

V-05.01 Introduction

The North Dakota Department of Transportation (NDDOT) will follow its standard practices for the hydraulic and structural design of pipes. The NDDOT will adopt additional performance criteria that will be used to evaluate the acceptability of alternate pipe materials based on application, local, and regional factors.

V-05.02 Selection Considerations

The NDDOT will evaluate the risk associated with the performance of the pipe materials and the long-term performance of the completed end product. Risk will be considered to the extent that it is influenced by the pipe, other materials, or installation techniques as they are used in the construction practice. It is the owner's prerogative and responsibility to establish reasonable performance standards. Project design and material selection is inherently based on balancing the engineering requirements with the budgetary constraints of the project.

Risk is mitigated for NDDOT by following the AASHTO and ASTM national standards for pipe material. When reviewing the installation procedures of pipes the following criteria are considered:

- AASHTO standards;
- NDDOT research and experience;
- Other DOTs research and experience; and
- Manufacturers' recommendations.

During the design process it may become necessary to eliminate certain types of pipes due to physical characteristics of the pipe material, and project specific design constraints (e.g. matching existing inverts). A larger pipe diameter may be required if the Manning's "n" value is higher than 0.012.

Storm drains are limited to smooth interior pipe with a maximum Manning's "n" value of 0.012. This allows for the use of the following pipe materials:

- Reinforced Concrete;
- Plastic; and
- Spiral-Rib Metal.

Project location is considered for evaluation of alternate pipe materials as they relate to the following:

- Engineering;
- Cost; or
- Performance criteria.

Local agencies can provide the NDDOT with soil samples from the project for consideration to variances in the Corrosion Zone.

Pipe material selection for **projects on the state highway system** will follow the guidance of this document. If local agencies want a specific pipe material, that is not covered in this document, installed on a state highway system, the local agency may request bidding it as an option along with the alternative pipe materials. The request should be made in writing, and addressed to the Director of the Office of Project Development.

For all **projects off of the state highway system** and not receiving federal funds, the local governing authority has the ability to specify culvert and storm sewer material types they want to include on their construction project.

The following sections describe the selection procedure that supports the general policy statement. They refer to the processes and procedures that identify the specific engineering, cost analysis, and performance criteria used to evaluate the acceptability of alternate pipe materials. It is NDDOT's practice to allow alternate pipe materials where they can be used.

Any limitations to materials will be documented and will be kept in order to ensure valid engineering reasoning for any material limitations.

V-05.03 Bid Items

New Pipe Installations

Bid items for new pipe installations are broken into 3 main categories which are:

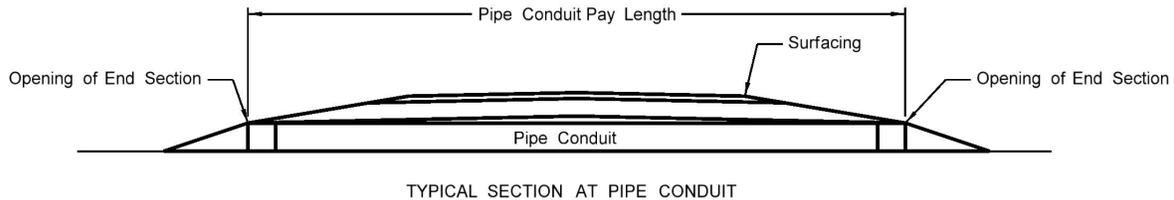
1. **Pipe Conduit __ IN:** Typical transverse centerline culvert
2. **Pipe Conduit __ IN – Storm Drain:** Urban/storm sewer drainage
3. **Pipe Conduit __ IN – Approach:** All approach pipe designations.

The plans, specifications and bid documents for the project identify all alternate pipe materials deemed to be acceptable for each installation application, based on the results of the evaluation.

End sections for new pipe installation are included in the contract unit price for "Pipe Conduit__".

The pay length for pipe conduit is measured along the top of the conduit between the openings of the end sections, as shown in Figure V-05.03.01. When using cross sections to determine pipe length, include the topsoil to ensure the proper total length of pipe is found. Calculate length to the nearest foot. Include the barrel lengths for Reinforced Concrete Pipe.

Figure V-05.03.01 – Pipe Conduit Pay Length



Pipe Extensions

Pipe extensions and their bid item will match the existing pipe material. End sections will be bid separately for pipe extensions. Reuse the existing end section if they are in satisfactory condition. If the end sections need to be replaced, they should be paid for by the each installed of the type and size required.

For example, a 30” concrete pipe extension needing a new end section would be paid for as “PIPE CONC REINF 30IN CL III” (LF) and “END SECT-CONC REINF 30 IN” (EA). If the end section is in a condition to be reused, the end section should be paid for as “REMOVE & RELAY END SECTION-ALL TYPE & SIZES” (EA).

V-05.04 Design Service Life

The DSL of highway drainage structures is the period of little to no rehabilitative maintenance and is not assumed to be at or near collapse at the end of their service life. Drainage structures are designed to provide a minimum DSL. The minimum DSL for Mainline Drainage and Storm Drain Trunk Lines & Lateral pipes is 75 years, while Approach Drainage pipes have a minimum DSL of 40 years.

The DSL for reinforced concrete pipe is from installation to the exposure of the reinforcing steel or the appearance of significant cracking due to distress. The DSL for metal pipe for Mainline Drainage, Storm Drain Trunk lines, and Lateral Drainage application is from installation until the point where perforation to the metal occurs on any portion of the pipe. The DSL for metal pipes used for Approaches is from installation until the point where perforation of the metal occurs on the invert. The DSL for plastic pipe is from installation until the point where excessive cracking, perforation, or deflection occurs.

V-05.05 Pipe Material

Table 1, “Pipe Materials” lists the pipe material’s corresponding references to the NDDOT *Standard Specifications for Road and Bridge Construction*. These pipe materials are considered appropriate for Mainline Drainage, Approach Drainage, and Storm Drains; with certain exceptions for Plastic Pipes under paved roadways. For the purpose of this manual, a paved

roadway is defined as any public roadway with an HBP or concrete surface, including raised median islands. Areas not considered paved roadways would include such items as parking lots, private drives, or pedestrian/bike paths.

Plastic Pipes are only allowed under paved roadways if all the following conditions are met:

- Pipe material is Polypropylene Pipe (Type S);
- Pipe diameter is 36 inches or less;
- Paved roadway is on either a Level 2 or 3 State Strategic Freight System route. -See link “Freight Map” at <http://www.dot.nd.gov/divisions/planning/freight/>
- Paved roadway is classified as a State Corridor, District Corridor, or District Collector; and
- Paved roadway has a current ADT less than 2,000.

Concrete is the only type of pipe material allowed to be installed under divided highways with depressed medians. These pipes will likely be connected in the median with shallow cover and possibly require a slotted drain. The shallow cover in these areas makes pipes susceptible to crushing and replacement activities would have detrimental impacts to the traveling public.

- One exception to the above requirement is that smooth-walled steel pipe for Jacked/Bored pipe shall be allowed under divided highways with depressed medians. However, the non-Jacked/Bored portions of the crossing (as shown on Standard Drawing D-714-16) must still be concrete pipe only.

Material	NDDOT Specifications
Concrete Pipe	714.03 & 830.01
Metal Pipe	714.03 & 830.02
Plastic Pipe	714.03 & 830.03

The NDDOT may consider new pipe materials or products for inclusion in future projects based on:

- Conformance with national standard specifications (AASHTO or ASTM);
- Product performance history; and
- NDDOT or other DOT research findings.

If a product or material is found to be acceptable, it may be considered for evaluation on specific projects or on an experimental basis, before it is included into the NDDOT Standard Specifications.

Consider the following factors when selecting pipe materials:

- Hydraulic Capacity,
- Structural Capacity,
- Service Life,
- Soil/Water Corrosivity,
- Fill Height,
- Bed Load Abrasion,
- Resistance to Fire, and
- Water Tight Joints.

The list of factors to be considered above are not intended to be all inclusive, therefore a proper engineering analysis is required for all installations. For large installations, the analysis should include installation cost comparisons.

The fill height tables for various pipes are located in Section V-05A of the NDDOT Design Manual. These tables will be used to determine the applicability of the various alternate pipe materials, shape, gauge, and wall thickness. If tables for an allowable pipe material do not exist, the manufacturer's recommendations will be followed.

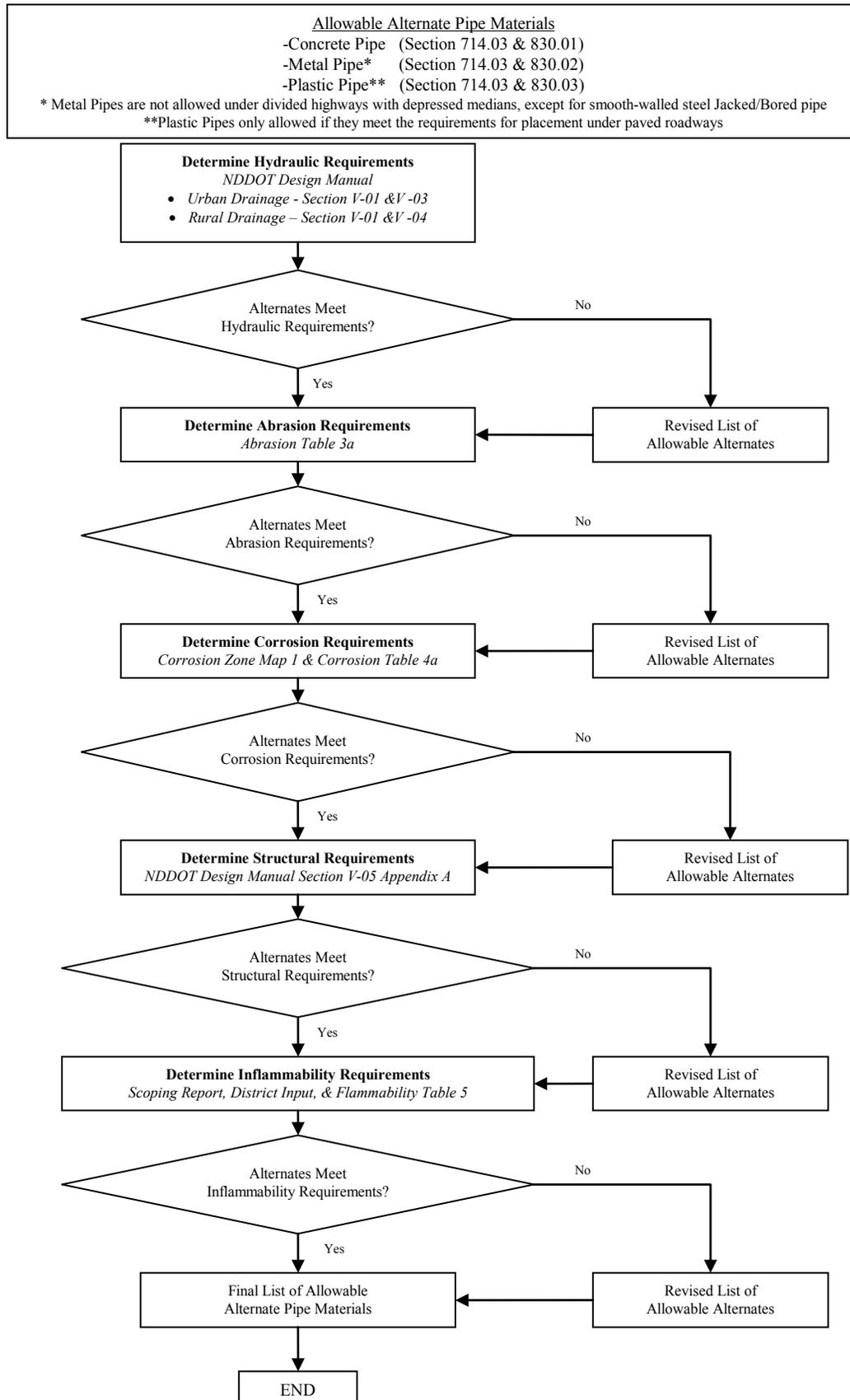
V-05.06 Pipe Material Selection Process

The Designer will follow the selection steps shown in the flow chart for the specific pipe application. Flow charts titled Mainline Drainage, Approach Drainage, and Storm Drain Trunk Line and Laterals; guide the Designer through the process of evaluating the critical criteria to determine the alternate pipe materials allowable for the project application.

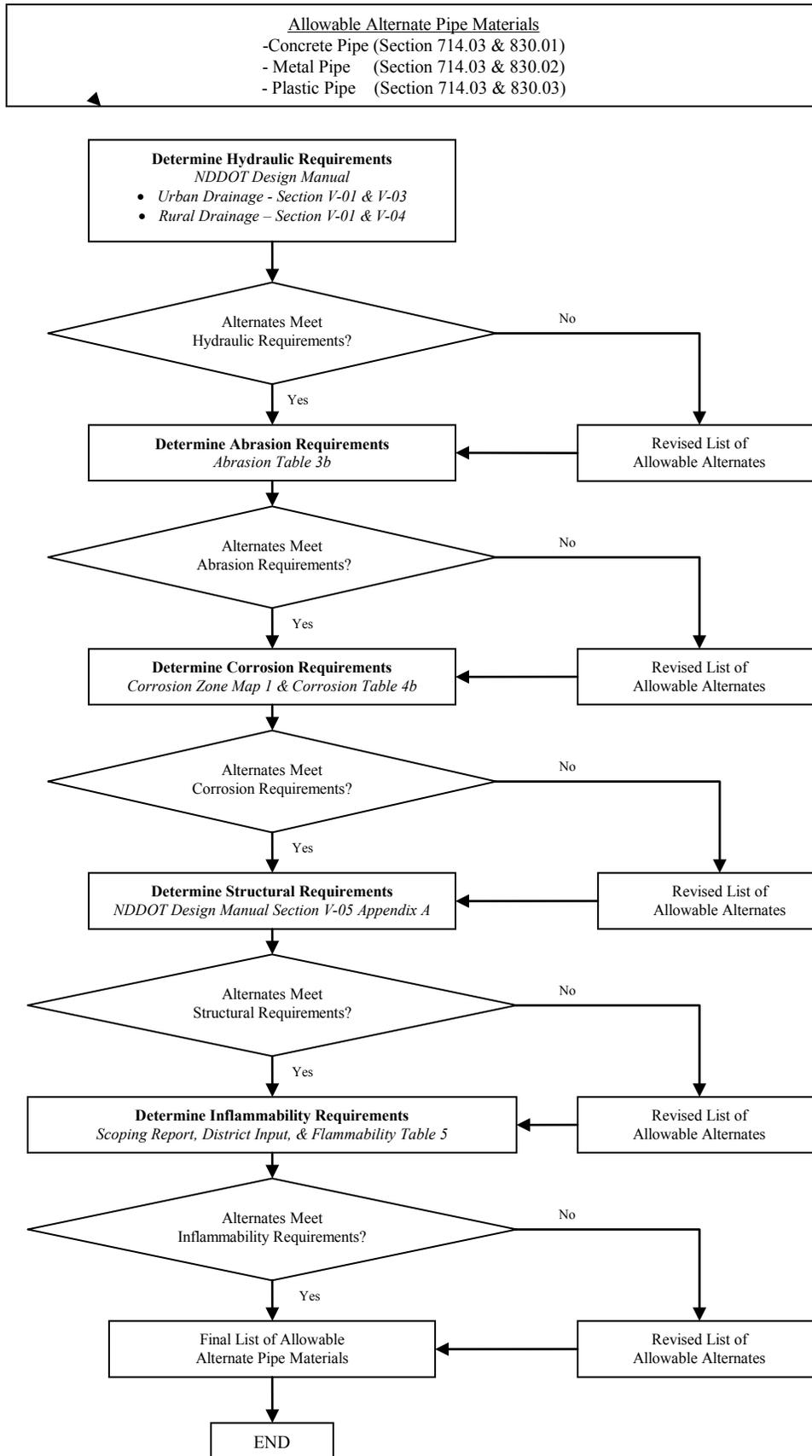
The Designer will use the following resources in the Procedure based for the specific design application:

- Application Requirements (Allowable Pipe Materials)
 - Section V-05.05 Pipe Materials (in this document)
 - NDDOT Standard Specifications for Road and Bridge Construction
 - Section 714, “Culverts, Storm Drains, Edgedrains, and Underdrains” and Section 830, “Pipe and Drainage Structures”
 - NDDOT Supplemental Specifications
- Hydraulic & Hydrostatic Design Requirements
 - NDDOT Design Manual
 - Rural Drainage – Section V-01 & V-04
 - Urban Drainage – Section V-01 & V-03
- Abrasion Requirements
 - Abrasion Tables 3a and 3b (in this document)
- Corrosion Requirements
 - Corrosion Zone Map 1 (in this document)
 - Corrosion Table 4a – Mainline Drainage (in this document)
 - Corrosion Table 4b – Approach Drainage (in this document)
 - Corrosion Table 4c – Storm Drain Trunk Line & Lateral Drainage (in this document)
- Structural Requirements
 - Concrete Pipe : NDDOT Design Manual Section V-05 Appendix A
 - Metal Pipe: NDDOT Design Manual Section V-05 Appendix A
 - Plastic Pipe
 - High-Density Polyethylene (HDPE): Manufacturer’s Recommendation
 - Polypropylene (PP): NDDOT Design Manual Section V-05 Appendix A
- Inflammability Requirements
 - NDDOT Project Scoping Report
 - NDDOT District Engineer Input
 - Flammability Table 5 (in this document)

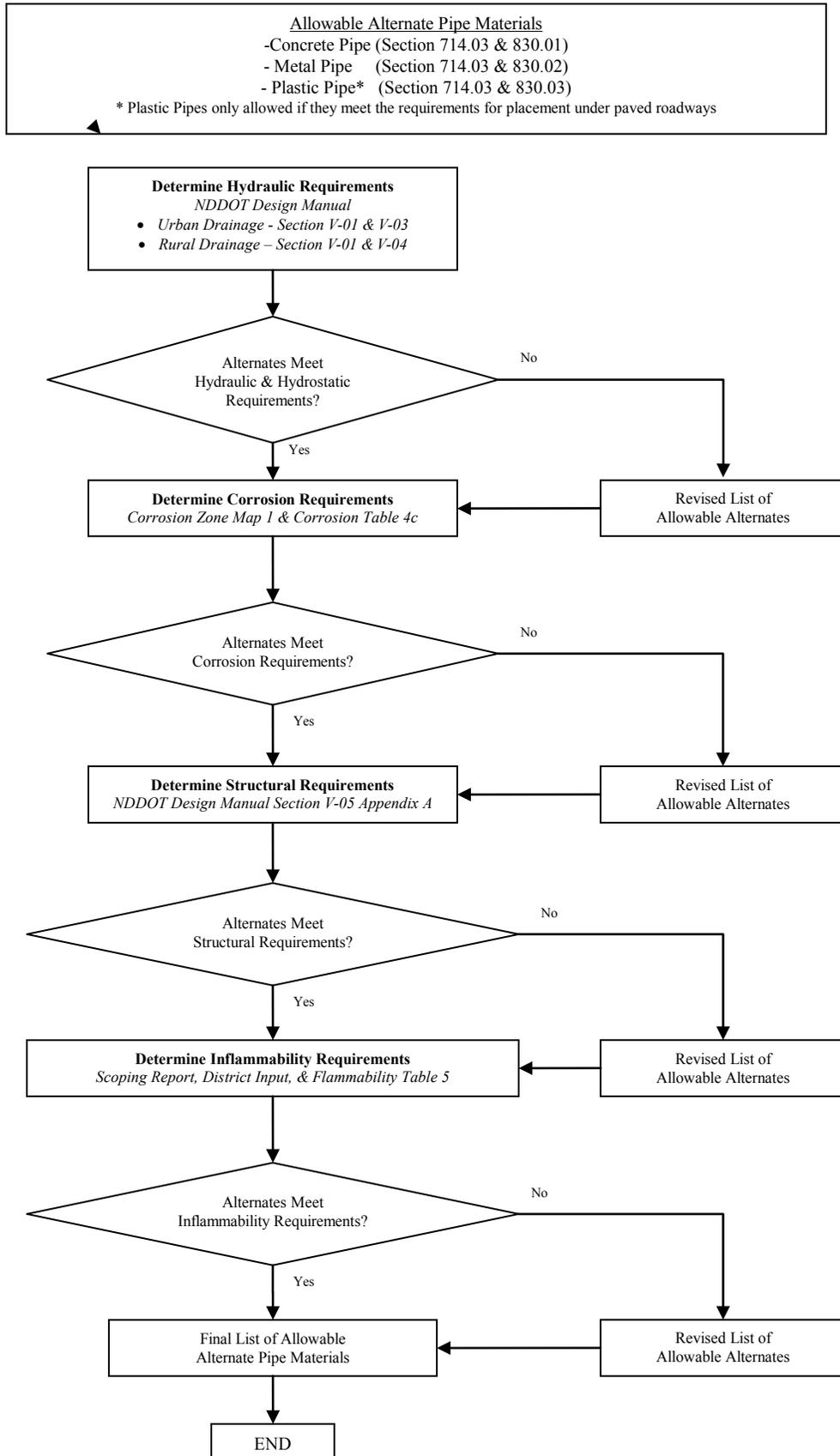
Mainline Drainage Flowchart
(Design Service Life – 75 Years)



Approach Drainage Flowchart
(Design Service Life – 40 Years)



Storm Drain Trunk Line & Lateral Drainage Flowchart
(Design Service Life – 75 Years)



Abrasion Table: 3a

Mainline Drainage
(Design Service Life – 75 Years)

Pipe Material	Abrasion Level				
	Level 1	Level 2	Level 3	Level 4	Level 5
Concrete Pipe (Section 830.01)	Y	Y	Y	Y	Y
Metal Pipe (Section 830.02)					
Zinc Coated Corrugated Steel	Y	Y			
Aluminum Coated Corrugated Steel (Type 2)	Y	Y	Y		
Polymeric Coated Steel (over Zinc or Aluminum Coated Steel)	Y	Y	Y	Y	
Plastic Pipe (Section 830.03)					
Polypropylene Pipe (Type S)	Y	Y	Y	Y	Y

Level 1 – No bedload – regardless of velocity.

Level 2 – Bedload of sand, gravel, and debris with velocities of 0 to 5 ft/s.

Level 3 – Bedload of sand, gravel, and debris with velocities of 5 to 10 ft/s.

Level 4 – Bedload of sand, gravel, and debris with velocities of 10 to 15 ft/s.

Level 5 – Bedload of sand, gravel, and debris with velocities greater than 15 ft/s.

Abrasion velocities based on a 2 year design frequency.

Source: National Corrugated Steel Pipe Association, West Virginia DOT Design Directive DD-503 and ADS Inc. Drainage Handbook Section 4 - Durability.

Abrasion Table: 3b

Approach Drainage
(Design Service Life – 40 Years)

Pipe Material	Abrasion Level				
	Level 1	Level 2	Level 3	Level 4	Level 5
Concrete Pipe (Section 830.01)	Y	Y	Y	Y	Y
Metal Pipe (Section 830.02)					
Zinc Coated Corrugated Steel	Y	Y			
Aluminum Coated Corrugated Steel (Type 2)	Y	Y	Y		
Polymeric Coated Steel (over Zinc or Aluminum Coated Steel)	Y	Y	Y	Y	
Plastic Pipe (Section 830.03)					
High-Density Polyethylene (Type S)	Y	Y	Y	Y	Y
Polypropylene Pipe (Type S)	Y	Y	Y	Y	Y

Level 1 – No bedload – regardless of velocity.

Level 2 – Bedload of sand, gravel, and debris with velocities of 0 to 5 ft/s.

Level 3 – Bedload of sand, gravel, and debris with velocities of 5 to 10 ft/s.

Level 4 – Bedload of sand, gravel, and debris with velocities of 10 to 15 ft/s.

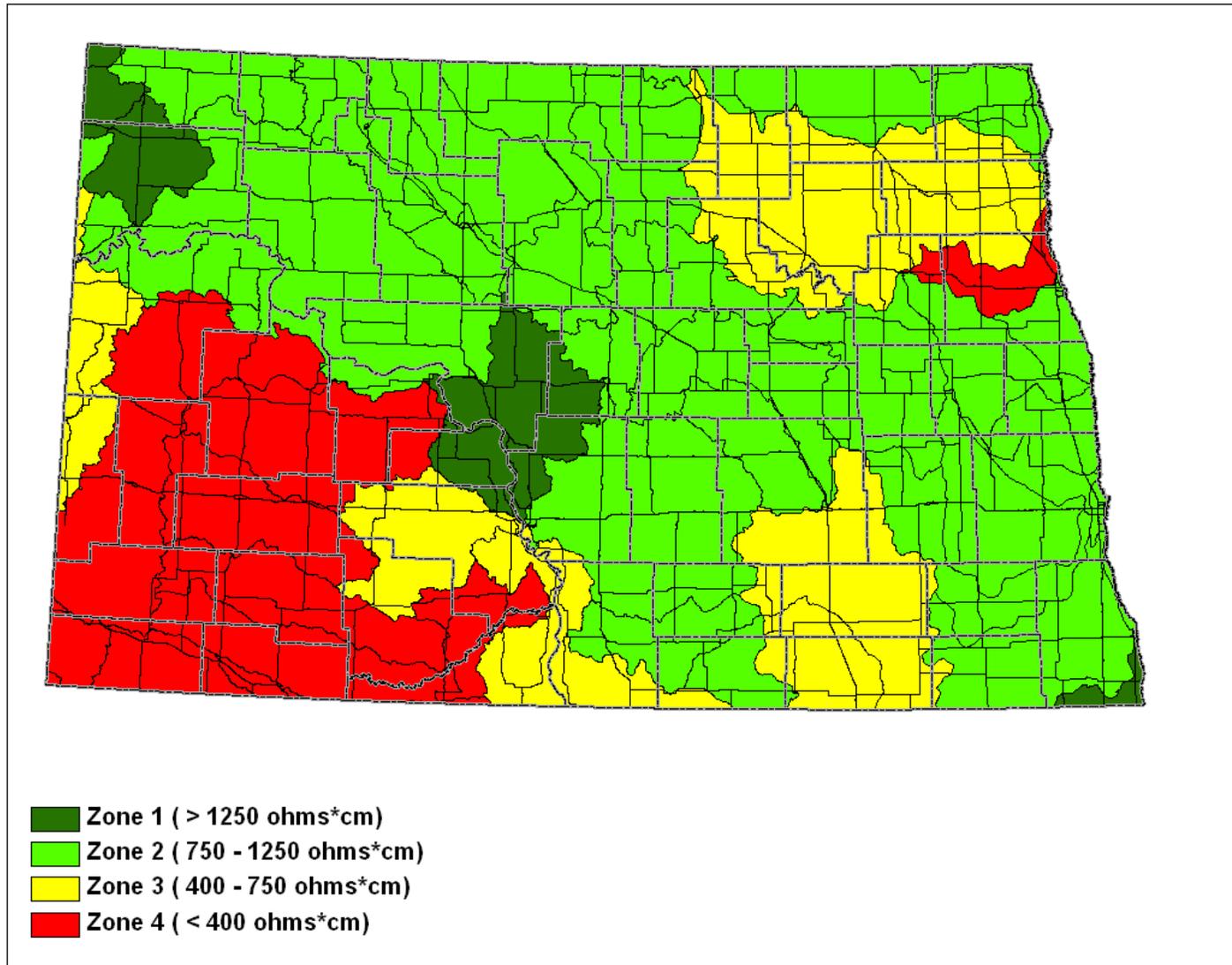
Level 5 – Bedload of sand, gravel, and debris with velocities greater than 15 ft/s.

Abrasion velocities based on a 2 year design frequency.

Source: National Corrugated Steel Pipe Association, West Virginia DOT Design Directive DD-503 and ADS Inc. Drainage Handbook Section 4 - Durability.

Corrosion Zone Map & Tables

North Dakota Corrosion Zones (Map 1)
(Based on Soil Resistivity)



Data Source: United States Environmental Protection Agency's (EPA) Environmental Monitoring Assessment Program.

Corrosion Table: 4a

Mainline Drainage
(Design Service Life – 75 Years)

Pipe Material		Corrosion Zone			
		Zone 1	Zone 2	Zone 3	Zone 4
Concrete Pipe (Section 830.01)		Y	Y	Y	Y
Metal Pipe (Section 830.02)					
Gauge					
Zinc Coated Corrugated Steel	16 ga.				
	14 ga.				
	12 ga.				
	10 ga.	Y			
	8 ga.	Y	Y		
Aluminum Coated Corrugated Steel (Type 2)	16 ga.				
	14 ga.				
	12 ga.	Y			
	10 ga.	Y	Y		
	8 ga.	Y	Y	Y	
Polymeric Coated Steel (over Zinc or Aluminum Coated Steel)	16 ga.	Y	Y	Y	Y
	14 ga.	Y	Y	Y	Y
	12 ga.	Y	Y	Y	Y
	10 ga.	Y	Y	Y	Y
	8 ga.	Y	Y	Y	Y
Plastic Pipe (Section 830.03)					
Polypropylene Pipe (Type S)		Y	Y	Y	Y

(Based on Caltrans research formula for metal pipe service life and industry service life multipliers for coated metal pipe)

Corrosion Table: 4b

Approach Drainage
(Design Service Life – 40 Years)

Pipe Material		Corrosion Zone			
		Zone 1	Zone 2	Zone 3	Zone 4
Concrete Pipe (Section 830.01)		Y	Y	Y	Y
Metal Pipe (Section 830.02)					
Gauge					
Zinc Coated Corrugated Steel	16 ga.	Y	Y	Y	Y
	14 ga.	Y	Y	Y	Y
	12 ga.	Y	Y	Y	Y
	10 ga.	Y	Y	Y	Y
	8 ga.	Y	Y	Y	Y
Aluminum Coated Corrugated Steel (Type 2)	16 ga.	Y	Y	Y	Y
	14 ga.	Y	Y	Y	Y
	12 ga.	Y	Y	Y	Y
	10 ga.	Y	Y	Y	Y
	8 ga.	Y	Y	Y	Y
Polymeric Coated Steel (over Zinc or Aluminum Coated Steel)	16 ga.	Y	Y	Y	Y
	14 ga.	Y	Y	Y	Y
	12 ga.	Y	Y	Y	Y
	10 ga.	Y	Y	Y	Y
	8 ga.	Y	Y	Y	Y
Plastic Pipe (Section 830.03)					
High-Density Polyethylene (Type S)		Y	Y	Y	Y
Polypropylene Pipe (Type S)		Y	Y	Y	Y

(Based on AISI formula for metal pipe invert life and industry service life multipliers for coated metal pipe)

Corrosion Table: 4c

Storm Drain Trunk Line & Lateral Drainage
(Design Service Life – 75 Years)

Pipe Material		Corrosion Zone			
		Zone 1	Zone 2	Zone 3	Zone 4
Concrete Pipe (Section 830.01)		Y	Y	Y	Y
Metal Pipe (Section 830.02)					
Gauge					
Zinc Coated Corrugated Steel	16 ga.				
	14 ga.				
	12 ga.				
	10 ga.	Y			
	8 ga.	Y	Y		
Aluminum Coated Corrugated Steel (Type 2)	16 ga.				
	14 ga.				
	12 ga.	Y			
	10 ga.	Y	Y		
	8 ga.	Y	Y	Y	
Polymeric Coated Steel (over Zinc or Aluminum Coated Steel)	16 ga.	Y	Y	Y	Y
	14 ga.	Y	Y	Y	Y
	12 ga.	Y	Y	Y	Y
	10 ga.	Y	Y	Y	Y
	8 ga.	Y	Y	Y	Y
Plastic Pipe (Section 830.03)					
High-Density Polyethylene (Type S)		Y	Y	Y	Y
Polypropylene Pipe (Type S)		Y	Y	Y	Y

(Based on Caltrans research formula for metal pipe service life and industry service life multipliers for coated metal pipe)

Flammability Table: 5

Pipe Material Allowable Where Burning is Anticipated

Pipe Material	Application		
	Mainline Drainage	Approach Drainage	Storm Drain Trunk Line and Lateral Drainage
Concrete Pipe (Section 830.01)	Y	Y	Y
Metal Pipe (Section 830.02)			
Zinc Coated Corrugated Steel	Y	Y	Y
Aluminum Coated Corrugated Steel (Type 2)	Y	Y	Y
Polymeric Coated Steel (over Zinc or Aluminum Coated Steel)	Y*	Y*	Y*
Plastic Pipe (Section 830.03)			
High-Density Polyethylene (Type S)	N	Y*	Y*
Polypropylene Pipe (Type S)	Y*	Y*	Y*

Notes:

* Only used in flammable applications with the addition of non-flammable segments and/or end treatments as determined by the Designer.