than four, the cement may not react properly and will not bond the particles of the FDR together.

Sulfate-induced heave can result from the expansive material ettringite, which is formed when lime or cement reacts with clay, sulfate minerals, and water. This should not be problematic if the soluble sulfate content is less than 3,000 ppm.

Additional cement may be required if the organic content of the FDR layer is 2% or greater.

Atterberg limits should be performed on the soil to determine the plasticity of the materials on the site. Highly plastic soils may require special treatments.

The required chemical stabilization application rate is the rate needed to improve the strength, durability, and moisture sensitivity of the reclaimed mixture without causing excessive dry shrinkage cracking.

The chemical stabilizing additives can be applied by spreading ahead of the pulverizing process in dry powder form or can be disbursed in slurry form, on the ground ahead of the pulverizer or through a spray bar integrated into the reclaimer's mixing chamber.

The use of calcium chloride and magnesium chloride can also be accomplished in dry or liquid form. These products do result in some strength gain, but the more important result is the lowering of the mixtures freezing point, which helps reduce cyclic freeze/thaw events.

3. **Bituminous:** Bituminous stabilization involves the use of emulsified asphalt or foamed asphalt. These liquids can be blended into the reclaimed material through the reclaiming machine's integrated liquid injection system either during the pulverization pass or a subsequent blending pass if a multiple pass process is employed.

   After blending of asphalt emulsions with the pulverized material, there is a period of time in which the emulsion "breaks". This involves the point at which the water dissipates from the emulsion and the bitumen droplets rejoin, thus reverting to a continuous film that coats the reclaimed material particles. It is important to begin the breakdown compaction as soon as the emulsion breaks.

   The other asphalt material used to stabilize the mix is foamed asphalt. Asphalt foaming occurs when small amounts of water come into contact with hot asphalt. The main advantage of using foamed asphalt is that there are no additional costs after the initial investment in the foaming apparatus. Foamed asphalt stabilized mixtures can be placed, shaped, compacted, and opened to traffic immediately after mixing. A disadvantage of using foamed asphalt over asphalt emulsions is that foamed asphalt requires a minimum of 5% of fine material passing the No. 200 sieve. If insufficient fines are present, the foamed asphalt does not disburse properly and forms asphalt rich stringers that sit in an unstable state. Small amounts of cement or lime may be added to meet the minus No. 200 fraction.

4. **Stabilizer Selection:** The characteristics of the reclaimed material must be considered in selecting the stabilizer to be used. Testing of the mixture using the selected stabilizer to determine the correct amount to use in combination with the reclaimed mixture to achieve the required structural strength is required. The following guidelines should be used in the selection process.

Table 5J-3.01: General Guidelines for Selecting Stabilizers for FDR

Type and Typical Trial Percent of Stabilizer	Characteristics of Reclaimed Pavement Materials
Hydrated Lime or Quicklime (2% to 6% by weight)	RAP having some amount of silty clay soil from subgrade with a plasticity index greater than 10.
Class C Fly Ash (8% to 14% by weight)	Material consists of 100% RAP or blends of RAP and underlying base or soil. The soil fraction can have plasticity indices similar to soils acceptable for lime treatment.
Portland Cement[1] (3% to 6% by weight)	Materials consisting of 100% RAP or blends of RAP and underlying base, non-plastic, or low plasticity soil. There should be sufficient fines to produce an acceptable aggregate matrix for the cement treated base produced, which contain no less than 45% passing the No. 4 sieve.
Emulsified or Foamed Asphalt[2] (1% to 3 % by weight)	Materials consisting of 100% RAP or blends of RAP and underlying base, non-plastic, or low plasticity soil. The maximum percent passing the No. 200 sieve should be less than 25%; the plasticity index less than 6 or the sand equivalent 30 or greater; or the product of multiplying the plasticity index and the percent passing the No. 200 sieve is less than 72.
Calcium Chloride	Materials consisting of a blend of RAP and non-plastic base soils with 8% to 12% minus No. 200 material. Small amounts of clay (3% to 5%) are beneficial.

[1] Class C fly ash has been combined with cement in varying ratios for stabilization. Combining of the materials could result in better mix properties at a lower cost than either one used independently.

[2] Small amounts of cement (1.0%) or hydrated lime (1.5%) can be added with asphalt emulsion to produce mixes with higher early strength and greater resistance to water damage.

E. Construction

Regardless of the type of equipment used by the contractor, the following steps should be completed:

- Pulverizing and sizing of the existing asphalt layers
- Incorporating and mixing of the existing underlying materials
- Applying mechanical, chemical, or bituminous stabilizing agent and additives, if required
- Mixing of reclaimed materials with stabilizing agents and additives, if used
- Breaking down compaction
- Rough grading or initial shaping
- Intermediate compaction
- Intermediate shaping
- Final compaction
- Final trimming or tight blading
- Removing any loose material
- Curing
- Microcracking, if needed
- Applying the surface course

All utilities should be field located according to Iowa One Call laws. Shallow underground facilities should be exposed by pot holing (vacuum excavations) to determine exact elevations to prevent unnecessary accidents from occurring during the pulverization process. Any utilities within 4 inches of the bottom of the reclaimed material should be relocated or lowered. Manholes, valves, and other castings should be lowered to at least 4 inches lower than the anticipated FDR depth. Work to bring the casting to final grade can take place after the surface course has been placed. If it is not possible to lower the structures, the material surrounding the structures can be pulled away to the depth of the FDR treatment and carefully pulverized and mixed with stabilizing agents that can then be replaced and compacted.

The most efficient temperature for proper sizing of the reclaimed material is between 50°F and 90°F. An FDR project should not commence when the air temperatures are below 40°F.

If an FDR project is developed in an urban area, it is important to evaluate the elevation restrictions, especially with curb and gutter. It may be necessary to mill off a portion of the asphalt street prior to pulverizing the remaining portion. The reduction of the RAP will need to be accounted for in the mix design. An alternative method is to pulverize the entire section and then remove the appropriate amount of excess material from the site. This process has the advantage of creating a uniform mixture.

If a stabilizing agent will be added to the mixture, more than one pass of the reclaimer is usually required. The second mixing pass of the reclaimer should maintain a more consistent working speed and thus a more uniform, accurate application of the stabilizing agent. To reduce the risk of a thin layer of untreated reclaimed material being left beneath the stabilized layer, the depth of the pulverizing pass should be 1 to 2 inches less than the mixing pass. The gradation of the pulverized material should be verified to ensure it meets the specified mix design.

Before the mixing pass to add stabilizer, the reclaimed material should be lightly rolled and reshaped as a means to more accurately control mixing depth because the material will be more uniform in depth. The reclaimed material is unlikely to be at the optimum moisture content for compaction. Aeration to dry the material or additional water to moisten it to the optimum point is usually necessary prior to compaction.

Due to the thickness and the material properties of the reclaimed mixture, the compaction rollers are typically large and heavy. Segmented padfoot, vibratory padfoot, pneumatic-tired, and vibratory single or double drum rollers can be used. The degree of compaction achieved has the primary impact on the future performance of the FDR project. The depth of the reclaimed mixture being compacted and specified level of compaction will influence the weight and amplitude/frequency of vibration for the vibratory rollers and the static weight of the pneumatic rollers. The degree of compaction required is typically an average of 98% of Standard Proctor Density with no individual tests being less than 96%. Care should be taken to attain proper compaction without over-compaction. If the FDR layer is over-compacted, aggregate crushing and loosening of the surface layer may occur resulting in a non-uniform and weakened base. Over-compaction can also lead to surface raveling due to premature surface drying.

Correct moisture is critical to achieving proper compaction. A light application of water applied to the surface may be needed prior to final compaction.

The properties of stabilizing agent and additives will dictate the type and length of curing required before the roadway can be opened for traffic and will influence the type and timing of surface course construction. Chemical stabilizing agents require a time of moist cure so they do not dry out and develop severe shrinkage cracks. Moist curing consists of periodic applications of water or placement of a bituminous curing membrane using a diluted emulsified asphalt. If a curing membrane is used, it should be applied as soon as possible but not later than 24 hours after completion of the finishing operations. The dilution rate is up to 60% with water and the application rate for the diluted emulsified asphalt is 0.10 to 0.20 gallons per square yard.

If a cementitious material is used as a stabilizing agent, microcracking is an optional activity. This technique will prevent shrinkage cracking and reduce reflective cracking in the surface course. Microcracking is typically initiated after the surface has gained some initial strength, which is usually after 24 to 48 hours of curing. It is accomplished by a 12 ton vibratory steel drum roller, traveling at a speed of approximately 2 mph and vibrating at maximum amplitude and lowest frequency. Typically, one to four passes are required. After each pass, the stiffness of the FDR section should be checked and activities terminated when a minimum of a 40% reduction is achieved.

An alternative to microcracking is to add a thin (2 inch) interlayer of road stone or a 1 inch, highly polymerized HMA interlayer prior to placement of the surface course. The interlayer will mitigate the potential reflective cracking from the cement-stabilized layer. The use of the interlayer must be considered in the final roadway elevations if the project has vertical constraints.

Field inspection and testing involves the monitoring of five main factors:

- Bituminous and chemical stabilizing agent content
- Moisture content
- Mixing
- Compaction
- Curing

After the FDR section has adequately cured, the surface course can be applied. Surface courses should be applied within 48 hours of the completion of the reclaimed base unless a bituminous membrane is used for curing. Surface courses can range from chip seals and seal coats to thin overlays of asphalt or concrete. In preparation for surfacing, the FDR mixture should be power broomed to remove all loose material from the surface. If an asphalt overlay is to be placed, a tack coat should be applied prior to the overlay.

F. References

Reeder, G.D., Harrington, D., Ayers, M.E., Adaska, W. *Guide to Full-Depth Reclamation (FDR) with Cement.* Portland Cement Association. National Concrete Pavement Technology Center/Institute for Transportation, Iowa State University. 2017.

Asphalt Recycling and Reclaiming Association (ARRA). *Full Depth Reclamation: A Century of Advancement for the New Millennium.*

Asphalt Recycling and Reclaiming Association (ARRA). *Basic Asphalt Recycling Manual.* FHWA. Second Edition, 2015.

2. Applications: There are six widely recognized functions for geosynthetic applications as shown across the top of Table 6H-1.01. The typical classes of geosynthetic used for each function are also shown. Although the table indicates only primary functions, most geosynthetic applications call for the material to satisfy at least one secondary function as well (e.g., a separation layer under a pavement may also be required to reinforce the subgrade and influence drainage under the pavement).

Table 6H-1.02 provides a summary of the most commonly used geosynthetic functions for transportation applications. Comparison of Tables 6H-1.01 and 6H-1.02 reveals that the geotextile and geogrid materials are the most commonly used in transportation, although certainly others are sometimes used. This generality is more accurate when only the pavement itself (not including the adjoining fill or cut slopes, retaining walls, abutments, or drainage facilities) is considered. The most common usage for geosynthetics in the United States has historically been for unpaved roads but use in paved, permanent roads is increasing.

Each of these functional classes, while potentially related by the specific application being proposed, refers to an individual mechanism for the improvement of the soil subgrade. The separation function describes the maintenance of materials of different gradations as separate and distinct materials. In the specific case of the pavement application, separation relates to the maintenance of unbound granular base course materials as distinct from the subgrade (Koerner 1998; Christopher and Holtz 1991).

These materials may tend to become mixed in service due to pumping of the subgrade into the subbase, or due to localized bearing capacity failures leading to migration of aggregate particles into the subgrade (TRB 1987). This potential behavior has been confirmed in the field, as well as the ability of geosynthetic materials to resist it (Macdonald and Baltzer 1997; McKeen 1976). Once the unbound subbase is mixed with the subgrade, its strength and drainage properties may be detrimentally affected.

Table 6H-1.01: Functions of Geosynthetic Materials

Geosynthetic Materials	**Function**					
	Filtration	***Drainage***	***Separation***	***Reinforcement***	***Fluid Barrier***	***Protection***
Geotextile	x	x	x	x		x
Geogrid			x	x		
Geomembrane					x	
Geonet		x				
Geocomposites:						
Geosynthetic Clay Liner					x	
Thin Film Geotextile Composite					x	
Field Coated Geotextile					x	

Source: Laguros and Miller 1997.

Table 6H-1.02: Transportation Uses of Geosynthetic Materials

Function	Specific Use
Filtration	• Beneath aggregate subbase for paved and unpaved roads and airfields or railroad ballast
Drainage	• Drainage interceptor for horizontal flow • Drain beneath other geosvnthetic systems
Separation (of dissimilar materials)	• Between subgrade and aggregate subbase in paved and unpaved roads and airfields • Between subgrade and ballast for railroads • Between old and new asphalt layers
Reinforcement (of weak materials)	• Over soft soils for unpaved roads, paved roads, airfield, railroads, construction foundations

Source: Koerner 1998

a. Reinforcement Function: The reinforcement function is very similar to the reinforcement process in reinforced concrete elements. The geosynthetic is introduced to provide elements with tensile resistance into the unbound material, which on its own would exhibit very low tensile resistance. The specific improvements imparted to pavement designs include the potential for improved lateral restraint of the subbase and subgrade, modifications of bearing capacity failure surfaces, and tensile load transfer under the wheel load. The lateral restraint arises as the subbase material tends to move outward under load beneath the wheel. The geosynthetic tends to be pulled along as a result of friction or interlock with the aggregate particles, and resists that tendency through its own tensile strength. The particles are therefore held in place as well. Bearing capacity surfaces may be forced to remain above the geosynthetic, in the stronger base course. Finally, the tendency of the subbase to bend under the wheel loads introduces tensile stress at the subbase/subgrade interface, which may be taken by the geosynthetic. Careful consideration must be given to the mobilization behavior of the geosynthetic, which may require fairly large strains to provide the desired reinforcement.

b. Filtration Function: The filtration function is similar to the separation function, but in this case the reason for mixing or migration of particles is the seepage forces induced by water flowing through the unbound material. The function of the filter is to provide a means to allow water to flow through unbound material without excessive loss of soil due to seepage forces, and without clogging (Koerner 1998). Zonal filters may offer the same protection, but may be less convenient or practical to install. The drainage function is related to the filtration function, in that once again the desired behavior is the movement of water out of or through the unbound material with sufficient maintenance of the fine particles in place. The difference arises in the focus and intent; filtration applications tend to be predicated on the maintenance of the soil, while drainage applications tend to attach more importance to the quantity of flow to be maintained or the desired reduction in pore water pressure. Further, the drainage function may be carried out by designing for drainage along the plane of the geotextile itself, rather than through surrounding unbound material.

The specific function to be provided by the geosynthetic in transportation applications is a function of the soil conditions. Table 6H-1.03 indicates that the following functions most commonly arise as a function of the soil strength.

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General Information

A. Purpose

In an effort to protect the nation's waters from pollution, the Environmental Protection Agency (EPA) has developed a system of regulations, under the Clean Water Act, entitled the National Pollutant Discharge Elimination System (NPDES). These regulations require the owner of a site to obtain a permit prior to construction, and ensure that proper steps are taken during construction to help prevent erosion and prevent sediment from leaving construction sites.

The purpose of this chapter is to explain the erosion and sedimentation process, and describe methods that may be used to protect natural resources by reducing both. In addition, the steps required to comply with the EPA's NPDES regulatory requirements will be explained. The regulatory information in this section is included as a convenience to the designer. The actual regulations of the Iowa Department of Natural Resources (DNR) govern if there are any discrepancies.

B. Background

Approximately 40% of the nation's waterways have been identified as impaired, meaning that they do not meet the water quality standards for their intended use. In Iowa, the most common reason for a waterway to be designated as impaired is due to high levels of suspended sediment. One of the main sources of suspended sediment found in waterways is construction site stormwater runoff.

Sediment in runoff from construction sites is a direct result of the erosion created when the site is stripped of its stabilizing vegetation. According to the U.S. Environmental Protection Agency (EPA), sediment rates in stormwater runoff from construction sites are typically 10 to 20 times greater than for agricultural lands. In urban areas, stormwater runoff is quickly intercepted by the storm sewer and does not have a chance to travel over vegetated areas where suspended sediment can be removed. The sediment in this runoff eventually reaches streams, ponds, lakes, and rivers. High levels of suspended sediment can quickly form large silt deposits, filling in these waterways.

Silt deposits can cause damage to public and private property. Silt deposits often flow onto adjacent property, causing damage; flow onto public streets, creating mud and dust; and clog storm sewers and ditches. The financial impact caused by this sediment is substantial. Waterways must be dredged to remove the deposits, streets swept, ditches and storm sewers cleaned, and property damaged by sediment must be repaired or replaced. While the financial impacts are significant, the loss of natural resources is just as important.

High levels of sediment in storm runoff can impact an ecosystem. Sediment is often contaminated with other pollutants such as phosphorous, nitrates, pesticides, and heavy metals. In high enough concentrations, these pollutants become poisonous. In addition, the suspended sediment filters out sunlight, killing off aquatic vegetation. Many species of animals depend on this vegetation for habitat and nourishment. If enough vegetation is destroyed, the levels of dissolved oxygen in the water can drop to levels where aquatic wildlife cannot survive. Waterfowl and other animals, dependent on the fish and vegetation for sustenance, may die or leave the area.

C. Definitions

Aggregate: Crushed rock or gravel screened to different sizes for various uses in construction projects.

Annual Plant: A plant that completes its life cycle and dies in one year or less.

Apron: A floor or lining to protect a surface from erosion. Normally at the inlet or outlet of a storm conduit.

Berm: A raised area that breaks the continuity of a slope.

Best Management Practices: Schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Channel: A stream that conveys continuous or intermittent water; a ditch or channel excavated for the flow of water.

Channel Stabilization: Erosion prevention and stabilization of velocity distribution in a channel using jetties, drops, revetments, vegetation, and other measures.

Clay (Soils): (1) A mineral soil separate consisting of particles less than $6.6x10^{-6}$ feet (0.002 mm) in equivalent diameter. (2) A soil textural class. (3) A fine-grained soil that has a high plasticity index in relation to the liquid limits.

Clean Water Act (CWA): The Federal Water Pollution Control Act.

Clod: A compact, coherent mass of soil 2 inches or larger, produced artificially, usually by digging, etc., especially when these operations are performed on soils that are either too wet or too dry for normal soil movement.

Code of Federal Regulations (CFR): A codification of the final rules published daily in the Federal Register. Title 40 of the CFR contains the environmental regulations.

Compaction: The process by which the soil grains are rearranged to decrease void space and bring the grains into closer contact with one another and thereby increase the weight of solid material per cubic foot.

Construction Site: A site or common plan of development or sale on which construction activity, including clearing, grading, and excavating, results in soil disturbance. A construction site is considered one site if all areas of the site are contiguous with one another and one entity owns all areas of the site.

Contour: An imaginary line on the surface of the ground connecting points of the same elevation.

Cover: (1) Vegetation or other material providing protection. (2) Ground and soils: any vegetation producing a protective mat on or just above the soil surface. (3) Stream: generally trees, large shrubs, grasses, and forbs that shade and otherwise protect the stream from erosion, temperature elevation, or sloughing of banks. (4) Vegetation: all plants of all sizes and species found on an area, regardless of whether they have forage or other value. (5) Artificial: any material (natural or synthetic) that is spread or rolled out over the ground to protect the surface from erosion.

Detention Basin (Pond): A structure barrier built to divert part or all of the runoff water from a land area and to release the water under a controlled condition.

Drainage: The removal of excess surface water or groundwater from a land area.

Erosion: (1) The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. (2) Detachment and movement of soil or rock fragments by water, wind, ice, or gravity.

Filter Strip: Strip of vegetation above ponds, diversion structures, or other elements to retard flow of runoff water and thereby reduce sediment flow.

Final Stabilization: Period when all soil-disturbing activities at the site have been completed and a uniform perennial vegetative cover with a density of 70%, sufficient to preclude erosion, for the entire disturbed area of the permitted project has been established, or equivalent stabilization measures have been employed, or which has been returned to agricultural production.

Gabion: A rectangular or cylindrical wire mesh cage filled with rock and used as a protecting apron, revetment, retaining wall, etc., against erosion.

General Permit: An NPDES permit issued under 40 CFR 122.28 that authorizes a category of discharges under the CWA within a geographical area. A general permit is not specifically tailored for an individual discharger.

Grade: (1) The slope of a road, channel, or natural ground, or any surface prepared for the support of construction such as paving. (2) To finish the surface of a roadbed, top of embankment, or bottom of excavation.

Grass: A member of the botanical family Gramineae characterized by blade-like leaves arranged on the culm or stem in two ranks.

Grassed Channel (Waterway): A natural or constructed waterway, usually broad and shallow, covered with erosion-resistant grasses, used to conduct surface water from land.

Ground Cover: Grasses or other plants grown to keep soil from being blown or washed away.

Gully: A channel or miniature valley cut by concentrated runoff, through which water commonly flows only during and immediately after heavy rains, or during the melting of snow. The gullies may be branching or linear, rather long, narrow, and of uniform width. The difference between a gully and rill is the depth. A gully is sufficiently deep that it would not be obliterated by tillage operations. A rill of lesser depth can be smoothed by regular tillage equipment.

Infeasible: Not technologically possible or not economically practicable and achievable in light of best industry practices.

Infiltration: The gradual downward flow of water from the surface through soil to ground water and water table reservoirs.

Large Construction Activity: As defined in 40 CFR 122.26(b)(14)(x), a large construction activity includes clearing, grading, and excavating, resulting in a land disturbance that will disturb five acres or more of land, or will disturb fewer than five acres of total land area, but is part of a larger common plan of development or sale that will ultimately disturb five acres or more. Large construction activity does not include routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the site.

Legume: A member of the Leguminosae family, one of the most important and widely distributed plant families. Leaves are alternate, have stipples, and are usually compound. Most legumes are nitrogen-fixing plants.

Loess: Soil material transported and deposited by wind and consisting predominantly of silt-sized particles.

Mulch: A natural or artificial layer of plant residue, or other materials such as straw, leaves, bark, sand, or gravel on the soil surface, to protect the soil and plant roots from the effects of raindrops, soil crusting, freezing, evaporation, etc.

Municipal Separate Storm Sewer System (MS4): A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) meeting the following criteria:

a. Owned and operated by a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to state law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under state law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act (CWA) that discharges to waters of the United States.
b. Designed or used for collecting or conveying stormwater
c. Which is not a combined sewer
d. Which is not part of a publicly owned treatment works (POTW)

National Pollutant Discharge Elimination System (NPDES): National program under Section 402 of the Clean Water Act for regulation of discharges of pollutants from point sources to waters of the United States. Discharges are illegal unless authorized by an NPDES permit.

Nurse Crop: Seeding of a short-life crop with a permanent species to aid in erosion control until the permanent species are established.

Organic Matter: Decomposition products of plant and animal materials, such as litter, leaves, and manure.

Perennial Plant: A plant that normally lives three years or longer.

Permeability, Soil: The quality of a soil horizon that enables water or air to move through it. The permeability of a soil may be limited by the presence of one nearly impermeable horizon even though the others are permeable.

Permitting Authority: The United States EPA, a Regional Administrator of the EPA, or an authorized representative. Under the Clean Water Act, most states are authorized to implement the NPDES permit program.

pH: A measure of hydrogen ion concentration. Values range from 0 to 14; a pH of 7.0 is neutral. All pH values below 7.0 are acidic, and all above 7.0 are alkalinic.

Planting Season: The period of the year when planting or transplanting is considered advisable from the standpoint of successful establishment.

Point Source: Any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock concentrated animal feeding operation (CAFO), landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff.

Pollutant: Dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials (except those regulated under the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.)), heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.

Qualified Personnel: Those individuals capable enough and knowledgeable enough to perform the required functions adequately well to ensure compliance with the relevant permit conditions and requirements of the Iowa Administrative Code.

Receiving Water: The "Water of the United States" as defined in 40 CFR 122.2 into which the regulated stormwater discharges.

Revetment: Facing of rip rap, or other material, either permanent or temporary, placed along the edge of a stream to stabilize the bank and protect it from the erosive action of the stream.

Rip Rap: Broken rock, cobbles, or boulders placed as revetment on earth surfaces such as the face of a dam or the bank of a stream, for the protection against the action of water or waves.

Runoff: That portion of the precipitation on a drainage area that is discharged from the area. Includes surface runoff and groundwater runoff.

Section 401 Certification: A requirement of Section 401(a) of the Clean Water Act that all federally issued permits be certified by the state in which the discharge occurs. The state certifies that the proposed permit will comply with state water quality standards and other state requirements.

Sediment: Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice.

Seed: The fertilized and ripened ovule of a seed plant that is capable, under suitable conditions, of independently developing into a plant similar to the one that produced it.

Seedbed: The soil prepared by natural or artificial means to promote the germination of seed and the growth of seedlings.

Small Construction Activity: Clearing, grading, and excavating resulting in a land disturbance that will disturb one acre or more and fewer than five acres of total land area, but is part of a larger common plan of development or sale that will ultimately disturb five or fewer acres. Small construction activity does not include routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the site.

Sod: A closely knit ground cover growth, primarily of grasses, held together by its roots.

Soil Amendment: Any material, such as compost, lime, gypsum, sawdust, or synthetic conditioner that is worked into the soil to make it more productive. This term is used most commonly for added materials other than fertilizer.

Soil Horizon: A layer of soil, approximately parallel to the soil surface, with distinct characteristics produced by soil-forming processes.

Soil Stabilization: The prevention of soil particles from being dislodged and moving, therefore preventing erosion from initiating or continuing.

Soil Structure: The combination or arrangement of primary soil particles into secondary particles or units. The secondary particles are characterized by size, shape, and degree of distinctness into classes, types, and grades.

Stormwater: Storm runoff, snow melt runoff, and surface runoff and drainage.

Stormwater Discharge Related Activities: Activities that cause, contribute to, or result in stormwater point source pollutant discharges, including excavation, site development, grading, and other surface disturbance activities; and measures to control stormwater, including the siting, construction, and operation of BMPs to control, reduce, or prevent stormwater pollution.

Stubble: The base portion of plants remaining after the top portion has been harvested.

Tacking: The process of binding mulch fibers together by adding a sprayed chemical compound.

Topsoil: The unconsolidated earthy material that exists in its natural state and is or can be made favorable to the growth of desirable vegetation. Usually the A-horizon of soils with developed profiles.

Uncontaminated Groundwater: Water that is potable for humans, meets the narrative water quality standards in subrule 567-61.3(2) of the Iowa Administrative Code, contains no more than half the listed concentration of any pollutants in subrule 567-61.3(3) of the IAC, has a pH of 6.5-9.0, and is located in soil or rock strata.

Vegetation: Plants in general or all plant life in the area.

Water(s) of the State: Any stream, lake, pond, marsh, watercourse, waterway, well, spring, reservoir, aquifer, irrigation system, drainage system, and any other body or accumulation of water, surface or underground, natural or artificial, public or private, which are contained within, flow through, or border upon the State of Iowa or any portion thereof.

Waters of the United States: All waters that are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters subject to the ebb and flow of the tide. Waters of the United States include all interstate waters and intrastate lakes, rivers, streams (including intermittent streams), mudflats, sand flats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds.

Weed: An undesired uncultivated plant.

Wetlands: 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 generally include swamps, marshes, bogs, and similar areas.

Regulatory Requirements

A. National Pollutant Discharge Elimination System (NPDES)

The Clean Water Act established a set of requirements called the National Pollutant Discharge Elimination System (NPDES). The NPDES regulates stormwater discharges associated with industrial activities, municipal storm sewer systems, and construction sites. The purpose of these regulations is to reduce pollution of the nation's waterways. At the present time there are no specific loss monitoring requirements. Uses of Best Management Practices (BMP) identified in an approved Stormwater Pollution Prevention Plan (SWPPP) have been identified as the means and methods to meet the NPDES requirements. On-going discussions indicate that in the future where NPDES authorities determine that construction discharges have the reasonable potential to cause or contribute to a water quality standard excursion, numeric effluent limitations may be imposed. In the future, specific emphasis will be placed on containing soil erosion and minimizing soil compaction.

The intent of this section is to describe the regulations and permitting requirements of the NPDES as they relate to construction sites. Refer to Chapter 2 - Stormwater for additional information.

Federal Construction and Development Effluent Guidelines for all sites and activities required to be authorized under NPDES permits shall comply with the following federal effluent guidelines as applicable to each site and activity. These requirements will be implemented by the Iowa Department of Natural Resources in conjunction with the General Permit No. 2 requirements.

1. **Erosion and Sediment Controls:** Design, install, and maintain effective erosion controls and sediment controls to minimize the discharge of pollutants. At a minimum such controls must be designed, installed, and maintained to:
   a. Control stormwater volume and velocity to minimize soil erosion in order to minimize pollutant discharges.
   b. Control stormwater discharges including both peak flow rates and total stormwater volume, to minimize channel and streambank erosion and scour in the immediate vicinity of discharge points.
   c. Minimize the amount of soil exposed during construction activity.
   d. Minimize the disturbance of steep slopes.
   e. Minimize sediment discharges from the site. The design, installation, and maintenance of erosion and sediment controls must address factors such as the amount, frequency, intensity, and duration of precipitation, the nature of the resulting stormwater runoff and soil characteristics including the range of soil particle sizes expected to be present on the site.
   f. Provide and maintain natural buffers around waters of the United States, direct stormwater to vegetated areas, and maximize stormwater infiltration to reduce pollutant discharges, unless infeasible.

2. **Soil Compaction and Topsoil Preservation:** Implement practices to minimize soil compaction and preserve topsoil according to Part IV D of the General Permit No. 2.

3. **Soil Stabilization:** Stabilization of disturbed areas must, at a minimum, be initiated immediately whenever any clearing, grading, excavating, or other earth disturbing activities have permanently ceased on any portion of the site or temporarily ceased on any portion of the site and will not resume for 14 calendar days. In drought stricken areas and areas that have recently received such high amounts of rain that seeding with field equipment is impossible and initiating vegetative stabilization is infeasible, alternative stabilization measures must be employed as specified by the regulatory agency. In limited circumstances, stabilization may not be required if the intended function of a specific area of the site necessitates that it remain disturbed.

4. **Dewatering:** Discharges from dewatering activities, including discharges from dewatering trenches and excavations, are prohibited unless managed by appropriate controls.

5. **Pollution Prevention Measures:** Design, install, and maintain effective pollution prevention measures to minimize discharge of pollutants. At a minimum such measures must be designed, installed, and maintained to:
   a. Minimize the discharge of pollutants from equipment and vehicle washing, wheel wash water, and other wash water. Wash waters must be treated in a sediment basin or alternative control that provides equivalent or better treatment prior to discharge.
   b. Minimize the exposure of building materials, building products, construction wastes, trash, landscape materials, fertilizers, pesticides, herbicides, detergents, sanitary waste, and other materials present on the site to precipitation and stormwater. Minimization of exposure is not required in cases where the exposure to precipitation and to stormwater will not result in a discharge of pollutants, or where exposure of a particular material or product poses little risk of stormwater contamination, such as final products and materials intended for outside use.
   c. Minimize the discharge of pollutants from spills and leaks and implement chemical spill and leak prevention and response procedures.

6. **Prohibited Discharges:** The following discharges are prohibited:
   a. Wastewater from wash out and cleanout of stucco, paint, form release oil, curing compounds, and other construction materials.
   b. Fuels, oils, and other pollutants used in vehicle and equipment operation and maintenance.
   c. Soaps or solvents used in vehicle and equipment washing.

7. **Surface Outlets:** When discharging from basins and impoundments, utilize outlet structures that withdraw water from the surface, unless infeasible.

B. NPDES Construction Site Permitting

1. **Permit Requirements:** For construction projects, an NPDES permit from the Iowa DNR is required for any site that disturbs and exposes one acre of land or more. A permit is also required for projects that will disturb one or more acres as part of a common plan of development, even if there will not be one acre of disturbed ground exposed at any given time. In addition to the Iowa DNR, many local agencies also have a permit process. It is necessary to check with the Jurisdictional Engineer to determine what, if any, information is needed for the local agency permit.

   An example of a common plan of development would be a property owner who has two acres of land that he plans to divide up into four half-acre lots. Even though each half-acre lot will be graded and sold off individually, an NPDES permit is required because the grading of the individual lot is part of an overall plan to grade and develop two acres of land.

   Additional information regarding projects that require an NPDES permit can be obtained from the Iowa DNR's website.

2. **Permitting Process:** For most construction projects, coverage under the NPDES program will be obtained from the Iowa DNR through General Permit No. 2. The steps required to obtain coverage under this permit are as follows:

   a. **Prepare a Stormwater Pollution Prevention Plan:** A Stormwater Pollution Prevention Plan (SWPPP) describes the site and identifies potential sources of pollution. The SWPPP also provides a description of the practices that will be implemented to mitigate erosion and sediment loss from the site. The SWPPP must be prepared prior to submittal of the Notice of Intent. Detailed information on the required SWPPP content is provided later in this section.

   b. **Publish a Public Notice:** Arrange for publication of a public notice of stormwater discharge that states the applicant's intention to file a Notice of Intent for coverage under the General Permit No. 2. This notice must be published for at least one day in the one newspaper with the largest circulation in the area of the discharge. A link to Iowa DNR for a copy of a typical public notice is contained in the Appendix.

   c. **Notice of Intent:** Complete and sign a "Notice of Intent for NPDES Coverage Under General Permit" form. Note that there are specific restrictions on which individuals are authorized to sign the Notice of Intent (NOI). The Notice of Intent must be signed by an authorized individual (see Part VI.G of the NPDES permit for a list of individuals authorized to sign the permit). Also note that that the form contains an area to fill in information for a contact person. This is the person to whom all future correspondence will be sent. This person does not need to be the owner or other authorized signatory, but should be a person who will be involved with the project for the duration of the permitting period. A link to Iowa DNR for a Notice of Intent is contained in the Appendix.

      Acceptable proof of publication consists of an affidavit from the publisher or a newspaper clipping of the NOI that includes the date of publication and newspaper name.

      Construction may not be initiated until the Iowa DNR issues a construction authorization.

   d. **Notice of Discontinuation:** The final step in the NPDES General Permit No. 2 process is to file a Notice of Discontinuation (NOD) with the Iowa DNR. The NOD ends the coverage of the site under the permit, relieving the permittees from the responsibilities of the permit and the possibility of enforcement actions against the permittees for violating the requirements of the permit.

      An NOD should be filed with the Iowa DNR within 30 days after the site reaches final stabilization. Final stabilization means that all soil-disturbing activities are completed, and that a permanent vegetative cover with a density of 70% or greater has been established over the entire site. It should be noted that the 70% requirement does not refer to the percent of the site that has been vegetated (i.e. 7 out of 10 acres). In order to file a Notice of Discontinuation, 100% of the disturbed areas of the site must be vegetated. The density of the vegetation across the site must be at least 70% and sufficient to preclude erosion from the entire site. The NRCS Line-Transect method can be used to determine vegetation density if actual measurements are required.

      Like the Notice of Intent, the Notice of Discontinuation must be signed by an authorized individual and must contain a specific certification statement. A link to Iowa DNR for a Notice of Discontinuation is provided in the Appendix.

e. Local Requirements: As part of the NPDES regulations, some communities are required to review SWPPPs for land-disturbing activities that occur within their communities. Other communities may have elected to pass erosion and sediment control ordinances that must be adhered to. The designer should check with the local jurisdiction to determine if local requirements exist.

3. Compliance with NPDES General Permit No. 2: Once a Notice of Intent has been filed, activities at the site must comply with the requirements of NPDES General Permit No. 2. These requirements include:

a. Implement pollution prevention practices as detailed on the SWPPP.

b. Maintain the SWPPP and keep it current by noting significant changes.

c. Inspecting the site and pollution prevention measures at the required intervals.

d. Contractors and subcontractors, identified in the SWPPP, are required to sign on as co-permittees.

e. Note changes of ownership or transfer of the permit responsibilities.

f. If there is a construction trailer, shed, or other covered structure located on the property, retain a copy of the SWPPP required by this permit at the construction site from the date of project initiation to the date of final stabilization. If there is no construction trailer, shed, or other covered structure located on the property, retain a copy of the plan from the date of project initiation to the date of final stabilization at a readily available alternative site approved by Iowa DNR and provide it for inspection upon request.

g. Retain copies of the SWPPP and all reports required by this permit, and records of all data used to complete the Notice of Intent covered by this permit, for a period of at least 3 years from the date that the site is finally stabilized and a Notice of Discontinuation has been submitted to Iowa DNR.

C. Stormwater Pollution Prevention Plans (SWPPP)

1. Purpose: The NPDES General Permit No. 2 requires that a Stormwater Pollution Prevention Plan (SWPPP) be developed. The practices described in the SWPPP designed to reduce contamination of stormwater that can be attributed to activities on a construction site. Construction creates the potential for contamination of stormwater from many different sources. Grading removes protective vegetation, rock, pavement, and other ground cover, exposing the soil to the elements. This unprotected soil can erode and be carried off by stormwater runoff to lakes and streams. In addition, construction often involves the use of toxic or hazardous materials such as petroleum products, pesticides and herbicides, and building materials such as asphalt, sealants, and concrete, which may pollute stormwater running off of the site.

The SWPPP must clearly identify all potential sources of stormwater pollution and describe the methods to be used to reduce or remove contaminants from stormwater runoff.

The SWPPP is not intended to be a static document; rather it must be updated as necessary to account for changing site conditions that have a significant impact on the potential for stormwater contamination. The SWPPP must also be revised if the current plan proves to be ineffective at significantly minimizing pollutants.

2. **Preparation of a SWPPP:** The individual preparing the SWPPP should have a thorough understanding of the project and the probable sequence of construction operations.

   The process of preparing a SWPPP should begin by reviewing the existing site, and identifying the work required to complete the desired improvements. Next, the project should be broken down into major components or phases (e.g. clearing, grading, utility work, paving, home building, etc.). The specific phasing may vary for each project, depending on the scope of the work. On large projects with multiple areas that will be completed in stages, each stage of construction should be broken down separately.

   Next, a system of erosion and sediment controls should be designed for each phase of construction. The system of controls should take into account the anticipated condition of the site during each stage. For example, at the end of the grading phase, it is likely that the entire site will be stripped and highly vulnerable to erosion; temporary seeding and/or other stabilization practices may be the major control employed at this stage. At the end of the utility phase, the site may now have storm sewer and other drainage structures installed. This creates a direct route for sediment-laden runoff to easily leave the site. Implementing sediment retention may be an important control at this stage.

   An individual erosion or sediment control practice should not be utilized as the sole method of protection. Each phase of construction should incorporate multiple erosion and sediment control practices. Utilizing a variety of both erosion control and sediment control practices is an effective and efficient method of preventing stormwater pollution.

   Once the phasing has been determined, and the methods of protection have been selected, a SWPPP can be developed. The following section summarizes the elements of a SWPPP that are required by General Permit No. 2.

3. **Required Content of the SWPPP:** Part IV of the Iowa DNR NPDES General Permit No. 2 contains a description of the specific items that must be included within the SWPPP. A summary of those items is provided below.

   a. **Site Description:** The first step in preparing a SWPPP is to provide a detailed description of the site. This description must include the following items:
      1) The nature of the construction activity (e.g. roadway construction, utility construction, single family residential construction, etc.) and major soil-disturbing activities (i.e. clearing, grading, utility work, paving, home building, etc.).
      2) An estimate of the total area of the project site and the area that is expected to be disturbed by construction.
      3) An estimate of the runoff coefficient for the site after construction (See Chapter 2 - Stormwater for determination of runoff coefficients).
      4) A summary of available information describing the existing soil and soil properties (e.g. type, depth, infiltration, erodibility, etc.).
      5) Information describing the quality of the stormwater runoff currently discharged from the site (required only if data exists, it is not necessary to collect and analyze runoff).
      6) The name of the receiving waters and ultimate receiving waters of runoff from the site. If the site drains into a municipal storm sewer system, identify the system, and indicate the receiving waters to which the system discharges.
      7) A site map that includes limits of soil-disturbing activities, existing drainage patterns, drainage areas for each discharge location (including off-site drainage), proposed grading, surface waters and wetlands, and locations where stormwater is discharged to surface water.
      8) Approximate slopes after major grading activities.

9) The location of structural and nonstructural controls.
10) The location of areas where stabilization practices are expected to occur.

b. Controls: The plan needs to show what erosion and sediment controls and stormwater management practices will be used to reduce or eliminate contamination of stormwater by pollutants.

1) Sequence: List the anticipated sequence of major construction activities and clearly describe the order for implementation of the control measures. It is not necessary to list anticipated dates for completion of the various stages of construction and implementation of practices; rather the SWPPP should indicate the stage of construction at which individual control measures are to be installed.

2) Stabilizing Practices:

- Describe the temporary and permanent stabilizing practices (protection of existing vegetation, surface roughening, seeding, mulching, compost blankets, Rolled Erosion Control Products (RECPs), sod, vegetative buffer strips, etc.).
- Note that areas not subject to construction activity for 14 calendar days or more must have stabilizing measures initiated immediately after construction activity has ceased.

3) Structural Practices:

- Describe any structural practices that will be used to divert flows away from disturbed areas, store runoff, limit erosion, or remove suspended particles from runoff (silt fence, filter socks, diversion structures, sediment traps, check dams, slope drains, level spreaders, inlet protection, rip rap, sediment basins, etc.).
- For sites with more than 10 acres disturbed at one time, which drain to a common location, a sediment basin providing 3,600 cubic feet of storage per acre drained is required where attainable. When sediment basins of the size required are not attainable, other methods of sediment control that provide an equivalent level of protection are required.
- For disturbed drainage areas smaller than 10 acres, a sediment basin or sediment control along the sideslope and downslope boundaries of the construction area is required. The sediment basin should provide 3,600 cubic feet of storage per acre drained.
- Unless infeasible, the following measures should be implemented at all sites: utilize outlet structures that withdraw water from the surface when discharging from basins, provide and maintain natural buffers around surface waters, and direct stormwater to vegetated areas to both increase sediment removal and maximize stormwater infiltration.
- According to General Permit No. 2 Part IV.D.2.A.(2).(c), the permittee(s) shall minimize soil compaction and, unless infeasible, preserve topsoil. "Infeasible" shall mean not technologically possible, or not economically practicable and achievable in light of the best industry practices. "Unless infeasible, preserve topsoil" shall mean that, unless infeasible, topsoil from any areas of the site where the surface of the ground for the permitted construction activities is disturbed, shall remain within the area covered by the applicable General Permit No. 2 authorization. Minimizing soil compaction is not required where the intended function of a specific area of the site dictates that it be compacted. Preserving topsoil is not required where the intended function of a specific area of the site dictates that the topsoil be disturbed or removed. The permittee(s) shall control stormwater volume and velocity to minimize soil erosion in order to minimize pollutant discharges and shall control stormwater discharges, including both peak flowrates and total stormwater volume, to minimize channel and streambank erosion and scour in the immediate vicinity of discharge points. An affidavit signed by the permittee(s) may be submitted to demonstrate compliance.

- For construction activity that is part of a larger common plan of development, such as a housing or commercial development project, in which a new owner agrees in writing to be solely responsible for compliance with the provisions of this permit for the property that has been transferred or in which the new owner has obtained authorization under this permit for a lot or lots (as specified in subrule 567-64.6(6) of the Iowa Administrative Code), the topsoil preservation requirements described above must be met no later than at the time the lot or lots have reached final stabilization as described in this permit.
- In residential and commercial developments, a plat is considered a project. For other large areas that have been authorized for multiple construction sites, including those to be started at a future date such as those located at industrial facilities, military installations, and universities, a new construction project not yet surveyed and platted out is considered a project. This stipulation is intended to be interpreted as requiring the topsoil preservation requirements on development plats and construction activities on other extended areas that may have several construction projects allowed under the same authorization to be implemented on those projects not yet surveyed and platted out prior to October 1, 2012, even if other plats and construction activities in the same development or other extended area were authorized prior to October 1, 2012.

4) Stormwater Management:

- Describe the features that will be installed during construction to control pollutants in stormwater after construction operations are completed.
- Pollutant removal features may include detention/retention ponds, vegetated swales, and infiltration practices.
- Post-construction erosion control features may include channel protection/lining and velocity dissipation at outlets.

5) Other Controls:

- Note in the SWPPP that any waste materials from the site must be properly disposed of.
- Describe practices for preventing hazardous materials that are stored on the site from contaminating stormwater.
- Describe a method to limit the off-site tracking of sediment by vehicles.
- Define construction boundaries to limit the disturbance to the smallest area possible.
- Identify areas to be preserved or left as open space.

6) State and Local Requirements:

- List additional state or local regulations that apply to the project. Note that some local jurisdictions may have an erosion and sediment control ordinance. The requirements of this ordinance must be listed in the SWPPP.
- List any applicable procedures or requirements specified on plans approved by state or local officials.
- Section 161A.64 of the Code of Iowa requires that prior to performing any "land-disturbing" activity (not including agricultural activities) in a city or county that does not have an erosion control ordinance and a 28E agreement with the Soil and Water District, a signed affidavit must be filed with the local Soil and Water Conservation District stating that the project will not exceed the soil loss limits stated. It should be noted that this requirement is not a condition of the NPDES General Permit No. 2.

c. Maintenance: The SWPPP must describe the maintenance procedures required to keep the controls functioning in an effective manner. For each type of erosion or sediment control practice utilized, a description of the proper methods for maintenance must be provided. In addition, maintenance should include removal of sediment from streets, ditches, or other off-site areas.

d. Inspections: The SWPPP must describe the inspection requirements of General Permit No. 2. Inspections are required every 7 calendar days. Check local agency regulations for permit inspection and reporting requirements. The inspections must include the following:

1) Inspect disturbed areas and areas used for storage of materials for evidence of pollutants leaving the site and/or entering the drainage system.
2) Inspect erosion and sediment control measures identified in the SWPPP to ensure they are functioning correctly.
3) Inspect discharge locations to ascertain if the current control measures are effective in preventing significant impacts to the receiving waters.
4) Inspect locations where vehicles enter/exit the construction site for signs of sediment tracking.
5) Prepare an inspection report that lists the date, the name of the inspector, and the inspector's qualifications. The report must summarize the inspection and note any maintenance of the controls or changes to the SWPPP that are required.
6) Implement required maintenance or changes to the SWPPP identified during the inspection as soon as practicable after the inspection, but no more than seven calendar days following the inspection. If the permittee determines that making these changes at the construction site or to the plan less than 72 hours after the inspection is impracticable, the permittee shall document in the plan why it is impracticable and indicate an estimated date by which the changes will be made.

The Project Engineer should note that SUDAS Specifications Section 9040 provides for two bid items related to the SWPPP. The first relates to the Contractor preparing the SWPPP. The second bid item involves management of the SWPPP, which includes the actions necessary to comply with the General Permit No. 2, conduct regular inspections, documentation, updates to the SWPPP, and filing of the Notice of Discontinuation.

e. Non-stormwater Discharges: Various non-stormwater related flows are allowed to be discharged into the stormwater system, provided that they are not contaminated by detergents or spills/leaks of toxic/hazardous materials. Allowable non-stormwater discharges include flows from fire hydrant and potable waterline flushing, vehicle washing, external building washdown that does not use detergents, pavement washwater where spills or leaks of toxic or hazardous materials have not occurred, air conditioning condensate, springs, uncontaminated groundwater, and footing drains. When there is a possibility for these types of discharges on the site, they must be identified in the SWPPP and include a description of the measures that will be implemented to prevent these flows from becoming contaminated by hazardous materials or sediment.

f. Contractors: The SWPPP must clearly identify all of the contractors or subcontractors that will implement each measure in the plan. Each contractor or subcontractor identified is required to sign a certification statement making them a co-permittee with the owner and other contractors. The certification must read as follows:

"I certify under penalty of law that I understand the terms and conditions of the general National Pollutant Discharge Elimination System (NPDES) permit that authorizes the stormwater discharges associated with industrial activity from the construction site as part of this certification. Further, by my signature, I understand that I am becoming a co-permittee, along with the owner(s) and other contractors and subcontractors signing such certifications, to the Iowa Department of Natural Resources NPDES General Permit No. 2 for "Storm Water Discharge Associated with Industrial Activity for Construction Activities" at the identified site. As a co-permittee, I understand that I, and my company, am legally required under the Clean Water Act and the Code of Iowa, to ensure compliance with the terms and

conditions of the stormwater pollution prevention plan developed under this NPDES permit and the terms of this NPDES permit."

Under most circumstances, the identity of the contractor and any subcontractors implementing the pollution prevention measures will not be known at the time of SWPPP preparation. The SWPPP should provide a blank certification form and a location to identify who will be responsible for implementing each pollution prevention measure. The contractor responsible for maintaining the SWPPP can then complete this information, as it becomes available.

D. Who is Responsible

1. **Property Owner:** Coverage under the NPDES General Permit No. 2 is granted to the property owner. The property owner has the ultimate responsibility for ensuring that the conditions of the permit are met. Enforcement actions associated with non-compliance with the permit are normally directed against the property owner.

2. **Designer:** The project designer typically prepares the initial SWPPP, although the contractor may be required to develop the SWPPP and obtain the NPDES permit if so directed in the contract documents. The designer may continue to review and approve changes to the SWPPP (on behalf of the owner).

3. **Jurisdiction:** On public improvement projects, the Jurisdiction serves as the owner of the site (see requirements for owners above).

   According to Iowa DNR regulations, certain MS4 jurisdictions are required to conduct inspections on public construction projects that require coverage under an NPDES permit. Under most circumstances, these inspections must be conducted utilizing the MS4's own staff. The contractor is not allowed to perform these inspections. The purpose of these inspections is to ensure that contractors are correctly implementing the BMPs identified in the SWPPP and to ensure that the jurisdiction maintains an active role in preventing stormwater contamination from its public improvements projects.

   The inspections by the jurisdiction must be conducted every 7 days. These jurisdictional inspections may also be used to satisfy the inspection requirements of the NPDES General Permit No. 2.

   The preparer of the SWPPP should check with the local jurisdiction for additional review and permitting requirements.

4. **Contractor/Builder:** Contractors and builders that are involved in implementing any of the measures identified for controlling pollution of stormwater runoff must sign on as a co-permittee with the owner. As a co-permittee, the contractor is required to comply with all of the requirements of the NPDES permit.

   In addition, most owners will contractually assign all responsibility for compliance with the NPDES permit to the contractor. Under this situation, any fines levied against the owner will normally be passed along to the contractor.

E. Transfer of Ownership and Responsibilities

On many construction projects, such as private residential subdivisions or commercial developments, it is common for a developer to sell off individual lots before work on the entire subdivision is complete. Coverage under General Permit No. 2 cannot be discontinued for individual portions of a project; the permit requires that the entire project reach final stabilization before a Notice of Discontinuation can be filed, and coverage for the entire site terminated. This creates a situation where the developer and any co-permittees are responsible for compliance with the permit for land they no longer own or have control over.

A provision within the Iowa Administrative Code [567 IAC 64.6(6)(b)] addresses this situation. This provision allows the developer and new property owner to become co-permittees under the NPDES permit. This provision requires that the new owner be notified, in writing, of the existence and location of the permit and the SWPPP and of their responsibility to comply with the permit.

This provision within the Code also allows the new owner to accept sole responsibility for compliance with the permit for the transferred property. This transfer of responsibility requires written acknowledgement by the new owner that they accept responsibility for complying with the permit for the property in question.

A copy of all property transactions, notifications of coverage, and transfer of responsibility agreements must be included with the SWPPP.

When a maintenance project modifies a crosswalk, installation of curb ramps at the crosswalks is recommended, if none already exists. The other accessibility improvements of this section are also recommended, but not required with such projects.

4. **Technical Infeasibility:** Examples of existing physical or site constraints that may make it technically infeasible to make an altered facility fully compliant include, but are not limited to, the following:
   - Right-of-way availability. Right-of-way acquisition in order to achieve full compliance is not mandatory, however, it should be considered. Improvements may be limited to the maximum extent practicable within the existing right-of-way.
   - Underground structures that cannot be moved without significantly expanding the project scope.
   - Adjacent developed facilities, including buildings that would have to be removed or relocated to achieve accessibility.
   - Drainage cannot be maintained if the feature is made accessible.
   - Notable natural or historic features that would have to be altered in a way that lessens their aesthetic or historic value.
   - Underlying terrain that would require a significant expansion of the project scope to achieve accessibility.
   - Street grades within the crosswalk exceed the pedestrian access route maximum cross slopes, provided an engineering analysis has concluded that it cannot be done without significantly expanding the project scope (for example, changing from resurfacing an intersection to reconstructing that intersection).

5. **Safety Issues:** When accessibility requirements would cause safety issues, compliance is required to the maximum extent practicable.

6. **Documenting Exceptions:** If the project cannot fully meet accessibility requirements because the accessibility improvements are structurally impracticable, technically infeasible, or safety issues, a document should be developed to describe how the existing physical or site constraints or safety issues limit the extent to which the facilities can be made compliant. This document should identify the specific locations that cannot be made fully compliant and provide specific reasons why full compliance cannot be achieved. It is recommended that this document be retained in the project file. For local agency projects administered through Iowa DOT, an "Accessibility Exceptions Certification" (Form 517118) with supporting documentation shall be signed by a registered professional engineer or landscape architect licensed in the State of Iowa and submitted to the Iowa DOT administering office. The certification shall be as prescribed by Iowa DOT Local Systems I.M. 1.080. For Iowa DOT projects, contact the Office of Design, Methods Section.

   Note: Documenting exceptions does not remove an agency's responsibility to consider making accessibility improvements the next time the facility is altered because physical or site constraints and safety issues may change over time. The determination of exceptions and corresponding documentation needs to be made each time a facility is altered, based on the existing conditions and the scope of the proposed project.

7. **Reduction in Access:** Regardless of whether the additions or alterations involve the modification of the existing pedestrian circulation path, the resulting work cannot have the result of reducing the existing level of accessibility below the minimum requirements. For example, the installation of a bench cannot have the effect of reducing the width of the pedestrian access route to 3 feet (4 feet is the minimum). Likewise, the construction of an overlay cannot result in a street cross slope of more than 5%, nor have a lip at the curb ramp that exceeds 1/2 inch.

Pedestrian facilities may be removed if they are being re-routed for safety reasons, or terminated because they do not connect to a destination or another pedestrian circulation path.

8. **Addition of Pedestrian Facilities:** If a sidewalk exists on both sides of the street, curb ramps shall be installed on both sides when the street is altered. PROWAG does not require construction of pedestrian facilities where none currently exists, although the jurisdiction's transition plan may require them.

9. **Utility Construction:** If the pedestrian circulation path is disturbed during utility construction, the requirements of this section and Section 12A-4 shall apply.

E. Standards for Accessibility

The following section summarizes the design standards for the elements of an accessible pedestrian access route. The minimum and maximum values stated are taken from the PROWAG. Target values are also provided. Designing features to the target values, rather than the allowable maximum or minimum, allows for appropriate construction tolerances and field adjustment during construction while maintaining compliance with the PROWAG standards.

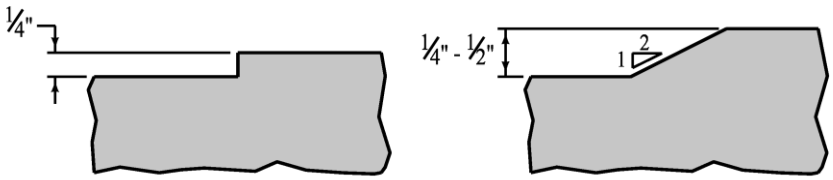
1. **General Requirements:** These requirements apply to all parts of the pedestrian access route.

   a. **Surfacing:** PROWAG requires all surfaces to be firm, stable, and slip resistant (R302.7). All permanent pedestrian access routes, with the exception of some Type 2 shared use paths (see Section 12B-2), shall be paved. When crossing granular surfaced facilities, consider paving wider than the pedestrian access route; see the shared use path section.

   b. **Vertical Alignment:** Vertical alignment (smoothness) shall be generally planar within the pedestrian access routes (R302.7.1). Although no definition for generally planar is provided, the Advisory statement for R302.7.1 indicates surfaces must be smooth and chosen for easy rollability and minimizing vibration for users of wheelchairs, scooters, and walkers. Surfaces that are heavily textured, rough, or chamfered and paving systems consisting of individual units that cannot be laid in plane should be reserved for borders and decorative accents located outside of and only occasionally crossing the pedestrian access route. Research has shown that bricks/pavers with no or narrow chamfers and narrow joint spacing between pavers can minimize vibration for all users. Bricks/pavers with sand bedding on natural soil should not be used in pedestrian access routes due to maintenance problems.

   c. **Changes in Level:** Changes in level, including bumps, utility castings, expansion joints, etc. shall be a maximum of 1/4 inch without a bevel or up to 1/2 inch with a 2:1 bevel. Where a bevel is provided, the entire vertical surface of the discontinuity shall be beveled (R302.7.2).

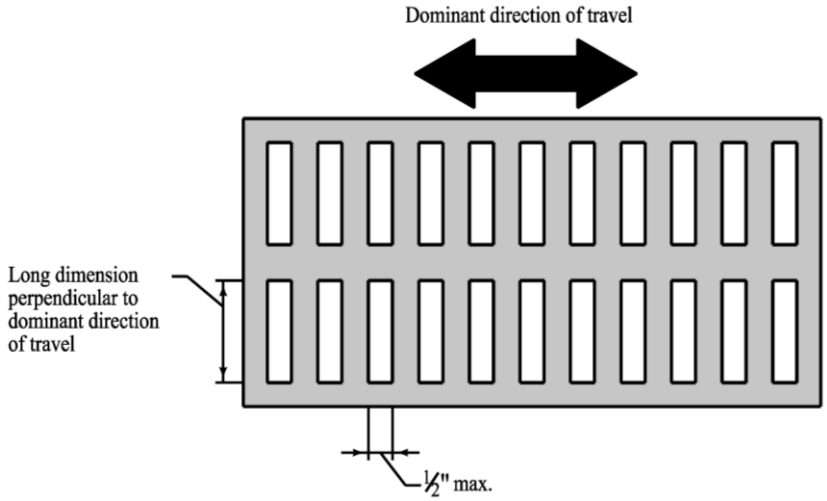
Figure 12A-2.01: Vertical Surface Discontinuities



d. Horizontal Openings: Horizontal openings shall not allow passage of a sphere more than 1/2 inch in diameter. Elongated openings in grates shall be placed so the long dimension is perpendicular to the dominant direction of travel. The use of grates within the pedestrian access route is discouraged; however, where necessary, the grate should be located outside of curb ramp runs, turning spaces, and gutter areas if possible. (R302.7.3)

It should be noted that none of the standard SUDAS/Iowa DOT intake grates meet the requirements for use within a pedestrian access route; therefore, a special design is required.

Figure 12A-2.02: Horizontal Openings



2. Standard Sidewalk: Sidewalks solely serving private residences are not required to follow these requirements.

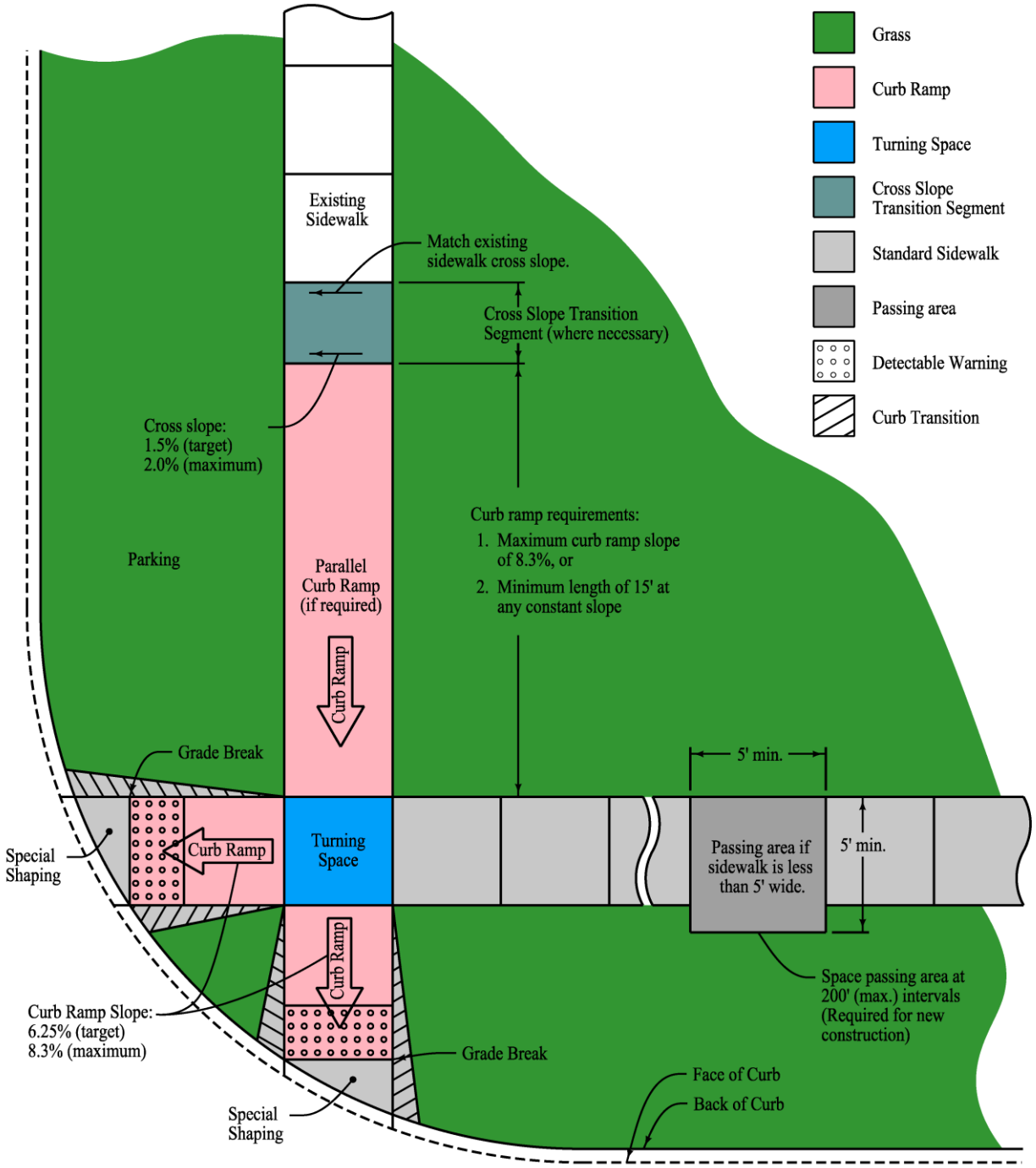
a. Cross Slope: The maximum cross slope is 2.0% with a target value of 1.5% (R302.6).

b. Running Slope: Sidewalks with a running slope of 5% or less are acceptable. However, where the sidewalk is contained within the street right-of-way, the grade of the sidewalk shall not exceed the general grade of the adjacent street (R302.5). For design, consider the general grade of the adjacent street to be within approximately 2% of the profile grade of the street.

c. Width: The minimum width of the pedestrian access route is 4 feet. Five foot sidewalks are encouraged and may be required by the Jurisdiction. Iowa DOT will design 5 foot sidewalks unless otherwise requested. (R302.3)

d. Passing Spaces: Where the clear width of the pedestrian access route is less than 5 feet, passing spaces are required at maximum intervals of 200 feet. The passing space shall be 5 foot minimum by 5 foot minimum. Passing spaces may overlap with the pedestrian access route. (R302.4). Driveways may be used as passing spaces, as long as the 2.0% maximum cross slope is not exceeded.

Figure 12A-2.03: Standard Sidewalk and Curb Ramp Elements



Protruding Objects

A. Introduction

This section provides guidance to comply with section R402 of PROWAG. The pedestrian area is any prepared area available for pedestrians (equivalent to the pedestrian circulation path as defined in PROWAG). A protruding object is any obstacle that reduces the clearance width and/or the clearance height within a pedestrian area. The pedestrian area is not limited to the sidewalk or the pedestrian access route intended by the designer. The pedestrian area includes any areas that may be perceived as a pedestrian walking space, including adjacent parking lots and paved frontage.

Common protruding objects include:

- Signs and Sign poles
- Landscaping and branches
- Utility boxes or poles and their stabilizing wires
- Mailboxes (public and private)
- Trash cans
- Transit shelters
- Bike racks
- Planters
- Fire hydrants
- Parking meters
- Benches
- Public Art

B. Protruding Object Locations

1. **Outside the Pedestrian Area:** A protruding object can result in narrow passing spaces, reduced access, and injury. Therefore, protruding objects should be placed completely outside of the pedestrian area whenever possible.

2. **Within the Pedestrian Area:** Ideally, the full width of the pedestrian area should be free of protruding objects and the pedestrian access route would be clearly separated from other paved surfaces. However, if some obstacles must be located within the pedestrian area, they should all be placed either right or left of center to provide a consistent pedestrian access route. Figure 12A-3.01 shows an acceptable pedestrian area with obstacles aligned, providing a consistent pedestrian access route. Figure 12A-3.02 shows an undesirable pedestrian area with a poorly defined pedestrian access route. The pedestrian access route within the pedestrian area must meet guidelines defined in this chapter. Special sidewalk treatments (such as brick pavers or stamped concrete) are recommended to provide a different surface texture to differentiate between the object corridor and the pedestrian access route.

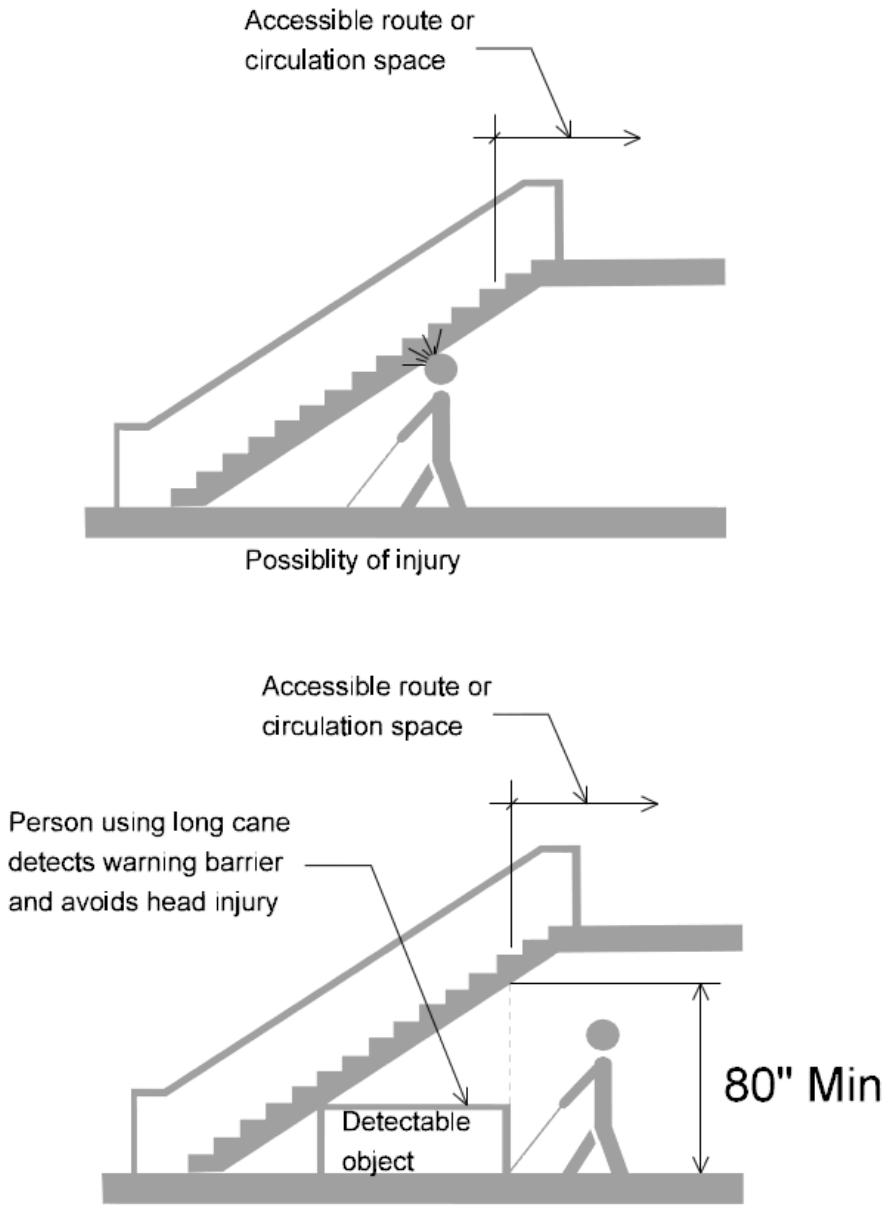
Figure 12A-3.01: Acceptable Pedestrian Area

Figure 12A-3.02: Undesirable Pedestrian Area

C. Clearance

1. **Vertical Clearance:** Vertical clearance is minimum unobstructed vertical passage space required along the entire width of the pedestrian corridor. A minimum vertical clearance of 80 inches must be provided or the object must be shielded with a barrier. The leading edge of the barrier shall be a maximum of 27 inches above the finished surface. See Figure 12A-3.03.

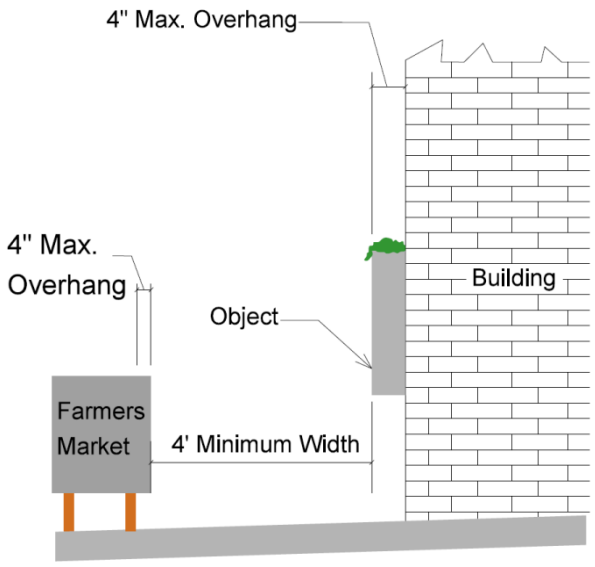
Figure 12A-3.03: Shielding for Vertical Clearance Obstacles



2. **Horizontal Clearance:** Objects mounted at or below 27 inches may extend from a fixed structure into the pedestrian area, provided the remaining sidewalk width complies with Section 12A-2. Objects that extend below 27 inches are easily detectable by most pedestrians.

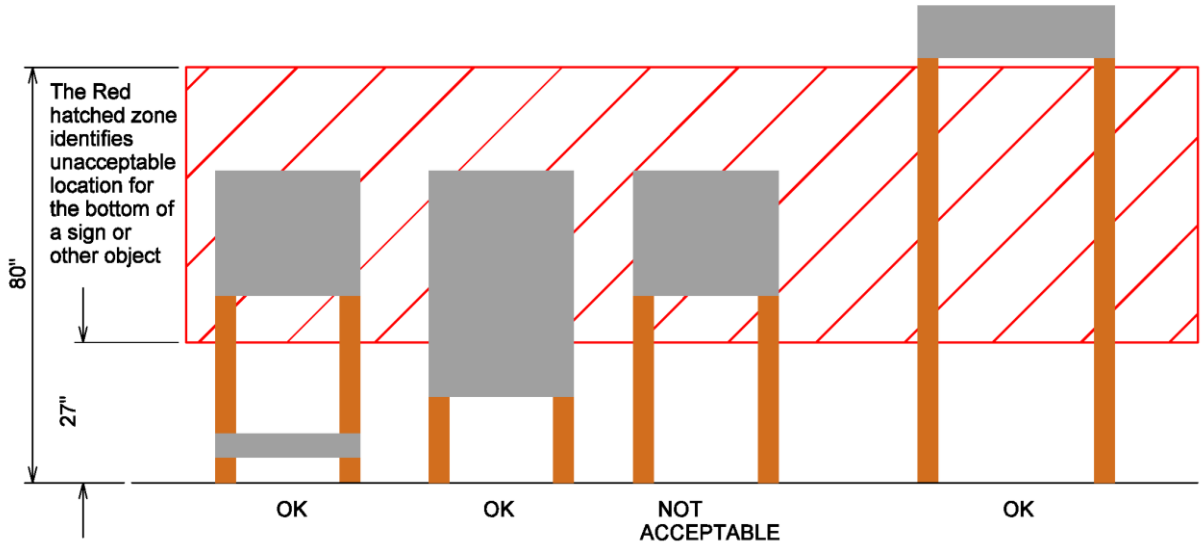
Objects that extend into the pedestrian area at a height above 27 inches are not easily detected with a cane and pedestrians may walk into them. This type of object cannot extend into the pedestrian corridor more than 4 inches from its base. The base shall be at least 2.5 inches in height. See Figure 12A-3.04.

Figure 12A-3.04: Horizontal Clearance



3. **Objects Mounted Between Posts:** Where an object is mounted between posts or pylons and the clear distance between the posts or pylons is greater than 12 inches, the lowest edge of the object shall be between 0 and 27 inches or 80 inches or more above the ground (see Figure 12A-3.05). For objects mounted on posts closer than 12 inches, follow the requirements for horizontal clearance defined above.

Figure 12A-3.05: Height Restriction for Signs Mounted Between Posts



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Chapter 13 - Traffic Signals

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Foundation size and depths vary according to pole style, mast-arm length, and pole loadings. The SUDAS Specifications provide figures for both pedestal poles and for mast-arm poles (Figure 13E-1.04). SUDAS standard Type A mast arm pole foundation in soil designs (Table 13E-1.01 and Figure 13E-1.04) are based on the following guidelines, parameters, and assumptions:

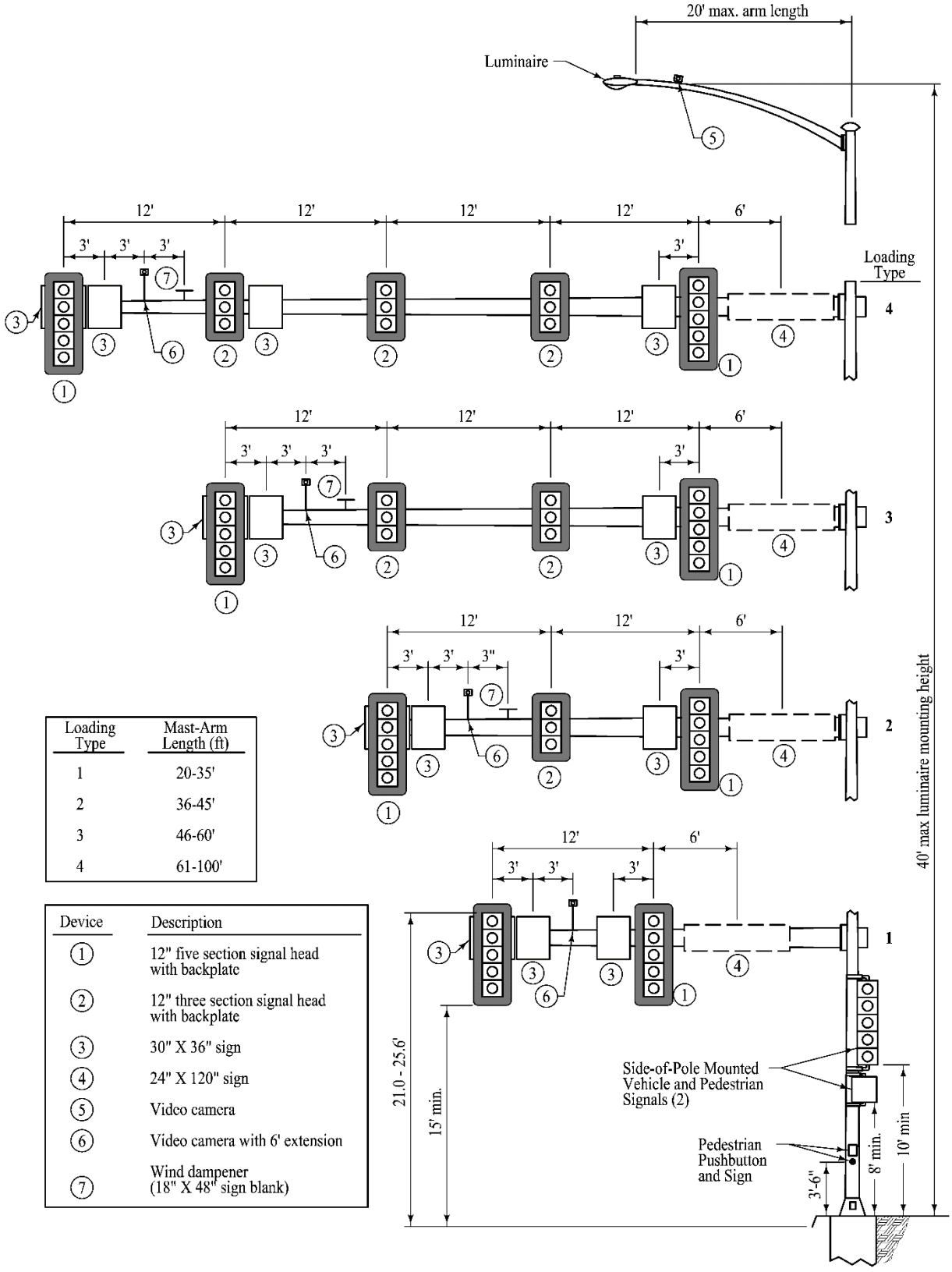
- Broms' method for lateral resistance (moment/shear design) per AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals*, 6th Edition, 2013 (AASHTO LTS-6), with a safety factor of 2.86, which accounts for the possible under capacity of the soil strength (0.7) and the overload factor for the loadings (2.0).
- Alpha method for torsion design per FHWA-NHI-10-016 *Drilled Shafts: Construction Procedures and LRFD Design Methods*, May 2010, with a safety factor of 1.0.
- Disturbed soil due to frost: 2.5 feet for moment/shear design, 5.0 feet for torsion design. Broms' method as presented in AASHTO LTS-6 includes an additional 1.5 diameters of foundation length to be added to the minimum foundation length required. The maximum value of 1.5 diameters or 2.5 feet shall be used when determining the disturbed soil for moment/shear design.
- Groundwater is present for moment/shear and torsion designs.
- Pole loadings as shown in Figure 13E-1.03, with poles designed per AASHTO LTS-6 specifications. Basic wind speed equals 90 mph with a 50 year mean recurrence interval and gust effect factor of 1.14 for strength design. Use Category II for fatigue design. Apply only natural wind gust loads (i.e. do not apply galloping loads, vortex shedding loads, or truck-induced gust loads) for fatigue design. Install vibration mitigation devices on all traffic signal pole mast arms over 60 feet in length as shown in the figures.
- Cohesive soils along the length of the foundation with an average blow count (N60) greater than or equal to 8, which equates to an average unconfined compressive strength (Qu) greater than or equal to 2.0 kips per square foot.
- Reinforced concrete design per AASHTO LTS-6 specifications.

For pole loading conditions greater than shown in Figure 13E-1.03, granular soils, or lower strength soils, special foundation designs will be required. Soil boring testing should be performed prior to construction to verify soil types and strengths if non-typical soils are suspected. If rock is anticipated at the project site and the designer intends to utilize the Type C mast arm pole foundation in rock or a Type B foundation (see Figure 13E-1.04), determine rock quality through a subsurface investigation completed by a geotechnical engineer licensed in Iowa. If rock is encountered unexpectedly, the contractor may undertake a subsurface evaluation conducted by a geotechnical engineer licensed in Iowa to determine the quality of the rocks encountered. Based on that investigation, the Engineer may approve the use of a Type B or Type C foundation in rock if requested by the contractor.

Table 13E-1.01: Standard Mast Arm Pole Foundation Designs

Loading Type (Figure 13E-1.03)	Maximum Mast Arm Length (feet)
1	35
2	45
3	55
3	60
4	70
4	80
4	90
4	100

Figure 13E-1.03: Mast Arm Pole Loadings for Standard Foundation Designs



Loading Type	Mast-Arm Length (ft)
1	20-35'
2	36-45'
3	46-60'
4	61-100'

Device	Description
1	12" five section signal head with backplate
2	12" three section signal head with backplate
3	30" X 36" sign
4	24" X 120" sign
5	Video camera
6	Video camera with 6' extension
7	Wind dampener (18" X 48" sign blank)

Figure 13E-1.04: Pole Foundation Details
(SUDAS Specifications Figure 8010.102)

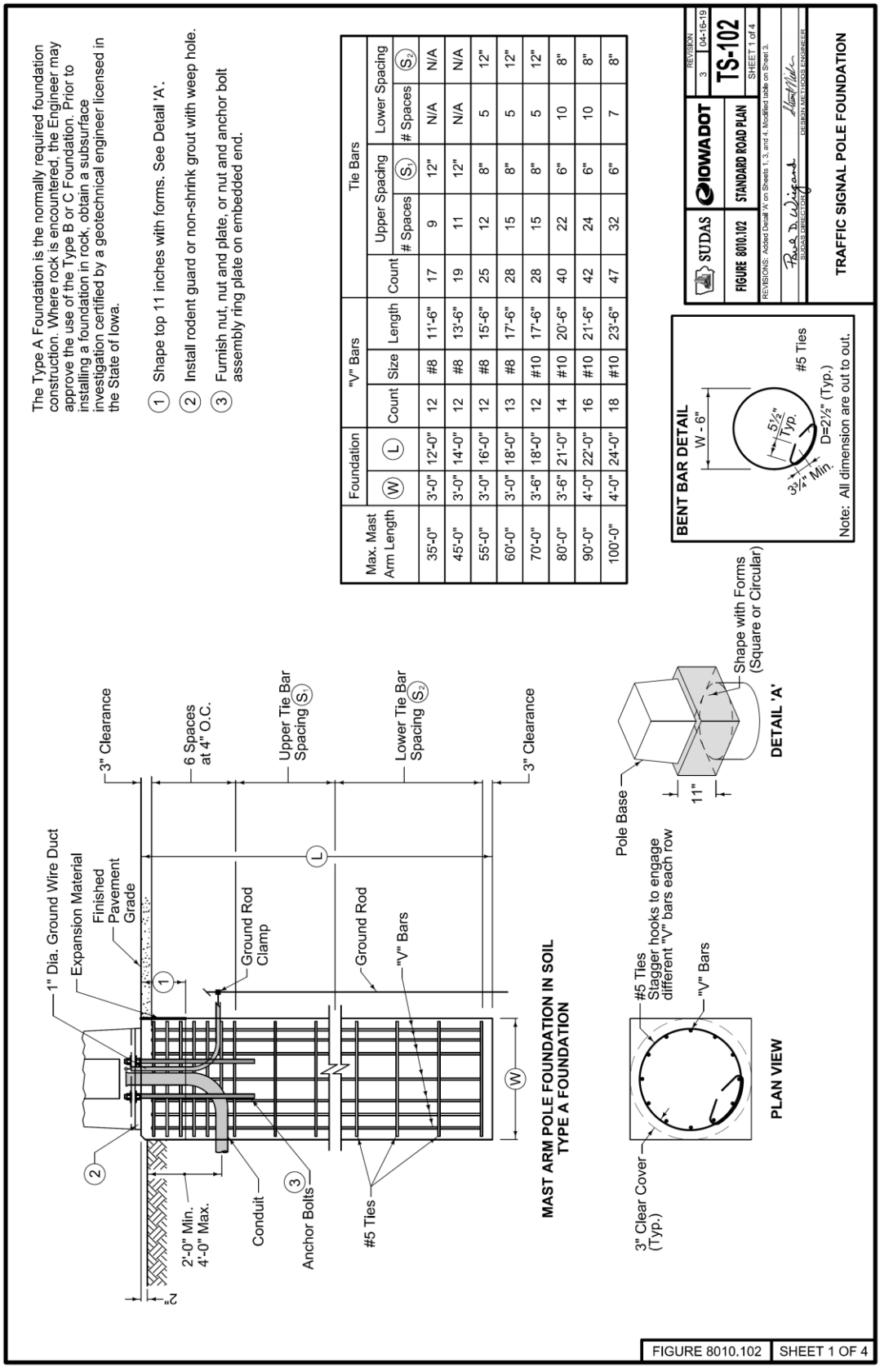


Figure 13E-1.04 (Continued): Pole Foundation Details
(SUDAS Specifications Figure 8010.102)

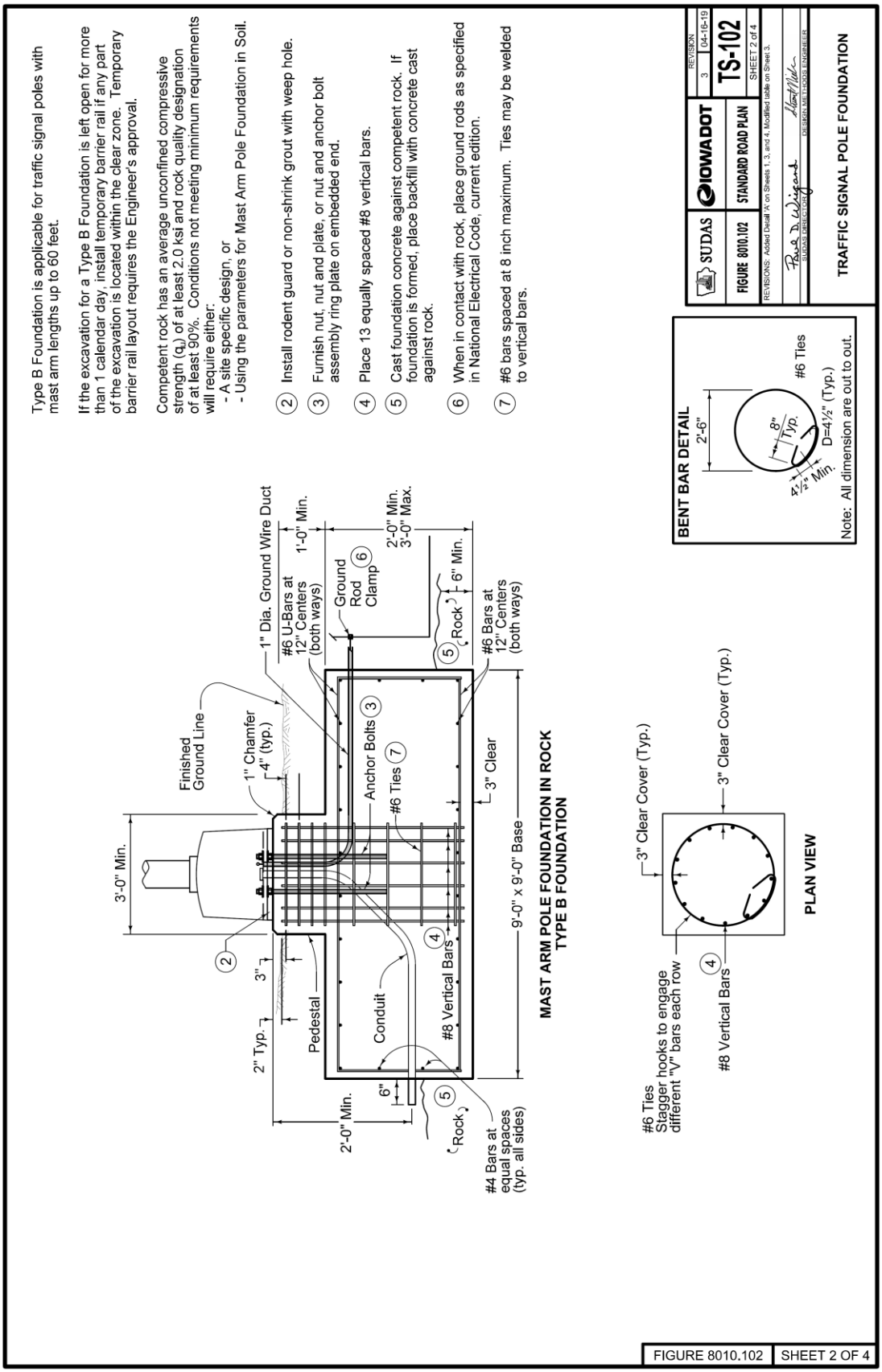


Figure 13E-1.04 (Continued): Pole Foundation Details
(SUDAS Specifications Figure 8010.102)

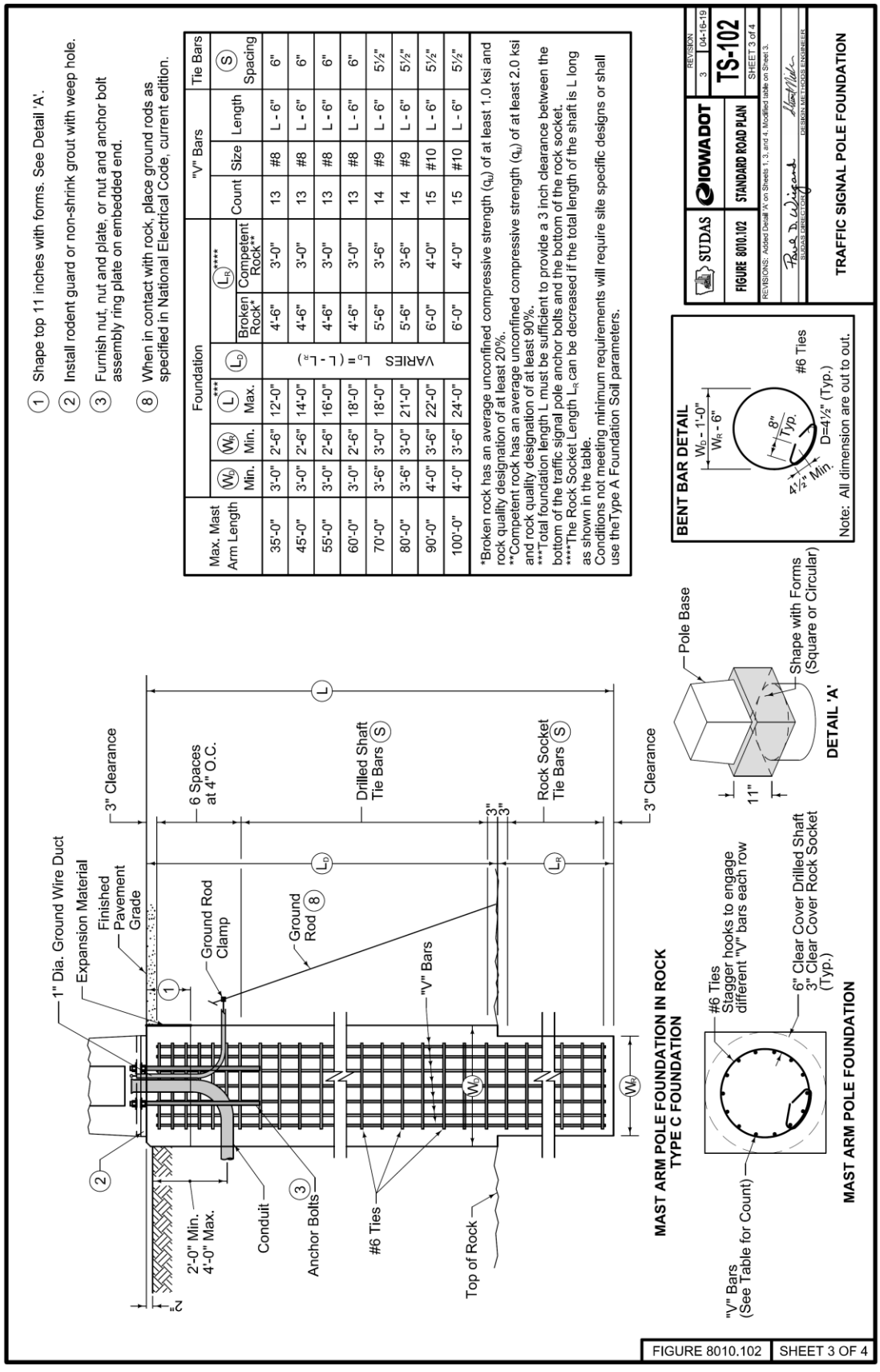
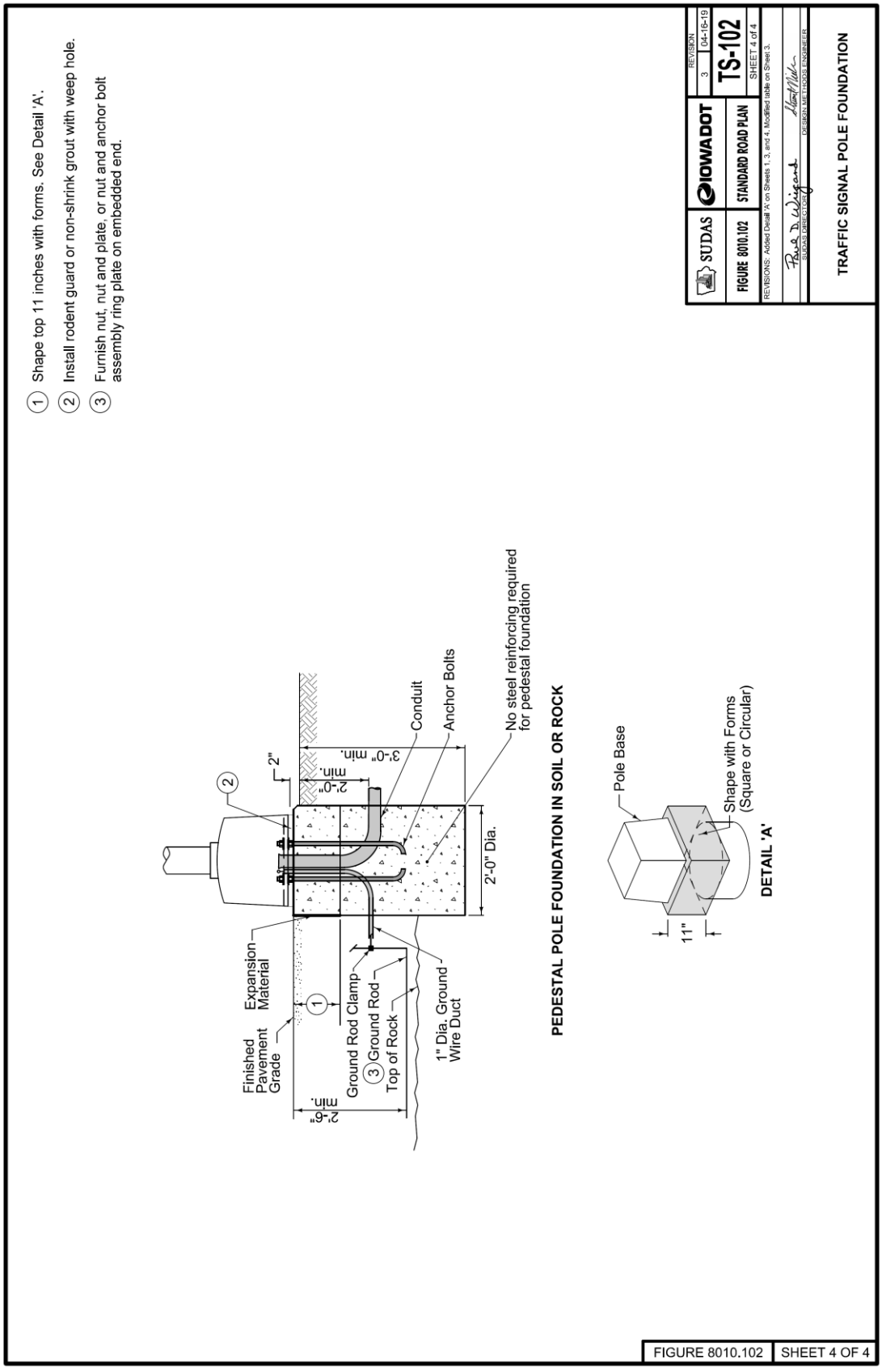


Figure 13E-1.04 (Continued): Pole Foundation Details
(SUDAS Specifications Figure 8010.102)



The designer should ensure that all foundations:

- Are located in compliance with applicable clear zone requirements
- Do not conflict with pedestrian walkways or ramps
- Are at the proper finish grade elevation

An online resource can be found through Chapter 10 - Foundations and Equipment Pads from Mn/DOT's Lighting and Signal Certification Field Guide, which provides the designer with a photographic resource for foundation types and installation details.

e. Bonding and Grounding: All traffic signal installations must be bonded and grounded according to the National Electrical Code.

Bonding is defined in the Code Book as the permanent joining of metallic parts required to be electrically connected. In a traffic signal, the term is used to describe the electrical and mechanical connection of conduit, metal poles, cabinets, and service equipment.

Grounding is defined in the Code as a conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conductive body that serves in place of earth.

The designer should ensure that the contract documents include sufficient notation for the traffic signalized intersection to be properly bonded and grounded. This includes placing ground rods at each traffic signal pole and at the controller as well as through use of bonding and grounding jumpers within the handholes.

An online resource can be found through Chapter 13 - Grounding and Bonding from Mn/DOT's Lighting and Signal Certification Field Guide, which provides the designer with a photographic resource for bonding and grounding details.

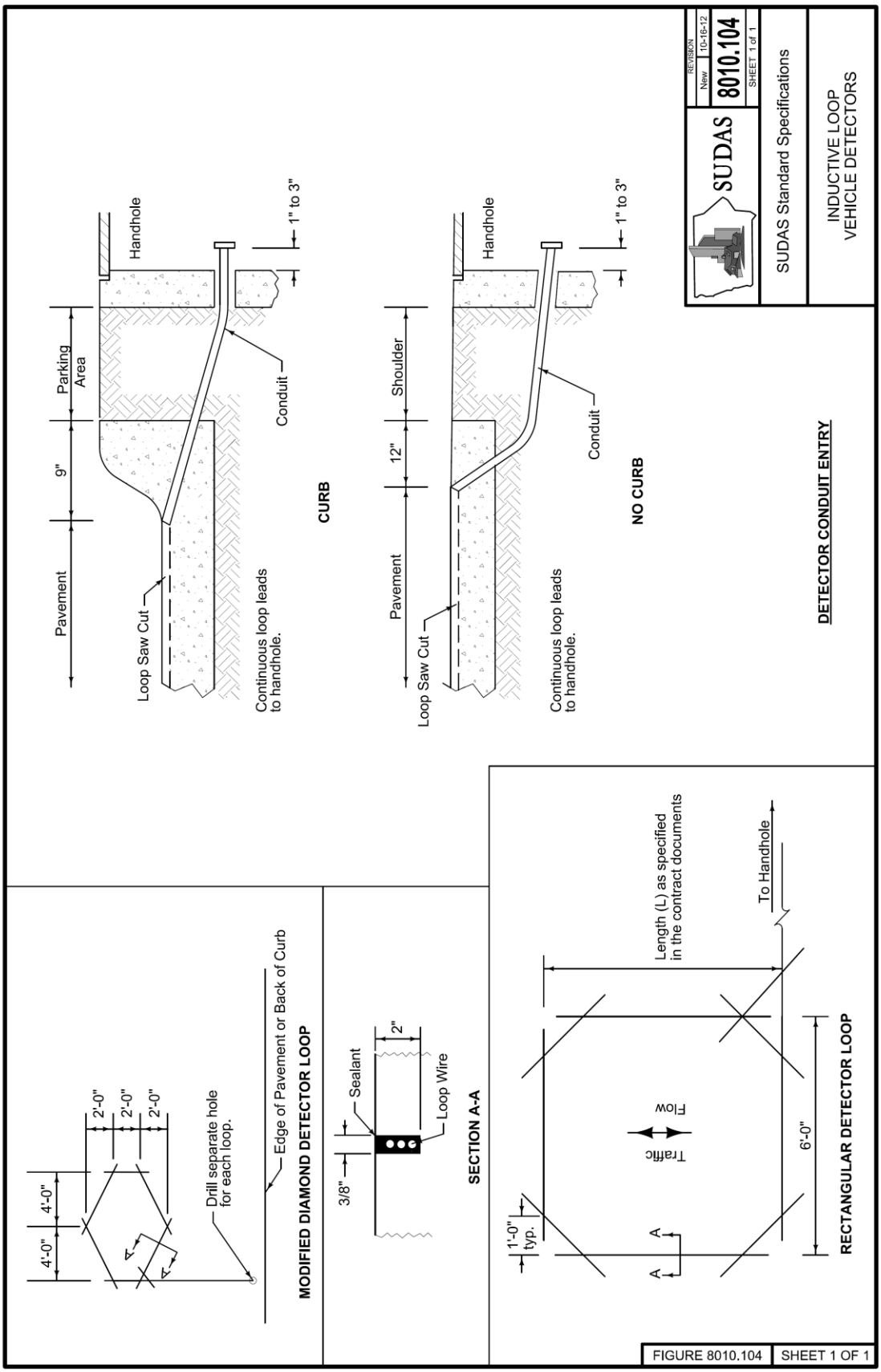
2. Detection: Detectors provide vehicle and pedestrian inputs to the traffic signal controller. Proper detector installation, operation, and maintenance is critical to the safe and efficient operation of any signalized intersection. An online resource to learn more about detection styles, modes, and typical layouts can be found within Chapter 9 - Traffic Signals from Mn/DOT's Traffic Engineering Manual. Since this document is a PDF, some of the information from this source is provided below.

Detector sizes and locations vary by agency and by location. SUDAS provides a standard drawing for a typical rectangular detector loop (Figure 13E-1.05).

An online resource can be found through Chapter 16 - Vehicle Detection from Lighting and Signal Certification Field Guide, which provides the designer with a photographic resource for installation and mounting details.

a. Inductive Loop Vehicle Detector: The most common type of vehicle detection device in use today is the inductive loop. This is a loop of wire imbedded in the pavement (saw cut in existing concrete or NMC loop in new concrete) carrying a small electrical current. When a large mass of ferrous metal passes over the loop, the magnetic field is disturbed and generates, or induces, a change in resonant frequency in the wire. This change in frequency is then recognized by the detector amplifier and signals the controller that a vehicle is present.

Figure 13E-1.05: Inductive Loop Vehicle Detectors
(SUDAS Specifications Figure 8010.104)



b. Pedestrian Push Button Detector: There are a number of ways to provide pedestrian actuation at a signalized intersection. The most common equipment used by far is the pedestrian pushbutton detector. Pressing the button provides a contact closure that actuates the call. There are plenty of examples of good and bad pedestrian pushbutton placement; however, part of the problem is getting the pedestrian to use the button. Specific information regarding pedestrian detectors can be found in the MUCTD Section 4E.08 Pedestrian Detectors.

An online resource can be found through Chapter 19 - Accessible Pedestrian Signal Push Buttons from Mn/DOT's Lighting and Signal Certification Field Guide, which provides the designer with a photographic resource for style, installation, and mounting details.

c. Video Detection Camera System: Vehicle detection by video cameras is a popular form of vehicle detection within Iowa. The rapid processing of video images provides the detection outputs to the controller. The designer should carefully consider the type of equipment necessary to provide video detection, the maintenance needs of this equipment, and the specific installation and mounting requirements necessary.

Designers should consider relevant manufacturer recommendations and other online resources such as the Guidelines for Using Video Detection at Intersections and Interchanges by Bonneson at Texas Transportation Institute.

d. Microwave Vehicle Detector: Microwave detection is often used within Iowa during temporary signal control to provide simple, non-intrusive vehicle detection. A variety of styles and levels of sophistication exist in the market today.

3. Communications: The designer may be required to provide supplemental specifications for these items given the highly proprietary nature of this equipment and the needs of the contracting agency. Generic specifications have been provided in the SUDAS Specifications.

4. Cabinet and Controller: The designer may be required to provide supplemental specifications for the controller, cabinet, and emergency vehicle pre-emption system given the highly proprietary nature of this equipment. Generic specifications have been provided in the SUDAS Specifications. New information was added to the specifications regarding uninterruptable power supply battery back-up system. The designer should carefully consider the cabinet and mounting requirements of the battery back-up system.

An online resource can be found through Chapter 22 - Traffic Signal Cabinets from Mn/DOT's Lighting and Signal Certification Field Guide, which provides the designer with a photographic resource for style, installation, and mounting details.

5. Poles, Heads, and Signs:

a. Vehicle Traffic Signal Head Assembly: Vehicle signal heads must comply with the following MUTCD sections:

Section 4D.16 Number and Arrangement of Signal Sections in Vehicular Traffic Control Signal Faces
Section 4D.17 Visibility, Shielding, and Positioning of Signal Faces
Section 4D.18 Design, Illumination, and Color of Signal Sections

An online resource can be found through Chapter 18 - Signal Heads from Mn/DOT's Lighting and Signal Certification Field Guide, which provides the designer with a photographic resource for style, installation, and mounting details.

b. Pedestrian Signal Head Assembly: Pedestrian vehicle signal heads must comply with the following MUTCD sections:

Section 4E.01 Pedestrian Signal Heads
Section 4E.02 Meaning of Pedestrian Signal Head Indications
Section 4E.03 Application of Pedestrian Signal Heads
Section 4E.04 Size, Design, and Illumination of Pedestrian Signal Head Indications
Section 4E.05 Location and Height of Pedestrian Signal Heads
Section 4E.06 Accessible Pedestrian Signals
Section 4E.07 Countdown Pedestrian Signals

c. Traffic Signal Poles and Mast Arms: Signalized intersections require poles and mast arms to achieve proper traffic signal and pedestrian head placement. Mast arm details and typical loadings are shown on Figure 13E-1.03; additional mast arm details are shown on Figure 13E-1.06. The designer should ensure that the plan locations comply with all clear zone, sight restriction, and pedestrian flow criteria. Vertical clearance to overhead utility lines is a constant issue that designers should take note of during pre-design field activities. Although the minimum height from the pavement to the bottom of the signal housing is 15 feet, the designer should consider the street classification and the volume of large trucks in establishing the signal height above the pavement. However, the top of the signal housing cannot exceed 25.6 feet above the pavement. If the project being designed has specific requirements relative to the elevation of the end of the mast arm in relation to the connecting point on the vertical pole, include those requirements in the special provisions of the contract documents.

An online resource can be found through Chapter 17 - Mast Arm Poles and Pedestals from Mn/DOT's Lighting and Signal Certification Field Guide, which provides the designer with a photographic resource for style, installation, and mounting details.

d. Traffic Signal Pedestal Poles: Pedestal poles provide alternate mounting heights for signal and pedestrian heads and are much easier to locate within a tight right-of-way. Pedestal pole details and typical head mounting information are shown in Figure13E-1.07.

e. Traffic Signs: The designer must ensure that all signs comply with Iowa DOT standards and the MUTCD.

Figure 13E-1.06: Mast Arm Pole Details
(SUDAS Specifications Figure 8010.105)

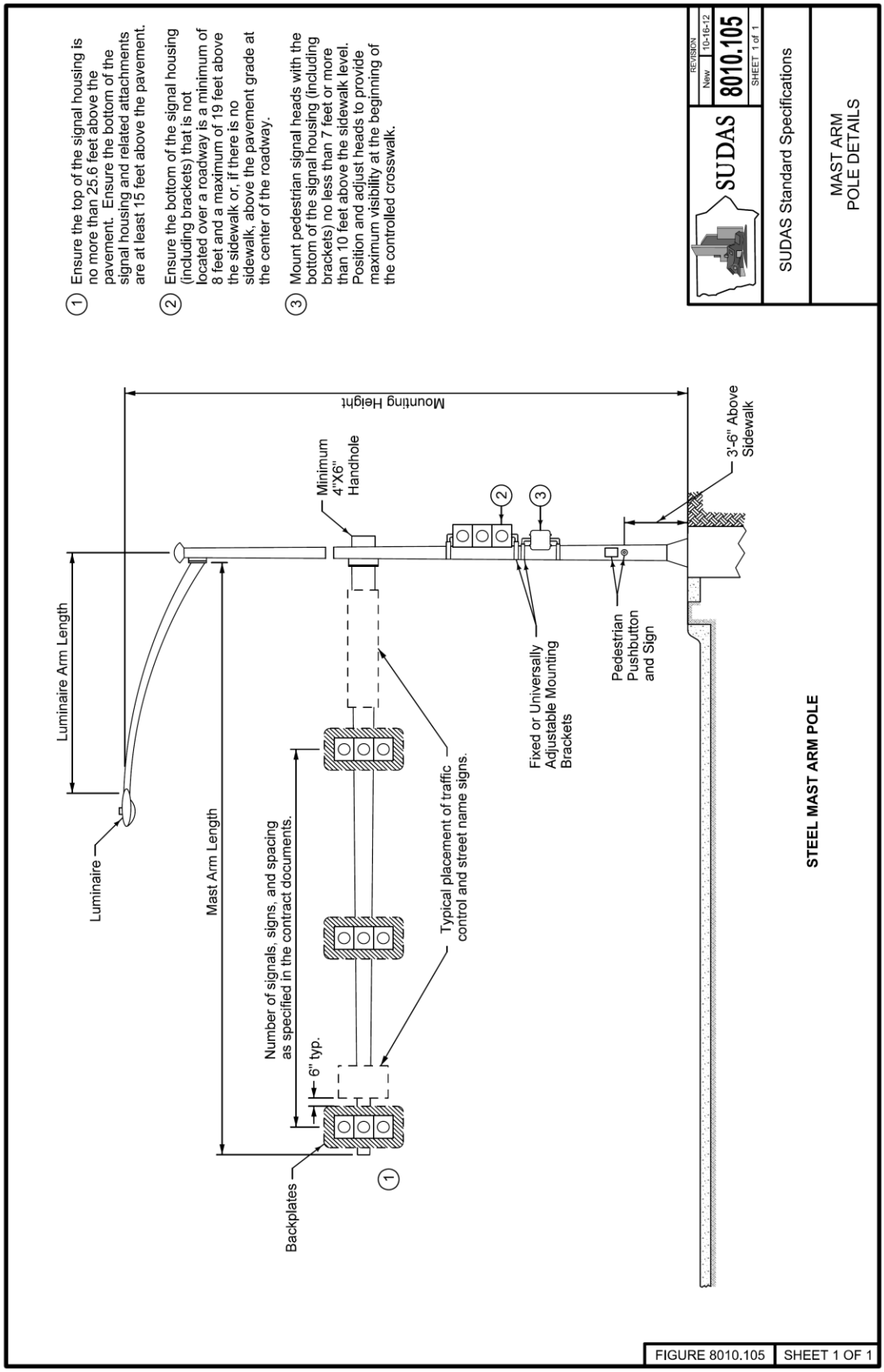
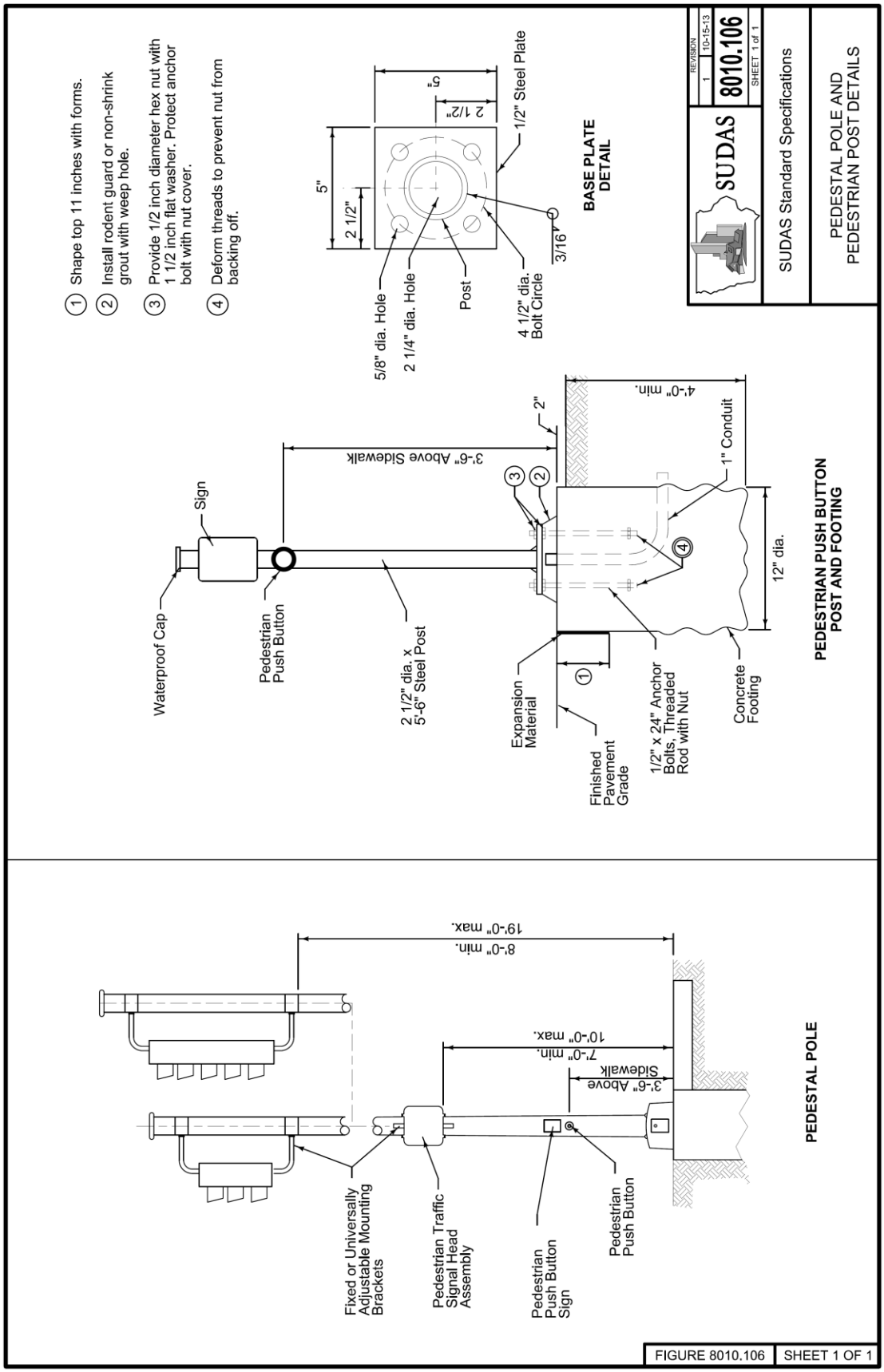


Figure 13E-1.07: Pedestal Pole and Pedestrian Post Details
(SUDAS Specifications Figure 8010.106)



C. Items Requiring Supplemental Specifications

A summary listing of items within SUDAS Specifications Section 8010 requiring supplemental specifications to be provided by the designer includes the following:

- Composite handhole and cover - specify materials and dimensions.
- Foundations - specify dimensions and any conduit stubs needed for future use.
- Communications - specify all traffic monitoring equipment along with any fiber optic equipment and materials.
- Cabinet, controller, and emergency vehicle preemption - specify all relevant equipment.
- Traffic signal poles and mast arms - specify specialty finish for pole if necessary.
- Traffic signs - specify sheeting, sign dimensions, and mounting requirements.